Economic Analysis of Cultural Services

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Susana Mourato, Giles Atkinson, Murray Collins, Steve Gibbons, George MacKerron and Guilherme Resende

Department of Geography and Environment

London School of Economics and Political Science

Houghton Street

London WC2A 2AE

United Kingdom

1. Introduction

In this report we present an economic evaluation of key cultural benefits provided by ecosystem services in the UK. We estimate both an aggregate measure of cultural benefits (as embodied in nature's amenity values) as well as selected individual cultural benefits (such as non-use values, education and ecological knowledge, and physical and mental health).

Firstly, we present a new hedonic price analysis of the *amenity value* provided by broad habitats, designated areas, private gardens and other environmental resources in the UK and in England. We define amenity value as the increased well-being associated with living in or within close proximity to desirable natural areas and environmental resources. This increased well-being can potentially be derived from increased leisure and recreational opportunities, visual amenity, increased physical exercise opportunities and possibly mental or psychological well-being. Our analysis is based on actual observed market data, namely house transactions, and assumes that the choice of a house reflects an implicit choice over the nearby environmental amenities so that the value of marginal changes in proximity to these amenities is reflected in house prices.

Secondly, we estimate the economic value of *educational and ecological knowledge* provided by ecosystem services based on the value of ecological knowledge acquired through school education in England. The core of our investigation is the ecological knowledge acquired through the national curriculum of subjects such as Geography and Biology, but we also look into other children's nature-based educational experiences such as school trips.

Thirdly, we compute a measure of the ecosystem-related *non-use values* that can be observed in market data. Specifically, we analyse legacies to key nature and conservation organizations in the UK as a proxy for observable non-use values.

We conclude our report with an analysis of the *physical and mental health effects* associated with natural spaces and related ecosystems in the UK. We analyse both the health benefits arising from increased physical exercise and those arising from more passive forms of contact with nature. Some of our analysis is based on geo-located data from a new national web-survey that estimated the physical functioning and emotional wellbeing associated with use of and proximity to natural spaces.

Table 1 illustrates how the cultural benefits evaluated in this report relate to those identified in the Cultural Services NEA chapter (Burgess et al., 2010). The first column displays the list of cultural benefits proposed in Burgess et al. (2010). The second column further develops this terminology for economic analysis by clarifying that the benefits identified can accrue from direct use of the resources (i.e. via direct contact with nature), from distant use (i.e. via books, films or other media), from potential future use (e.g. potential leisure visits, or potential health benefits), or can be unrelated to any personal use (non-use values). The last four columns show which economic benefits are actually measured in this report, from amenity values which cover a range of individual cultural benefits (column 3) to individual cultural benefits such as education/ecological knowledge, non-use values and physical/mental health (columns 4-6).

A generalised lack of knowledge and a dearth of quantitative (and monetary) information about a number of the cultural benefits categories listed in Table 1 – such as spiritual and religious benefits, community benefits, and distant use values such as those enjoyed via mediated natures and landscape art, for example – meant that it was not possible to estimate their disaggregated monetary value as part of this assessment. Moreover, some of the benefits listed are intrinsically bundled and may not be able to be separately identified. For example, aesthetic benefits, health benefits, cultural, spiritual and educational benefits can all be bundled within the value of a leisure visit to the countryside. In this respect, our amenity value calculation, as depicted in column 3, provides an aggregate measure of several categories of cultural benefits. But further original research is needed in order to attempt to separately identify and estimate of the monetary value of all the benefits in the table.

Table 1: Cultural benefits classification

Burgess et al. (2010) classification	Economic classification	Section 2: Amenity values	Section 3: Education and ecological knowledge	Section 4: Non-use values	Section 5: Physical and mental health
	Direct use values	**Direct use values**	**Direct use values**		**Direct use values**
Leisure, recreation and tourism	Leisure, recreation and tourism	Leisure, recreation and tourism			
Aesthetic and inspirational benefits	Aesthetic and inspirational benefits	Aesthetic and inspirational benefits			
Cultural heritage	Cultural heritage	Cultural heritage			
Spiritual and religious benefits	Spiritual and religious benefits	Spiritual and religious benefits			
Community benefits	Community benefits	Community benefits			
Education and ecological knowledge	Education and ecological knowledge	Education and ecological knowledge	Education and ecological knowledge		
Physical and mental health	Physical and mental health	Physical and mental health			Physical and mental health
	Distant use values		**Distant use values**		
	Aesthetic and inspirational benefits				
	Education and ecological knowledge		Education and ecological knowledge		
	Option values	**Option values**			
	Potential future use	Potential future use			
	Non-use values			**Non-use values**	
	Altruistic, bequest and existence values			Altruistic, bequest and existence values	

2. Amenity value of nature in the UK

2.1. Introduction

The UK is home to a wide range of ecosystems and natural habitats that play an important role in biodiversity conservation. Broad *natural habitats* include: marine and coastal margins; freshwater, wetlands and flood plains; mountains, moors and heathland; semi-natural grasslands; enclosed farmland; coniferous and broad-leaved / mixed woodland; urban; and inland bare ground. Enclosed farmland occupies the largest area, almost 50% of the country, followed by semi-natural grasslands and mountains which together cover approximately a third of the UK. Woodland covers just over 12% whilst urbanised areas constitute around 7% of the total. Many of these habitats provide a wide range of opportunities for recreation and leisure such as woodland walks, rock climbing, bird-watching and visits to the coast. There are over 5 billion day visits to the English countryside each year (TNS, 2004) and about one third of all leisure visits in England were to the countryside, coast or woodlands (Natural England, 2005).[1]

Some especially important, rare or threatened natural areas are formally designated under various pieces of national and international legislation to ensure their protection. One of the best known designations are *National Parks*, aiming to conserve the natural beauty and cultural heritage of areas of outstanding landscape value and to provide opportunities for the public to understand and enjoy these special qualities. There are 10 National Parks in England, 3 in Wales and 2 in Scotland. Most were established in the 50's, with the latest addition to the National Parks family being established in 2010 (South Downs). Resident population ranges from 2,200 people in Northumberland to 120,000 in South Downs. National Parks are particularly attractive for visitors due to their distinguishing features and attract many millions of visits every year. The most popular destinations are the Peak

[1] Appendix A contains detailed information on the extent of land cover of each broad habitat in the UK.

District, with over 10 million visits, the Yorkshire Dales with 9.5 million and the Lake District with just over 8 million visits (National Parks, 2010). [2]

Another commonly used designation is the *Green Belt*, used in planning policy in the UK to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighbouring urban areas. Green belts aim to avoid excessive urban sprawl, safeguard the countryside from encroachment, prevent towns from merging and provide open space. By retaining open countryside space, greenbelts provide opportunities for local outdoor leisure and recreation and aid nature conservation interests. There are around 14 Green Belts throughout England, covering 13% of land area. The largest Green Belt is the London Green Belt, at about 486,000 hectares, with other major green belts being located around the West Midlands conurbation, Manchester, Liverpool, and in South and West Yorkshire.

Some natural areas have especial heritage interest or historical importance. Many of these areas belong to the *National Trust* (NT), the UK's leading independent conservation and environmental organisation, acting as a guardian for the nation in the acquisition and permanent preservation of places of historic interest and natural beauty. The NT manages around 254,000 hectares (627,000 acres) of countryside moorland, beaches and coastline in England, Wales and Northern Ireland, 709 miles of coastline (1,141 km), as well as 215 historic houses and gardens, 40 castles, 76 nature reserves, 6 World Heritage Sites, 12 lighthouses and 43 pubs and inns of outstanding interest and importance (NT, 2010a). NT sites are very popular recreational sites: more than 14 million people visit its 'pay for entry' properties, and an estimated 50 million visit open air properties (NT, 2010a).

Green leisure opportunities are also provided at a much more localised scale, in people's own *domestic gardens*. Approximately 23 million households (87% of all homes) have access to a garden. Gardening is thought to be one of the most commonly practiced type of physical activity (Crespo et al., 1996; Yusuf et al.,1996; Magnus et al., 1979) with UK households spending on average 71 hours a year gardening (Mintel, 1997). Domestic gardens in England constitute just over 4%

[2] For a map of National Parks and a list with park summary statistics see Appendix A.

(564,500 ha) of total land cover with the majority being located in urban areas and covering an average 13% of the urban landscape (GLUD 2005). The average garden size has been estimated as 190m2 (Davies et al., 2009).

Despite modern trends, such as the paving over front gardens, it is increasingly recognized that domestic gardens provide crucial habitats for plant and animal species (Gaston et al, 2007). Many people in the UK actively try to attract wild species to their gardens with an increasing interest in wildlife gardening, keeping ponds, provision of bird nesting sites, and wild bird feeding, the most popular activity (Gaston et al., 2007). Approximately 12.6 million (48%) households provide supplementary food for birds, 7.4 million of which specifically use bird feeders (Davies et al., 2009). There are an estimated 29 million trees, 3.5 million ponds and 4.7 million nest boxes in UK gardens (Goddard et al., 2009). Plant-species richness recorded in gardens in five UK cities exceeded levels recorded in other urban and semi-natural habitats (Goddard et al., 2009). Although the exact composition of urban domestic gardens and the presence of features of relevance to biodiversity is poorly understood, survey data from Sheffield estimated that 14% contained ponds, 26% nest-boxes, 29% compost heaps and 48% had trees more than 3 m tall (Gaston et al. 2007).

Living within or in close proximity to natural habitats such as coasts or woodlands, to designated areas such as National Parks or Greenbelts, to National Trust managed properties, and in neighbourhoods with desirable environmental features such as a large share of domestic gardens, arguably provides positive welfare benefits to residents. These *increased benefits are derived from the range of cultural services provided by nature*: increased visual amenity, leisure and recreational opportunities, potential for green exercise and possibly mental or psychological well-being. In this section, we broadly refer to the increased well-being associated with living in or within close proximity to desirable natural areas and environmental resources as *amenity value*.

There are many market and non-market methodologies available to estimate the amenity value of natural areas. For example, we can implement a stated preference survey to find out how much people are willing to pay to preserve a greenbelt area from development. Or we can analyse actual recreation destination choices and use travel costs as a proxy for the value of accessing a woodland. We could even analyse the expenditure people incur in plants, seeds, bird food and ponds to increase biodiversity in their private gardens.

In this section we estimate the *amenity value associated with UK habitats, designated areas, heritage sites, domestic gardens and other natural amenities using a hedonic price approach*, a well-established and widely used method from the family of revealed preference techniques.

2.2. Methodology [3]

We use the *hedonic price method* (HPM) to estimate the amenity value of a range of habitats, designated areas, heritage sites, private gardens and several other environmental goods (Sheppard, 1999; Champ et al., 2003). The HPM – also known as hedonic regression – assumes that we can look at house transactions to infer the implicit value of the house's underlying characteristics (structural, locational/accessibility, neighbourhood and environmental). From a policy perspective this method is desirable as it is based on clear theoretical foundations and on observable market behaviour rather than on stated preference surveys.

There is a long tradition of studies looking at the effect of a wide range of environmental amenities and disamenities on property prices: road noise (Day at al., 2006; Wilhelmsson 2000), agricultural acitivities (Le Goffe 2000), water quality (Leggett and Bockstael, 2000; Boyle, Poor and Taylor, 1999), preserved natural areas (Correll, Lillydahl, and Singell, 1978; Lee and Linneman, 1998), wetlands (Doss and Taff, 1996; Mahan, Polasky, and Adams, 2000), forests (Garrod and Willis, 1992; Thorsnes, 2002), nature views (Benson et al., 1998; Patterson & Boyle, 2002; Luttik, 2000; Morancho, 2003), urban trees (Anderson and Cordell, 1985; Morales, 1980; Morales, Micha, and Weber, 1983), open space (Cheshire and Sheppard, 1995, 1998; McConnell and Walls, 2005) etc. Of note, in the UK, a very recent study of the

[3] Detailed information about the variables used in the hedonic analysis is presented in Appendix A.

London housing market by Smith (2010) found that each hectare of green park space within 1km of housing increases house prices by 0.08%. An earlier study by Garrod and Willis (1992) found that proximity to hardwood forests had a positive influence on house prices whilst mature conifers had a negative effect. Cheshire and Sheppard (2002) showed that the benefits associated with accessible open space (e.g. parks) considerably exceeded those from more inaccessible open space (e.g. green belt and farmland). All these studies support the assumption that that *the choice of a house reflects an implicit choice over the nearby environmental amenities so that the value of marginal changes in proximity to these amenities is reflected in house prices***.**

The most common methodological approach in these studies has been to include distance from the property to the environmental amenity as an explanatory variable in the model. More recently the use of GIS has improved the ability of hedonic regressions to explain variation in house prices by considering not just proximity but also amount and topography of the environmental amenities, for example by using as an explanatory variable the proportion of an amenity existing within a certain radius of a house.

Our units of analysis are individual houses located across England, Wales and Scotland. Our sample has around *1 million housing transactions* (with information on location at full postcode level, from the Nationwide building society) in the UK, over 1996-2008, along with the sales prices and several internal and local characteristics of the houses. Internal housing characteristics are property type, floor area, floor area-squared, central heating type (none or full, part, by type of fuel), garage (space, single, double, none), tenure, new build, age, age-squared, number of bathrooms (dummies), number of bedrooms (dummies), year and month dummies. We also have Travel To Work Areas (TTWA) dummies to control for labour market variables such as wages and unemployment rates and more general geographic factors that we do not observe. The specifications that include TTWA dummies, utilise only the variation in environmental amenities and housing prices occurring within each TTWA (i.e. within each labour market) and so take account of more general differences between TTWAs in their labour and housing market characteristics. For our main analysis, we only make use of house transactions for *England* as we do not have complete environmental data for the other regions. However, we present comparison estimates for Great Britain (England, Scotland and Wales) for those environmental amenities for which this is feasible.

With regards to local environmental characteristics, we use *9 broad habitat categories* (which we constructed from the Land Cover Map 2000) in our hedonic regressions describing the physical land cover in terms of the share of the 1km x 1km square in which the property is located: (1) Marine and coastal margins; (2) Freshwater, wetlands and flood plains; (3) Mountains, moors and heathland; (4) Semi-natural grasslands; (5) Enclosed farmland; (6) Coniferous woodland; (7) Broad-leaved / mixed woodland; (8) Urban; and (9) Inland Bare Ground. The habitat variables are defined as the proportional share (0 to 1) of a particular habitat within the 1 km square in which a house is located. The omitted class in this group is 'Urban', so the model coefficients reported in the results section should be interpreted as describing the effect on prices as the share in a given land cover is increased, whilst decreasing the share of urban land cover.

We also use *6 land use share* variables taken from the Generalised Land Use Database (CLG, 2007). These variables depict the land use share (0 to 1), in the Census ward in which a house is located, of the following land types: (1) Domestic gardens; (2) Green space; (3) Water; (4) Domestic buildings; (5) Non-domestic buildings and (6) 'Other'. The hedonic model coefficients indicate the association between increases in the land use share in categories (1) to (5), whilst decreasing the share in the omitted 'other' group. This omitted category incorporates transport infrastructure, paths and other land uses (Roads; Paths; Rail; Other land uses (largely hard-standing); and Unclassified in the source land use classification).

Two additional variables depicting *designation status* were created: respectively, the proportion (0-1) of Green Belt land and of National Park land in the Census ward in which a house is located. The model coefficients show the association between ward Green Belt designation, National Park designation and house prices.

We constructed five *'distance to'* variables describing distance to various natural and environmental amenities, namely (1) distance to coastline, (2) distance to rivers, (3) distance to National Parks (England and Wales), (4) distance to National Nature

Reserves (England and Scotland), and (5) distance to land owned by the National Trust.[4] The effects of these variables are scaled in terms of the distance, in 100s of kilometres, between each resource and each house identified by its postcode. Distance is measured as the straight line distance to the nearest of these features.

We also constructed a number of other geographic variables, included primarily as control variables. Five variables capture distances to various types of transport infrastructure (stations, motorways, primary roads, A-roads) and distance to the centre of the local labour market (Travel to Work Area, 2007 definition). The land area of the ward and the population density are also included as control variables. Local school quality is often regarded as an important determinant of housing prices (see for example Gibbons and Machin, 2003, and Gibbons, Machin and Silva, 2009), so we include variables for the effectiveness of the nearest school in raising pupil achievement (mean age 7-11 gains in test scores or 'value-added'), distance to the nearest school, and interactions between these variables.

The last variable for which a coefficient is reported is the 'distance to the nearest church'. This variable is intended to capture potential amenities associated with the places where churches are located – i.e. historic locations in town centres, with historical buildings, and focal points for business and retail – but may arguably also capture to some extent the amenity value of churches, via their architecture, churchyards, church gardens and cemeteries. This is only reported for a subset of metropolitan areas in England (spanning London, the North West, Birmingham and West Midlands) for which the variable was constructed by the researchers from

[4] It should be noted that our dataset includes distance to all (916) National Trust properties. Although the overwhelming majority of these properties contain (or are near) picturesque or important natural environmental amenities, some also contain houses and other built features. For example, NT's most visited property Wakehurst Place, the country estate of the Royal Botanic Gardens (Kew), features not only 188 hectares of ornamental gardens, temperate woodlands and lakes but also an Elizabethan Mansion and Kew's Millennium Seed Bank. Hence, the amenity value captured by the 'distance to land owned by the NT' variable reflects also some elements of built heritage that are impossible to disentangle from surrounding natural features.

Ordnance Survey digital map data. The sample is restricted to properties within 2km of one of the churches in this church dataset.

There are some limitations to this analysis. Firstly, although we have several years of house price data, we do not have good information on changes in land cover and other environmental amenities over time (and if we did, we suspect that the changes would be too small to be useful). We therefore estimate the cross-sectional relationship between environmental amenities and prices, using control variables in our regressions to account for omitted characteristics that affect prices and are correlated with environmental amenities, and which would otherwise bias our estimates. It is, however, impossible to control for all salient characteristics at the local neighbourhood level because we do not have data on all potentially relevant factors (e.g. crime rates, retail accessibility, localised air quality) and if we had the data it would be infeasible to include everything in the regressions. Our strategy is therefore to rely on a more restricted set of control variables (described above), plus the TTWA dummy variables, to try to ensure that the estimated effects of the environmental amenities reflect willingness to pay for these amenities rather than willingness to pay for omitted characteristics with which they are correlated. Our representation of the accessibility of amenities is fairly simplistic in that we look only at the land cover in the vicinity of a property and the distance to the nearest amenity of each type. We do not, therefore, consider the diversity of land cover or the benefits of accessibility to multiple instances of a particular amenity (e.g. if households are willing to pay more to have many National Trust properties close by). Our data also lacks detail on view-sheds and visibility of environmental amenities, which would be infeasible to construct given the national coverage of our dataset. Finally, the main part of our analysis only refers to England for the full set of environmental variables, as we do not have complete environmental data for the other regions. Even given these limitations, it turns out that the estimates are fairly insensitive to changes in specification and sample – once we take proper account of inter-labour market differences using TTWA dummies. This provides some reassurance that our regression results provide a useful representation of the values attached to proximity to environmental amenities in England.

Table 2 presents summary statistics for the housing transactions data in relation to the key environmental variables considered. The table contains mean land area shares (i.e. the proportion of land in a particular use) and other statistics given that there is a house sale there at some point during the sample period. Inspection of the table shows that housing transactions are more prevalent in certain types of land cover. For example, the average house sale is in a ward in which 20% of the land use is gardens. The table also indicates that, as expected, most of the houses are in wards that are urban (i.e. the missing base category among the land cover variables).

Table 2: Summary statistics for the housing transactions data

	Mean	Standard Deviation	Maximum
Ward share of:			
Domestic gardens	0.205	0.134	0.629
Green space	0.511	0.267	0.989
Water	0.024	0.068	0.888
Domestic buildings	0.067	0.049	0.311
Other buildings	0.031	0.034	0.496
Green Belt	0.155	0.321	1
National Park	0.003	0.049	1
Ward area (km2)	10385	19884	462470
Land in 1km square:			
Marine and coastal margins	0.005	0.036	1
Freshwater, wetlands, floodplains	0.006	0.025	0.851
Mountains, moors and heathland	0.029	0.017	0.782
Semi-natural grassland	0.076	0.087	1
Enclosed farmland	0.246	0.236	1
Coniferous woodland	0.056	0.025	0.94
Broadleaved woodland	0.060	0.077	0.90
Inland bare ground	0.007	0.026	0.90
Distance (100kms) to:			
Coastline	0.275	0.275	1.028
Rivers	0.011	0.012	0.467
National Parks	0.467	0.291	1.669
Nature Reserves	0.130	0.078	0.751
National Trust properties	0.072	0.053	0.459
Accessibility and other variables:			
Distance to station	0.028	0.032	0.599
Distance to motorways	0.137	0.199	2.161
Distance to primary road	0.020	0.024	0.581
Distance to A-road	0.013	0.019	0.330
Distance to TTWA centre	0.099	0.066	0.625
Population (1000s/km2)	3.205	2.404	17.92
Age7-11 Value Added (standardised)	0.000	1.000	4.949
Distance to School (km)	0.084	0.278	0.854
Distance x value-added	0.000	0.025	0.696
Distance to nearest church (100kms)[1]	0.008	0.005	0.019
Mean purchase price (£, 1996-2008)	135,750	(96,230)	1,625,000
Ln price	11.608	(0.656)	16.62

Notes: (1) Table reports unweighted means and standard deviations

(2) Sample is Nationwide housing transactions in England, 1996-2008.

(3) Sample size is 1,013,125, except [1] 448,936.

2.3. Results: hedonic estimates of amenity value

Table 3 presents the *ordinary least squares regression estimates from five 'hedonic' property value models* in which the dependent variable is the natural log of the sales price, and the explanatory variables are a range of environmental attributes characterising the place in which the property is located. Data are taken from the Nationwide transactions database, as described in section 2.2. The environmental variables are also described in section 2.2. and in Appendix A in more detail. The table reports coefficients and standard errors.[5]

Model 1 (Table 3) is a simple model in which only the environmental attributes (plus year and month dummies) are included as explanatory variables. Model 2 introduces a set of structural property characteristics listed in the table notes. Model 3 adds in Travel to Work Area dummies to take account of differences in wages and other opportunities in different labour markets. In this specification, the coefficients are estimated from variation in the variables within labour market boundaries, so broader level inter-labour market and inter-regional differences are ignored. Taking account of labour market differences in this way is important, because theory indicates (Roback, 1982) that the value of environmental and other amenities will be reflected in both housing costs and wages. Workers will be willing to pay more for housing costs and/or accept lower wages to live in more desirable places. Consequently, we can only value amenities using housing costs alone by comparing transactions at places within the same labour market, where the expected wage is similar in each place. Finally, Model 4 repeats the analysis of Model 3 for the sub-sample of metropolitan sales for which we have computed distance to the nearest church and Model 5 provides estimates for England, Scotland and Wales using only those attributes for which we have complete data for all these countries.

[5] Standard errors are clustered at the Travel to Work Area (TTWA) level to allow for heteroscedasticity and spatial and temporal correlation in the error structure within TTWAs.

Table 3: Property prices and environmental amenities (OLS regression estimates)

	Model 1: OLS	**Model 2: + housing characteristics**	**Model 3: + TTWA dummies**	**Model 4: Metropolitan areas TTWAs**	**Model 5: All Great Britain**
Ward share of:					
Domestic gardens	***2.03	***1.35	***1.01	***1.20	-
	(0.32)	(0.23)	(0.119)	(0.22)	
Green space	***1.50	***1.00	***1.04	***1.20	-
	(0.16)	(0.13)	(0.08)	(0.13)	
Water	***1.24	***0.75	***0.97	***1.09	-
	(0.19)	(0.14)	(0.08)	(0.15)	
Domestic buildings	**2.31	***1.21	***2.16	***2.30	-
	(0.92)	(0.45)	(0.30)	(0.16)	
Other buildings	***3.60	***2.89	***2.67	***3.02	-
	(0.44)	(0.35)	(0.23)	(0.29)	
Green Belt	-0.01	-0.03	0.02	**0.03	-
	(0.03)	(0.04)	(0.02)	(0.02)	
National Park	**-0.14	-0.02	0.05	0.01	-
	(-0.06)	(0.05)	(0.04)	(0.04)	
Ward area (km2)	***0.000002	*0.0000007	***0.0000009	**0.000001	-
	(0.0000005)	(0.0000004)	(0.0000002)	(0.0000005)	
Distance (100kms) to:					
Coastline	-0.15	**-0.15	-0.14	***-0.53	*-0.20
	(0.11)	(0.08)	(0.13)	(0.24)	(0.12)
Rivers	1.35	0.92	*-0.91	***-2.16	*-1.05
	(0.97)	(1.01)	(0.69)	(0.48)	(0.62)
National Parks	**0.22	**0.17	***-0.24	***-0.40	-
	(0.09)	(0.06)	(0.09)	(0.14)	
Nature Reserves	***-0.54	***-0.42	-0.07	-0.28	-
	(0.20)	(0.19)	(0.23)	(0.51)	
National Trust properties	***-1.85 (0.33)	***-1.67 (0.25)	***-0.70 (0.17)	-0.38 (0.33)	-
Land in 1km x 1km square:					
Marine and coastal margins	-0.36 (0.23)	**-0.26 (0.12)	0.04 (0.04)	-0.15 (0.12)	0.04 (0.04)
Freshwater, wetlands, floodplains	***1.05 (0.27)	***1.09 (0.21)	***0.40 (0.15)	***0.47 (0.02)	**0.32 (0.14)
Mountains, moors and heathland	0.09 (0.22)	0.19 (0.21)	0.09 (0.10)	0.08 (0.21)	-0.07 (0.08)
Semi-natural grassland	***-0.18 (0.06)	***-0.25 (0.06)	-0.01 (0.02)	-0.02 (0.04)	-0.02 (0.03)
Enclosed farmland	0.16	0.08	***0.06	***0.07	***0.09
	(0.07)	(0.03)	(0.01)	(0.02)	(0.02)
Coniferous woodland	**0.53 (0.22)	*0.33 (0.15)	*0.12 (0.06)	0.09 (0.12)	**0.15 (0.07)
Broadleaved woodland	***0.82 (0.08)	***0.60 (0.07)	***0.19 (0.04)	***0.17 (0.08)	***0.25 (0.04)

	Model 1: OLS	Model 2: + housing characteristics	Model 3: + TTWA dummies	Model 4: Metropolitan areas TTWAs	Model 5: All Great Britain
Inland bare ground	**-0.87 (0.31)	**-0.73 (0.27)	***-0.38 (0.10)	***-0.42 (0.12)	***-0.45 (0.12)
Accessibility/other:					
Distance to station	-	***-1.15 (0.25)	-0.14 (0.21)	-0.15 (0.58)	0.06 (0.20)
Distance to motorways	-	***-0.27 (0.07)	-0.17 (0.11)	-0.38 (0.41)	-0.06 (0.10)
Distance to primary road	-	0.69 (0.38)	-0.17 (0.17)	0.06 (0.46)	0.10 (0.18)
Distance to A-road	-	***-0.64 (0.24)	0.16 (0.20)	0.33 (0.58)	**0.51 (0.26)
Population (1000s/km2)	-	***0.03 (0.008)	0.002 (0.005)	0.004 (0.003)	0.002 (0.007)
Age7-11 Value Added (standard deviation)	-	***0.035 (0.006)	***0.022 (0.004)	***0.032 (0.004)	-
Distance to School	-	-0.17 (0.27)	***0.85 (0.33)	***4.49 (1.34)	-
Distance x value-added	-	*-0.27 (0.15)	**-0.20 (0.08)	-1.10 (0.26)	-
Distance to TTWA centre	-	***0.98 (0.14)	**-0.61 (0.27)	**-1.09 (0.49)	**-0.60 (0.26)
Distance to nearest church	-	-	-	***-4.21 (0.95)	-
House characteristics	No	Yes	Yes	Yes	Yes
TTWA fixed effects	No	No	Yes	Yes	Yes
R-squared	0.516	0.766	0.865	0.854	0.854
Sample size	1,013,125	1,013,125	1,013,125	448,936	1,135,234

Notes: (1) Table reports coefficients and standard errors from OLS regressions of ln house sales prices on environmental amenities. Standard errors are clustered at Travel To Work Area level (2007 definition).
(2) Ward share coefficients show approximate % change in price for 1 percentage point increase in share of Census Ward in land use. Omitted category is other land uses not listed.
(3) 1km^2 landcover share coefficients show approximate % change in price for 1 percentage point increase in share of the 1km square containing the property (≈ 10000 m^2 within nearest 1 million m^2). Omitted category is urban.
(4) Distance coefficients show approximate % change in price for 1km increase in distance.
(5) Sample is Nationwide housing transactions in England, 1996-2008, except for Model 5, where the sample refers to Great Britain.
(6) Unreported housing characteristics in Models 2 to 5 are property type, floor area, floor area-squared, central heating type (none or full, part, by type of fuel), garage (space, single, double, none), tenure, new build, age, age-squared, number of bathrooms (dummies), number of bedrooms (dummies), year and month dummies.
(7) Metropolitan areas in Model 4 includes North West, West Midlands and London and is restricted to sales within 2km of nearest church.
(8) ***p<0.01, **p<0.05, *p<0.10.

The coefficients report the change in log prices corresponding to a unit change in the explanatory variables (scaled as indicated in Table 3). The standard errors indicate the precision of the estimates. The asterisks indicate the level of statistical significance. The statistical significance relates to the precision of the estimate, and the degree of confidence that the association is not a feature of this particular sample rather than an underlying relationship in the population. Three stars indicates that the chance of observing this estimate if there is no underlying relationship is less than 1%, 2 stars indicates 5%, and one star indicates a weak level of statistical significance at 10%. No stars indicates that there is a high chance of observing this coefficient even if there is no underlying relationship, i.e. the coefficient is statistically insignificantly different from zero at the 10% level. Note that interpretation of the results requires that we take into account both the magnitude of the coefficient, and the precision with which it is measured. A coefficient can be large in magnitude implying potentially large price effects, but be imprecisely measured, and hence statistically insignificantly different from zero. In such cases, there must remain some uncertainty about whether or not the corresponding characteristic is economically important.

Looking at the coefficients and standard errors in Model 1 (Table 3) reveals that many of the land use and land cover variables are highly statistically significant, and represent quite large implied economic effects. For example, in the first row of Model 1, a one percentage point (0.01) increase in the share of gardens is associated with a 2% increase in the sales price. This figure can be calculated exactly by applying the transformation exp(0.01*beta)-1, or, to a good approximation, by reading off the coefficient beta as the % change in prices in response to a 0.01 change in the share of gardens. There are similarly large coefficients for other ward land use shares in Model 1, but no association of prices with Green Belt designation. The associations with physical land cover types present a mixed picture, with freshwater and woodland strongly associated with higher prices, semi-natural grassland and bare ground associated with lower prices, and other land cover types having small associations or associations that are statistically indistinguishable from zero. Some of the coefficients on the distance to environmental amenities variables in Model 1 (and indeed in Model 2) have counterintuitive signs, if interpreted as valuations of access to amenities.

The partially counterintuitive pattern in Model 1 is unsurprising, given that there are innumerable price-relevant housing characteristics and geographical attributes that are omitted from this specification. Many of these are likely to be correlated with the environmental and land use variables leading to potential omitted variable biases. However, introducing a set of housing characteristics and measures of transport accessibility as control variables in Model 2 has surprisingly little effect on the general pattern of results in terms of coefficient magnitude and statistical significance. There are some changes in the point estimates, and some coefficients become more or less significant, but the general picture is the same.

Including TTWA dummies to control more effectively for wage and other inter-labour market differences in *Model 3, our preferred model*, provides potentially more credible estimates of the influence of the environmental amenities on housing prices, and we now discuss these in more detail. The first column of Table 4 (All England) summarises the estimates of the *monetary implicit prices of environmental amenities in England corresponding to Model 3's regression coefficients*. Note that these implicit prices are capitalised values i.e. present values, rather than annual willingness to pay. Long run annualised figures can be obtained by multiplying the present values by an appropriate discount rate (e.g. 3%).

Domestic gardens, green space and areas of water within the census ward all attract a similar positive price premium, with a 1 percentage point increase in one of these land use shares increasing prices by around 1% (Model 3, Table 3). Translating these into monetary implicit prices in column 1 (All England model) on Table 4 indicates capitalised values of around *£2,000* for these land use changes. The share of land use allocated to buildings has a large positive association with prices. This may, in part, reflect willingness to pay for dense and non-isolated places where there is other proximate human habitation. However, there is a potential omitted variables issue here because build density will tend to be higher in places where land costs are higher, and where land costs are higher due to other amenities that we do not observe. As such, the coefficients may represent willingness to pay for these omitted amenities rather than willingness to pay for a more built up environment. Therefore, some caution is needed in interpretation.

Neither Green Belt nor National Park designation shows a strong statistical association with prices because the coefficients are not precisely measured. Despite this, the magnitudes indicate potentially sizeable willingness to pay for homes in these locations. *National Park designation appears to add about 5% to prices,* which at the mean transaction price of £194,040 in 2008 was worth around *£9,400* (note that the coefficient in Model 3, Table 3, and respective implicit price in Table 4 is for an increase of only one percentage point in the share of the ward designated as National Park).

The results on physical land cover shares (within 1km squares) indicate a *strong positive effect from freshwater, wetlands and flood plain locations* which is smaller than, though consistent with, the result based on ward shares (i.e. the ward share of water).[6] A one percentage point increase in the share of this land cover *attracts a premium of 0.4% (Model 3, Table 3), or £768 (All England model, Table 4)*. There is also a strong and large positive effect from *increases in broadleaved woodland (0.19% or £377), a weaker but still sizeable relationship with coniferous woodland (0.12% or £227*, but only marginally significant). *Enclosed farmland attracts a small positive premium (0.06% or £113).* Mountain terrain attracts quite a high premium (0.09% or £166), but the coefficient is not precisely measured. Proximate marine and semi-natural grassland land cover does not appear to have much of an effect on prices, whereas inland bare ground has a strong negative impact, with prices falling by 0.38% (£738) with each 1 percentage point increase in the share of bare ground. Given the scaling of these variables, these *implicit prices can also be interpreted as the willingness to pay for an extra 10,000 m^2 of that land use within the 1 million m^2 grid in which a house is located.*

[6] The ward-based water shares and 1km square freshwater, wetlands and floodplains shares are weakly correlated with each other which suggests they are measuring different water cover.

Table 4: Implicit prices by region (£ capitalised values)

	ALL ENGLAND	LONDON, SOUTH EAST AND WEST	MIDLANDS, EAST MIDLANDS AND EAST	NORTH, NORTH WEST AND YORKSHIRE
Ward share of:				
Domestic gardens	***1,970	***1,769	***1,955	***2,487
Green space	***2,020	***2,068	***1,200	***1,773
Water	***1,886	***1,794	***1,179	***1,911
Domestic buildings	***4,242	***4,796	610	**2,292
Other buildings	***5,244	***5,955	***2,858	4,593
Green Belt	41	19	81	17
National Park	94	*-184	***256	131
Ward area (+10 km2)	***0.017	***0.034	**0.013	***0.009
Distance to:				
Coastline	-275	-56	-94	-348
Rivers	*-1,751	-2,446	***-2,711	-884
National Parks	***-461	**-348	-188	***-782
Nature Reserves	-143	-1,322	632	-402
National Trust properties	***-1,347	***-3,596	-212	***-1,117
Landcover share in 1km square:				
Marine and coastal margins	70	138	53	58
Freshwater, wetlands, floodplains	***768	***1,332	36	233
Mountains, moors and heathland	166	-155	-258	***832
Semi-natural grassland	-27	6	-32	**-191
Enclosed farmland	***113	***123	32	**71
Coniferous woodland	*227	***305	307	-131
Broadleaved woodland	***377	***495	***412	*240
Inland bare ground	***-738	***-1,055	-111	**-479
Accessibility/other:				
Distance to station	-260	123	*-687	-294
Distance to motorways	-339	-459	-416	-30
Distance to primary road	-324	-344	227	99.4
Distance to A-road	318	997	-230	-508
Population (+100/km2)	***0.30	*0.12	***0.33	***0.20
Age7-11 Value Added (+ 1 standard deviation)	***4,300	***5,600	***3,800	***2,700
Distance to School	***1,661	***3,092	90	**1,534
Distance x value-added	**-393	-558	***-379	73

	ALL ENGLAND	LONDON, SOUTH EAST AND WEST	MIDLANDS, EAST MIDLANDS AND EAST	NORTH, NORTH WEST AND YORKSHIRE
Distance to TTWA centre	**-1,173	*-1,741	*-518	**-851
Sample size	1,013,125	476,846	341,527	194,752
Mean house price 2008	£194,040	£243,850	£181,058	£158,095

(1)The table reports implicit prices, i.e. marginal willingness to pay, evaluated at regional mean prices. The sample is Nationwide housing transactions in England, 1996-2008. Control variables are omitted from the table.
(2) For 'distance to' variables, the table shows the implicit prices associated with an increase of 1km to the specified amenity.
(3) For 'ward shares' the table shows the implicit prices for a 1 percentage point increase in the share of land in a specified use in the Census ward containing the property. For gardens, green space, water, domestic and other buildings the omitted category is other land uses not listed.
(4) For '1 km^2 land cover shares' the table shows implicit prices for 1 percentage point increase in share of the specified landcover in the 1km square containing the property (≈ 10000 m^2 within nearest 1 million m^2). Omitted category is urban.
(5) ***p<0.01, **p<0.05, *p<0.10.

The coefficients on the distance variables (Model 3, Table 3) show that increasing *distance to natural amenities is unambiguously associated with a fall in prices*. This finding is consistent with the idea that home buyers are paying for accessibility to these natural features. The biggest effect in terms of magnitude is related to distance to rivers, with *a 1km increase in distance to rivers lowering prices by 0.9% or £1,750* although this coefficient is only marginally statistically significant (see Tables 3 and 4). Smaller but more precisely measured effects relate to distance from National Parks and National Trust sites. Each *1km increase in distance to the nearest National Park lowers prices by 0.24% or £460*. Each *1km increase in distance to the nearest National Trust owned site is associated with a 0.7% or £1,350 fall in prices*. Distances to coastline and nature reserves also lowers prices (by about £140-£275 per km), although in these cases the estimates are not statistically significant. Note that these values should not be used for non-marginal changes or out of sample predictions (our calculations are all within local labour markets).

The accessibility variables at the bottom of Table 3 (and Table 4) are intended as control variables so we do not discuss these at length. It is worth noting that they generally have the expected signs when interpreted as measures of the value of transport accessibility, but are not individually significant. Distance to the TTWA centre reduces housing prices, which is consistent with the theory in urban economics that lower housing costs compensate for higher commuting costs as workers live further out from the central business district in cities. Note also that this coefficient in Model 2 does not have the sign we would expect from theory, which highlights the importance of controlling effectively for between-labour market differences as we do in Model 3. The estimates of the effect of school quality on house prices in Model 3 is in line with estimates using more sophisticated 'regression discontinuity' designs that exploit differences across school admissions district boundaries. The estimate implies that a one standard deviation increase in nearest primary school value-added raises prices by 2.2% for houses located next to the school, which is similar to the figure reported in Gibbons, Machin and Silva (2008). The interactions of school quality with distance also work in the directions theory would suggest, although distance from a school attenuates the quality premium more rapidly than we would expect, implicitly falling to zero by 110 metres from a school and turning negative beyond that distance.[7]

Restricting the sample to major metropolitan regions in Model 4 (Table 3) leads to a pattern of coefficients that is broadly similar to those discussed above for Model 3. However, some effects become more significant and the implicit prices larger, particularly those related to distance to coastline, rivers and National Parks. As might be expected, Green Belt designation becomes more important when looking at major metropolitan areas. The results indicate a *willingness to pay amounting to around £5,800 for houses in Green Belt locations,* which offer access to cities, coupled with tight restrictions on housing supply.

[7] From the coefficients, the derivative of prices with respect to school quality is obtained as 0.022 - 0.20 x distance (in km)

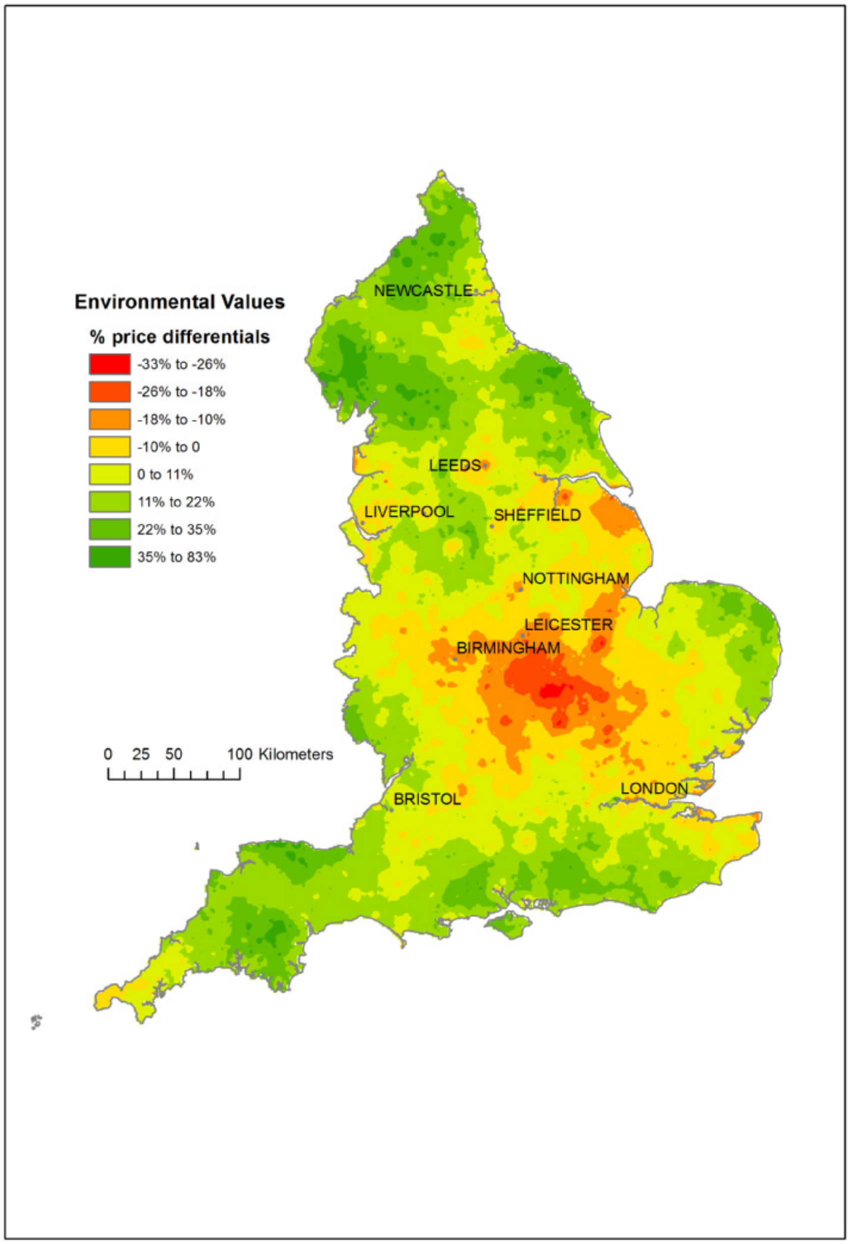
Distance to churches (those classified as having steeples or towers on Ordnance Survey maps) also comes out as important, with 1km increase in distance associated with a large 4.2% fall in prices, worth about £8,150 (Model 4, Table 3). This figure may be best interpreted as a valuation of the *places* with which churches are associated – traditional parts of town centres, focal points for businesses and retail, etc. – rather than a valuation of specifically church-related amenities and spiritual values. However, the environmental amenities provided by church grounds and architectural values of traditional churches could arguably also be relevant factors.

Model 5 in Table 3 extends the analysis to the whole of Great Britain. The ward land use shares are not available outside of England, and we do not have data on National Parks in Scotland, Nature Reserves in Wales or National Trust properties in Scotland, nor any school quality data except in England. These variables are therefore dropped from the analysis. The patterns amongst the remaining coefficients are similar to those in the Model 3 regression for England only, *providing some reassurance that the estimates are transferrable to Great Britain as a whole*. Indeed, the coefficients on the 1 km2 land cover variables are generally insensitive to the changes in sample between Models 3, 4 and 5 in Table 3.

Using the coefficients from Table 3, *we can predict the (log) house price differentials that can be attributed to variations in the level of environment amenities across the country*. We do this using the coefficients from Model 3 (Table 3), and expressing the variation in environmental quality in terms of deviations around their means, and ignoring the contribution of housing attributes and the other control variables and TTWA dummies in the regression. The resulting predictions therefore show the *variation in prices around the mean in England*, and are mapped in Figure 1.

Figure 1 shows the house price variation in 10 categories. The mean house price in 2008 was around £194,000, so, for example, the green shaded areas represent the places with the highest value of environmental amenities, amounting to valuations of £67,900 and above in present value terms. Annualised over a long time horizon, this is equivalent to a willingness to pay £2,000 per year at a 3% discount rate. These highest values are seen in areas such as the Lake District, Northumberland, North York Moors, Pennines, Dartmoor and Exmoor. The implication is that home buyers are willing to pay some £2,000 per year to gain the environmental amenities and accessibility of these locations, relative to the average place in England. Lowest levels of environmental value occur in central England, somewhere in the vicinity of Northampton. We estimate that people are prepared to pay around £2,000 per year to avoid the relatively poor accessibility of environmental amenities that characterises these locations relative to the average in England.

Figure 1: Geographical distribution of environmental value (predicted price differentials from property value regressions)



Note: % price differentials are based on log price differentials, and correspond to maximum % differentials relative to the national mean price level.

As a final step in the analysis, we report separate results for grouped Government Office Regions in England. Columns 2-4 of Table 4 show the implicit prices (capitalised) for these groups, derived from separate regressions for each regional group sample and based on the mean 2008 house price in each sample (reported in the last row of the table). Looking across these columns, it is evident that there are differences in the capitalised values and significance of the various environmental amenities according to region, although the results are qualitatively similar. The ward land use shares of gardens, green space and water have remarkably similar implicit prices regardless of region. The first notable difference is the *greater importance of National Park designation in the midlands regions* (the Peak District and Broads National Parks), but lesser importance of National Trust sites. It is also evident that the *value of freshwater, wetlands and floodplain locations is driven predominantly by London and the south of England*. *Coniferous woodland attracts value in the regions other than the north, but broadleaved woodland attracts a positive premium everywhere*. Although *mountains, moors and heathland cover had no significant effect on prices in England as a whole, we see it attracts a substantial positive premium in those locations where this land cover is predominantly found, i.e. the North, North West and Yorkshire* (see Appendix A, Figure A3).

2.4. Conclusions and knowledge gaps

Overall, we conclude that the house market in England reveals *substantial amenity value attached to a number of habitats, protected and managed areas, private gardens and local environmental amenities*. Although results are generally similar, for some amenities we found evidence of significant differences across regions within England. Many of the key results appear to be broadly transferable to Great Britain. A summary of our key findings for England is presented in Table 5.

Our analysis also highlighted a number of gaps in data availability for this type of hedonic analysis. First, we do not have good information on changes in land cover and other environmental amenities over time. Second, we do not have local neighbourhood data on potentially relevant factors such as crime rates, retail accessibility, localised air quality access, etc. Third, we do not have information on diversity of land cover outside the immediate vicinity of a property or on the benefits of accessibility to multiple instances of a particular amenity. Fourth, data from Scotland, Wales and Northern Ireland for the environmental (and other) variables that were used was limited. Ward land use shares were not available outside of England, and we did not have access to data on National Parks in Scotland, Nature Reserves in Wales, National Trust properties in Scotland, nor any school quality data outside of England. Fifth, we could not locate data directly relating to spiritual values, such as a data base of places of religious or spiritual significance, nor indeed of cemeteries and church gardens. Sixth, it would have been useful to have GIS data on the quality of environmental amenities, such as, for example, river water quality. Seventh, the analysis focuses mostly on environmental amenities due to lack of data on disamenities such as proximity to landfill sites or to flood risk areas. Eight, the data also lacks detail on view-sheds and visibility of environmental amenities, which would be infeasible to construct given the national coverage of our dataset. Finally, we note that implicit prices, as estimated here, should only be interpreted as values for marginal changes in the level of the amenities of interest, i.e. they are not accurate welfare measures for non-marginal changes, which would require the estimation of demand curves for these amenities.

Table 5: Implicit prices for environmental amenities in England (£ capitalised values)

Environmental amenity	% change in house value with:	Implicit price in relation to average 2008 house price	
	1 percentage point increase in share of land cover:		
Marine and coastal margins	0.04% increase in house prices	£70	
Freshwater, wetlands, floodplains	0.40% increase in house prices	£768	***
Mountains, moors and heathland	0.09% increase in house prices	£166	
Semi-natural grassland	0.01% decrease in house prices	-£27	
Enclosed farmland	0.06% increase in house prices	£113	***
Broadleaved woodland	0.19% increase in house prices	£377	***
Coniferous woodland	0.12% increase in house prices	£227	*
Inland bare ground	0.38% decrease in house prices	-£738	***
	1 percentage point increase in land use share:		
Domestic gardens	1.01% increase in house prices	£1,970	***
Green space	1.04% increase in house prices	£2,020	***
Water	0.97% increase in house prices	£1,886	***
	Designation:		
Being in the Green Belt *(in major metropolitan areas)*	3.00% increase in house prices	£5,800	**
Being in a National Park	5.00% increase in house prices	£9,400	
	1 km increase in distance:		
Distance to coastline	0.14% fall in house prices	-£275	
Distance to rivers	0.91% fall in house prices	-£1,751	*
Distance to National Parks	0.24% fall in house prices	-£461	***
Distance to Nature Reserves	0.07% fall in house prices	-£143	
Distance to National Trust land	0.70 % fall in house prices	-£1,347	***

Note: The stars indicate statistical significance levels ***p<0.01, **p<0.05, *p<0.10.

3. Education and ecological knowledge

3.1. Introduction

Engaging with nature can lead to increased environmental knowledge. There are a number of definitions of *ecological knowledge*. Pilgrim et al. (2008) define it specifically as 'accumulated knowledge about nature' which is acquired through frequent interaction with the local environment.[8] Berkes et al. (2000) offer a hierarchical definition based on knowledge of: biotic and abiotic components of ecosystems, their specific functions, through to more holistic knowledge. For current purposes, we follow the definition put forward in the Cultural Services NEA chapter (Burgess et al., 2010) and interpret the term – ecological knowledge – broadly as the '*contribution to educational experiences and advancement of expert and lay environmental knowledges'.*

Our applied focus, in this section, is more specific. It is deliberately targeted on a context where knowledge accumulation is explicit to interactions with nature, both via direct contact and via books and other media: namely, where this contact occurs within the *formalized educational system for school age children*. This knowledge can take a number of forms. First, learning about aspects of nature and the natural world will form part of the *educational curricula taught within the classroom*, particularly in subject areas such as geography and biology. Second, learning might also be part of the *extra-curricula elements of the school day* or say after-school 'clubs'. Either way, such learning can be reinforced by (formal or extra-curricula) field-trips *outside of the classroom* (Rickinson, 2001; Fien et al., 2001; Dillon et al., 2005; Capra, 2002; Hicks, 2002; Ofsted, 2008).

An *economic interpretation* of these learning experiences is that they are one element of the output of the education sector – an *investment in human capital* (broadly defined) – in the sense of the pioneering work of Jorgenson and Fraumeni (1989, 1992). Doubtless, however, there are ambiguities inherent in seeking to

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[8] For Pilgrim et al. (2008), however, such interactions are driven by a need to pursue daily subsistence strategies for food and economic provision. This is a somewhat specific and distinct focus to that which might characterize ecological knowledge among UK citizens.

disentangle the ecological component from the accumulation of educational capital more generally. The focus of this section is on two types of investment in the ecological knowledge of *children*, related to respectively indoor and outdoor learning. These are: (i) the *ecological knowledge embodied in successful student outcomes in (relevant) GCSE and A-level examinations*; and, (ii) *nature-related school trips,* taking place outside the school, as well as *'citizen science' projects* taking place within (and around) school grounds.

3.2. Ecological knowledge and educational attainment

We began this chapter with the assertion that the formation of ecological knowledge – as one element of the output of schooling – can be seen as an investment in human capital. Broadly speaking, the literature on the accumulation of educational capital identifies two crucial benefits arising from this investment. The first benefit typically is viewed through the lens of the *boost in lifetime earnings* for individuals that additional education is reckoned to provide (see, for example, Kroch and Sjoblom, 1986). On this basis, there is a case for saying that ecological knowledge gained through schooling is one contributory factor in this increase earnings profile.[9] A second benefit of this investment, however, lies outside of the market. Jorgenson and Fraumeni (henceforth, JF) (1989, 1992) argue that education *enhances the (future) quality of life* that an individual might enjoy, in particular, through more productive use of non-work time (such as leisure opportunities) over his or her lifetime. Thus, in the analytical framework proposed by JF, both of these educational benefits – market or non-market – are components of the investment in human capital.

The portion of human capital that can be attributed to ecological knowledge attained in formal schooling will be accumulated throughout a child's schooling in a diverse number of ways as we have indicated previously. In what follows, we provide a

[9] Of course, it would be difficult to categorize the extent to which, for example, the ecological component of schooling increases earnings as opposed to other attributes that this learning provides such as transferable skills, scientific inquiry and so on.

tentative assessment of the value of ecological knowledge embodied in the educational attainment of candidates who successfully sat GCSE and A-level examinations in geography and biology at the end of the school year 2009/10.[10,11] Thus our basic physical accounting unit is the number of students who have achieved this level of achievement in that year. Before we proceed to outline the way in which we have valued these attainment outcomes, it should be noted that the data that we provide cannot be interpreted as the net benefit of the production of ecological knowledge (i.e. relative to other forms of education). Ours is purely an *accounting framework that attempts, in a very approximate way, to identify (some portion) of the ecological component of school education*. Nevertheless, we would argue that the findings are instructive not least in indicating, in explicit terms, that the value of this ecological knowledge is possibly substantial.

Our accounting framework is built on an approximation of the JF approach as previously discussed. Core to that method is the calculation of the present value (PV) of (lifetime) earnings from spending an *additional* year in formal education. These earnings, in each year of an individual's (working) life, upon leaving formal education, are weighted by probabilities of survival (to the next year) as well as labour market participation. This stream of earnings is assumed to grow at some (fixed) rate and is, finally, discounted in order to determine its PV. Ideally, a full implementation of the JF would be desirable in the current context. In practice, we take a more crude but pragmatic approach, which we take (as a working assumption) to reflect a mix of benefits related to enhanced earnings and leisure.[12]

We begin our calculations with an estimate of the possible starting wage of someone leaving school at 16 without any basic qualifications. We assume that this can be approximated by the current minimum wage for 16 to 18 years olds (£3.64 per hour)

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[10] In this sense, we are attributing the outcome of possibly two years of study (i.e. towards a GCSE or an A-level) to one year's "output" (i.e. the year the certificate is issued). Put another way, we need to be cautious in interpreting this entire value as investment in 2009/10.

[11] For relevant exam results in England see DfE (2010a and b).

[12] JF account for the non-market benefits of human capital using a time-use account identifying hours spent in work and leisure. Valuation in both cases, however, is based on an individual's wage.

and use this as our basic measure of what somebody with little or no qualifications might be likely to earn.[13] We then make use of estimates of the (gross) returns that individuals receive as a result of having a particular qualification (relative to not having it or any other 'replacement' qualification of that same level of attainment). Dearden (1999, 2000) and Blundell et al. (1999, 2004) investigate the impact on earnings of educational qualifications including those attained at GCSE and A-level. Drawing on these studies, we assume that having a GCSE – in the grade range from A to C – implies a return of 15% (relative to having no qualification).[14] The corresponding return to an A-level is 22% (again relative to having no qualification). The earnings stream for such (representative) individuals in each group is adjusted by the survival probabilities (ONS, 2009) but not labour market participation rates.[15] Using these data, we estimate the PV of future income from age 17 to 68 for successful GCSE students in 2010 and from age 19 to 68 in 2010 for successful A-level students (all passing grades). We take the discount rate to be 3.5% and income growth to be 1.5%.

Next we seek to identify the ecological component of this educational attainment and its value. We focus on geography and biology as the fields of study where, at school level, there is formal evidence of significant ecological components to the curriculum either in guidelines provided by national curricula (e,g, in the case of GCSE) and/ or official exam boards (e.g. in the case of A-level). In addition, pupils studying for GCSE (Basic) Science will study biology (and acquire ecological knowledge) therein as one component of that composite qualification. Examples of this documentation which outline curricula and examinable course content can be

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[13] Of course, this income might grow because of subsequent education, training on-the-job as well as experience more generally. However, given that we are interested here in the value of (ecological) knowledge then ignoring these consequent elements is (largely) justified.

[14] There is a higher return to each GCSE grade if a worker has five such qualifications at A* to C.

[15] This will have the effect, on the one hand, of biasing our estimates upwards (in that implicitly we are assuming full participation in the labour market). On the other hand, the extent of this bias will also depend on the relative participation rates between those with GCSE, A-levels and those with no qualifications (with the latter being our case relative to which returns are defined).

found in, for example, AQA (2010, 2009) and Edexcel (2008a,b) Determining the precise weight that ecological education has in these studies is clearly contentious and subject to variation across schools. Nevertheless, on the basis of consulted documentation, we assume that the *weights reflecting the ecological components* to be the following: *GCSE Geography – 0.15; GCSE Biology – 0.25; GCSE (Basic) Science – 0.08; A-level Geography – 0.15; and, A-level Biology – 0.25.*

Table 6: The value of ecological knowledge in GCSE and A-level attainment (2010)

	Candidates ('000)		Value of Ecological Knowledge (£m)		
	GCSE	**A-level**	**GCSE**	**A-level**	**Total**
Geography	118.2	29.2	426.9	134.7	561.6
Biology	110.2	52.7	663.4	405.9	1,069.2
Science	258.4	n.a.	497.8	n.a.	756.2
Total	486.8	81.9	1,588.1	540.6	2,128.7

Note: the values refer to successful candidates who would have received their results in these GCSEs and A-levels in the Summer of 2010.

Our basic results are provided in Table 6. On the left hand side of the table is given the number of students accomplishing specified examination outcomes. On the right hand side, are corresponding values. These are the product of pupil numbers and the 'ecologically adjusted' present values for representative individuals achieving, in 2010, the relevant qualifications (as estimated above). In total, our tentative findings indicate that the *value of ecological knowledge embodied in this educational attainment at the end of the academic year 2009-10 was just over £2.1 billion*. Thus, these (initial) findings are that the value of this (implied) investment in ecological knowledge is substantial. In essence this is a result of the fact that human capital investment generally is significant combined with the apparently increasing emphasis in UK schools on teaching that involves the dissemination to school-aged children of ecological knowledge.

Needless, to say our results are sensitive to changes in the various assumed values above. For example, it would be particularly desirable to impose – in future work – more 'method' on the process of choosing ecological weights than was possible here. Nevertheless, our assertion here is that we have erred on the conservative side in the current context.

3.3. Ecological value of outdoor learning

In order to illustrate specific educational examples that involve the accumulation of ecological knowledge we focus, for the remainder of this section, on *nature-based school trips*. To date, research on 'outdoor learning' has focused on the personal and social development associated with the outdoor learning experiences of children. For example, a recent evaluation by Borradaile (2006) concluded that these experiences raise self-esteem, self-respect and confidence of the children who participate. This, in turn, can lead to improved attitudes towards others and the environment. Brunwin *et al*. (2004) provide relatively detailed information on school trip frequency in general, with some indication of destinations including explicitly nature-related trips such as nature walks. In their recent assessment of Scottish forestry, Edwards *et al*. (2010) assess the educational value of forests and provide several cases of forest-based learning. However, as far as we can ascertain to date, there appears to be no estimates of monetary value of the benefits of educational nature trips.

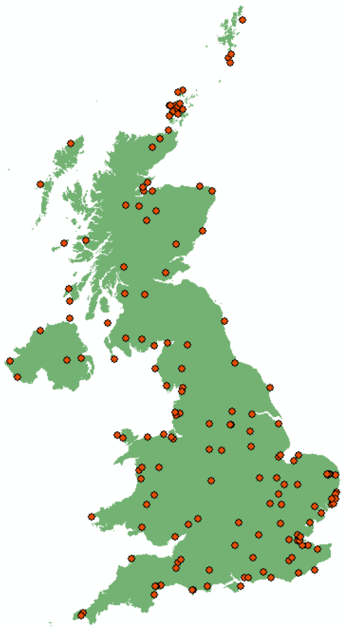
While the assertion that these nature-based trips provide a benefit that has an economic value strikes us as uncontroversial, it is far easier to state this in the abstract than to empirically estimate the value of this (ecological) output. There is also a legitimate discussion to be had about the degree to which the output of these trips is consumption or investment. In the former, benefits are consumed in the form say of the enjoyment of current amenities. In the latter, future opportunities are enhanced and the output can be construed, as in the preceding section, as an investment in human capital. This is not a question that we are able to resolve empirically here. However, we speculate that given that these activities are being undertaken typically within school hours, the human capital element is arguably predominant.

We now proceed to an investigation of two case studies. The first of these entails educational visits to *RSPB reserves around the UK*. The second short case study involves a 'citizen-science' project, specifically bird-watching within school grounds via the *RSPB Big School Bird Watch*.

3.3.1 Case Study 1: School Visits to RSPB Reserves

The UK's *Royal Society for the Protection of Birds* (RSBP) was established in 1889. It is the largest wildlife conservation organisation in Europe with over one million members. It runs 200 nature reserves across the UK, covering 142,044 hectares in 2008/09 (RSPB, 2010a). The reserves are distributed around the UK, as shown in Figure 2 below. Detailed information on each reserve can be found on the RSPB website http://www.rspb.org.uk/reserves/.

Figure 2. RSPB reserves across the UK in 2010



Our specific interest is *visits by school children to these reserves as part of organised school trips*. RSPB data show there were 1,968 such trips to 51 RSPB reserves in 2009-10. This means that only about a quarter of all RSPB sites are known to have received educational visits. These visits comprised a total of 57,471 staff and students in 2009-2010. There is some uncertainty inherent in these data, however, due to e.g. possible misreporting. The likelihood is that these records, in some instances, may be underestimates. More generally, it is likely that a great many field-trips undertaken by schools in pursuit of ecological knowledge are not recorded in easily available and accessible statistics.

The RSPB records on school visits to its sites are summarised in Table 7 below. The table indicates that some of these sites appear to be relatively well visited. Some of these variations undoubtedly can be explained by proximity to population centres (e.g. Rainham Marshes) as well as the character of the reserve itself. It is also clear that a number of sites are infrequently visited. What this suggests is that it is undoubtedly the case that, while a non-trivial portion of learning within schools can be construed as the accumulation of ecological knowledge, it is far from straightforward to ascribe that significant gain of knowledge to precise locations.

However, in order to provide an indicative and illustrative value to the aggregate of these RSPB visits, we assume the following. Broadly, we use a *'cost of investment' approac*h.[16] This approach will not provide an estimate of the welfare benefit of the knowledge gained in RSPB school visits but rather an indication of outlay that is made in its acquisition. The data in Table 7 indicate only the aggregate number of those visiting during school trips. This total will include both staff and students. However, there are fairly fixed guidelines about pupil:staff ratios for school visits and for current purposes we assume a ratio of 10:1 which is in the vicinity of these rules.

[16] In principle, and in keeping with the method outlined previously in section 3.2, one alternative way to try to get at value of the human capital created by these visits is to estimate the value of an additional year spent in each year of school education and calculate the portion of this value attributable to time spent on these ecologically motivated field trips.

Table 7: RSPB Reserve visits in 2009/10 by Schools

Reserve	Total number of children/ adults	Region	Reserve	Total number of children/ adults	Region
Rainham Marshes	3934	England - South East	Nagshead	591	England - South West
Dearne Valley	3918	England - Northern	Dolygaer	556	Wales
Newport Wetlands	3853	Wales	Dungeness	450	England - South East
Rye Meads	3093	England - South East	Abernethy Forest	404	Scotland - North
Greenmount College	3038	Northern Ireland	Mersehead	354	Scotland - South and West
Pulborough Brooks	2698	England - South East	Middleton Lakes	254	England - Midlands
Sandwell Valley	2460	England - Midlands	Geltsdale	163	England - Northern
Leighton Moss & Morecambe Bay	2449	England - Northern	Symonds Yat Rock and Nagshead	148	England - South West
Saltholme	2440	England - Northern	Insh Marshes	146	Scotland - North
Conwy	2401	Wales	Ham Wall	133	England - South West
Kelvingrove	2390	Scotland - South and West	Northward Hill	115	England - South East
Vane Farm	2282	Scotland - East	Moray outreach	112	Scotland - East
Minsmere	2269	England - Eastern	The Lodge	83	England - Eastern
Fairburn Ings	2207	England - Northern	Forsinard	73	Scotland - North

Reserve	Total number of children/ adults	Region	Reserve	Total number of children/ adults	Region
Ribble Discovery Centre	1841	England - Northern	Portmore Lough	52	Northern Ireland
Lochwinnoch RSPB	1709	Scotland - South and West	Frampton Marsh	51	England - Eastern
Bempton Cliffs	1430	England - Northern	Birsay Moors	42	Scotland - East
Freiston Shore	1323	England - Eastern	NSRO - Field Teaching/Outreach	39	Scotland - North
Loch of Strathbeg	1145	Scotland - East	Snelsmore	38	England - South East
Lake Vyrnwy	1039	Wales	Orkney	14	Scotland - East
Fineshade Wood	986	England - Midlands	South Essex	8	England - Eastern
Fowlmere	921	England - Eastern	Fairy Glen	7	Scotland - North
Ynys-Hir	888	Wales	Hampstead Heath	0	England - South East
Whitlingham	794	England - Eastern	Rowlands Wood	0	England - South East
Coombes & Churnet Valleys	768	England - Midlands	Nigg and Udale Bays	0	Scotland - North
Thatcham Nature Discovery Centre	724	England - South East	Snelsmore	--	England - South East
Enniskillen College	638	Northern Ireland			

Source: RSPB

Our valuation is based on the costs of making these trip 'investments' in ecological knowledge. This, in turn, is based on the *travel costs* (e.g. Champ et al., 2002) involved in providing educational knowledge through nature-related school trips. We value both the *resource costs* to parents of meeting the costs of these trips and the *value of time spent travelling* and *waiting to travel*. Our intention here is to focus on the costs incurred *over and above those costs incurred in gaining knowledge* that would be provided *within a normal classroom environment*.

Transport-related costs are valued using the average costs for parents of a primary and secondary school day trip in the UK (Brunwin et al, 2004). We assume, from that study, that these costs lie between £8 and £12 per pupil. It is assumed that the amount parents pay cover all vehicle costs and the entry fees for students and accompanying adults.

We value time spent on these trips in two dimensions: (i) the time spent travelling 'in-vehicle' to and from the reserve and (ii) 'excess time', which is defined as the time spent waiting or walking to and from school vehicles. In the former, we use the cost to the government of students in education (about £5,140 per student, per year) to value children's time in terms of the per hour cost (Department for Children, Schools and Family, 2009).[17,18] The value of teachers' time (inclusive of social overheads) is implicitly included in this total. As a result, we do not account separately for the teachers' time spent travelling. Origin (of school) post codes for visitors were not available and so it was not possible to estimate reserve-specific

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[17] This includes school premises costs, books and equipment, and certain other supplies and services, less any capital items funded from recurrent spending and income from sales, fees and charges and rents and rates. It excludes the central cost of support services such as home to school transport, local authority administration and the financing of capital expenditure.

[18] We assume that children attend school for 190 days each academic year. We calculated hourly rates based upon the recommended weekly minima for hours taught per week as suggested by the Department for Education (Department for Education and Science, 1990), around 24 hours of teaching per week.

distances travelled. We therefore assumed that these travel times were between 20 and 40 minutes (each way).

For the value of "excess time" (such as waiting etc.), we assume a fixed period of 15 to 22.5 minutes each way, totalling 30 to 45 minutes per trip. Mackie et al. (2003) recommend that walking and waiting time in UK transport appraisals is valued at 200% to 250% of (in-vehicle) travel time. We use 250% of (in-vehicle) travel time in this tentative analysis. We apply this to staff time (based on an assumption about teachers' hourly wages)[19] as well as pupil time.

Table 8: Illustrative value of recorded school visits to RSPB Reserves in 2009/10

		Transport cost	Total time cost		
		1	2	3	1 + 2 + 3 =
	Total number	**Trip cost to parents**	**In-vehicle time**	**Excess time**	**Total travel cost**
Children	51,724	£400,861-£620,688	£93,276-£186,551	£279,829-£419,740	£851,364-£1,323,683
Adults	5,747	--	--	£64,470-£96,704	

In total, the *costs of the investment expended, in 2009/10, in the pursuit of ecological knowledge on nature based trips to RSPB reserves by schools ranges from just under £850,000 to just over £1.3 million*.

Clearly, these values are highly contingent on a number of assumptions particularly with regards to 'waiting time' and so on. As well as being subject to numerous caveats, these values need to be viewed in context. The number of (officially

[19] We use the average teacher salary of £35,000 (Bolton, 2008). We assume that teachers are available to work for 195 days each academic year and work 8 hours a day (DfES, 1990). The calculation we make, however, also includes an adjustment (downwards) to take account of the fact that some of this value will counted (implicitly) in the value of excess time for pupils.

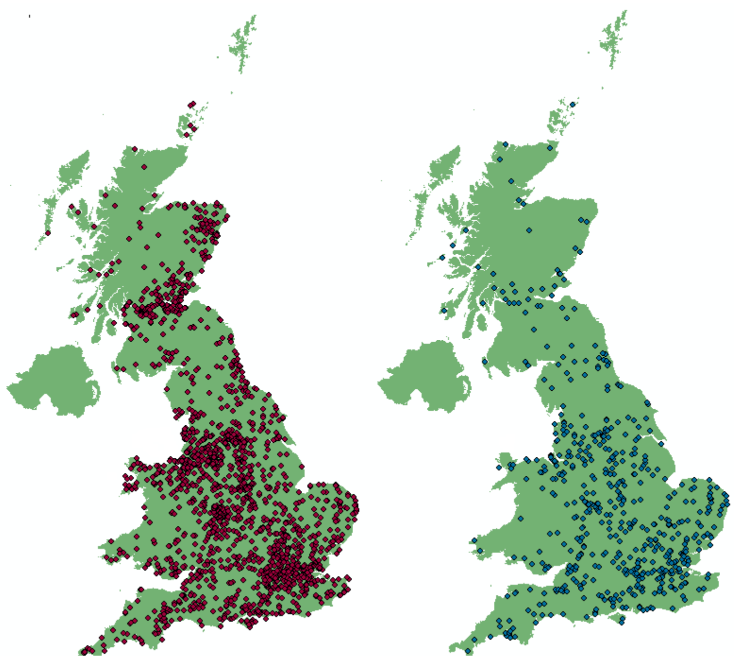
recorded) school visitors to RSPB reserves is comparatively low. For example, the London Wetland Centre – a relatively small site consisting of 42 hectares of wetland in Barnes, west London (and owned and managed by the Wetland and Wildfowl Trust) – was visited by over 20,000 children during organised school visits during 2009. The majority of these young visitors (over two-thirds) were nursery and primary school aged children (WWT, 2010).

3.3.2 Case study 2: RSPB's Big School Birdwatch

"Citizen science" projects is the name given to projects that involve members of the public voluntarily helping scientific studies by participating in activities such as bird watching, bee counting, recording appearance of first leaves, flowers or fruits, observing comets and stars, etc. Data collected by the public are then used by professionals for scientific research. Current on-going citizen science projects in the UK include the University of Cambridge's UK Ladybird Survey, Monitoring Bats for the Bat Conservation Trust, Moths count for Butterfly Conservation and Nature's Calendar Survey for the Woodland Trust. Although citizen science projects are thought to improve scientific knowledge and environmental awareness, the value of the benefits accruing from participation in these projects does not appear to have been estimated.

The *Big Schools' Bird Watch* (BSBW) is one of a series of an annual citizen science surveys organised by the RSPB. This is a further element of the accumulation of ecological knowledge in schools: namely, *learning outside the classroom but within (or around) school grounds*. This particular citizen science survey started in 2001 and focuses solely upon the participation of children at school in bird watching. Groups of children, led by a teacher, count the numbers of different species of birds visiting their school for *one hour* on any day between 24 January and 4 February. The RSPB suggests that participation in the survey provides learning opportunities such as practical outdoors work, data handling, personalization of learning (RSPB, 2010b). In addition, it may encourage schools to develop their grounds in order to help pupils learn about the natural world and sustainable living (RSPB, 2010b). The BSBW was joined in 2010 by the Little Schools' Bird Watch, an initiative designed specifically for engaging 3-5 year olds in bird watching.

Figure 3. Schools participating in BSBW in 2004 (right) and in 2010 (left)



RSPB data on participation in the BSBW between 2004 and 2010 indicates that over this period there was a strong upward trend in participation across the UK with 14,675 people taking part in 2004, rising to 75,500 in 2010 (69,101 children and 6,275 adults). Whilst the numbers of people participating in the BSBW between 2004 and 2010 increased by 514%, the number of participating schools increased from 602 in 2006 to 1,986 in 2010, an increase of 330%, indicating a broader audience and wider participation. Figure 3 maps participating schools in 2004 and 2010. Table 9 contains the results of average sightings of particular birds as part of the BSBW. On average, each school spotted around 35 individual birds. The most commonly seen species are blackbirds and starlings, with species such as the wren and goldfinch being amongst the least likely that will be spotted. Presuming that children participating in this exercise engage with the activity, the table indicates that a good deal of ecological knowledge might be gained in recognising and appreciating a variety of bird species.

Table 9: Bird species and sightings in the Big School Birdwatch

Abundance rank	Species	Average sightings per school	Abundance rank	Species	Average sightings per school
1	Blackbird	4.27	14	Jackdaw	0.81
2	Starling	3.85	15	Collared Dove	0.69
3	Woodpigeon	3.06	16	Greenfinch	0.43
4	House Sparrow	2.93	17	Coal Tit	0.43
5	Black Headed Gull	2.78	18	Pied Wagtail	0.42
6	Blue Tit	2.56	19	Song Thrush	0.40
7	Carrion Crow	2.54	20	Long Tailed Tit	0.37
8	Magpie	1.88	21	Dunnock	0.35
9	Robin	1.70	22	Rook	0.31
10	Chaffinch	1.65	23	Wren	0.28
11	Common Gull	1.12	24	Herring Gull	0.24
12	Great Tit	1.07	25	Goldfinch	0.18
13	Feral Pigeon	1.06			

Source: RSPB

Regarding the value of the BSBW, we again take a '*cost of investment'* approach to tentatively say something about this ecological knowledge. And as before, this is not the benefit of this knowledge but rather an indication of outlay that is made in its acquisition. We assume all adults and students involved spend one hour in this activity. This is required by the project but possibly may not always be the case. We further assume that this birdwatching takes place during school-time. To the extent that it takes place outside teaching time, it might be construed as replacing leisure (or play) time instead. Finally, our results are conditional on the range of assumptions made to calculate travel time values. As in section 3.3.1, we use the cost to government of students aged 3-19 in education for valuing the (investment) cost of children's time. *The value of this time is about £374,000*. This value is a proxy for the *ecological knowledge gained by participation in the Big School Birdwatch* in 2010. This corresponds to an average of about *£188 per school*.

3.4. Conclusions and knowledge gaps

We provide what is, to our knowledge, the *first accounting study of the investment value of ecological knowledge in schools*. This investment value is two-fold: a boost in lifetime earnings and a (non-market) enhancement of (future) quality of life through more productive use of leisure time. Specifically we analyse two types of investment in the ecological knowledge of children, related to respectively indoor and outdoor learning: (i) the ecological knowledge embodied in successful student outcomes in (relevant) GCSE and A-level examinations; and, (ii) nature-related school trips, taking place outside the school, as well as 'citizen science' projects taking place within (and around) school grounds.

We found that the value of the (implied) investment in ecological knowledge is substantial. A tentative assessment of the value of ecological knowledge embodied in the educational attainment of candidates who successfully sat GCSE and A-level examinations in geography and biology (and science for GCSC) at the end of the school year 2009/10 places the value at just over £2.1 billion. We then used two case studies to investigate the value of ecological education outside the classroom. Using a 'cost of investment' approach we found that the costs of the investment expended, in 2009/10, in the pursuit of ecological knowledge on nature based trips to RSPB reserves by schools (involving a total of 57,471 staff and students) ranged from just under £850,000 to just over £1.3 million. Finally, also using the 'cost of investment' approach, we estimated the value of ecological knowledge gained by participation in the Big School Birdwatch in 2010 (involving 69,101 children and 6,275 adults) to be about £374,000,

Our discussion has highlighted many of the large data gaps existing in this area of research, as very little is currently known about the welfare value of educational knowledge for children in the UK. Substantially more information would be required if we were to estimate net benefit of the production of ecological knowledge (i.e. relative to other forms of education) rather than looking at investment costs as in our accounting approach. Within our approach, it would be desirable to have a more systematic way of assessing the ecological component of various disciplines, to incorporate labour market participation rates, to extend the analysis to the ecological education gained in years other than GCSE and A-level years, to investigate how the value of ecological education varies across primary, secondary and university education, and to see how values have changed across time. Regarding the value of nature-based school visits, there is no comprehensive database of school visits, with detailed information on origin and destination postcodes that would allow a national assessment. More detailed information is needed about school trips and the visitors to be able to calculate consumer surpluses. There is also no comprehensive database of nature-related after-school clubs and activities across the country. Finally, very little is known about the value of ecological education for adults as no systematic database of participation in nature-based educational activities exists.

4. Non-use value

4.1. Introduction

Human wellbeing can be derived without making personal use of a good or service, such that a nature reserve may have value to an individual even though he has never visited nor intends to visit that nature reserve. *Non-use values* are the benefits that can be gained even though there is no use (either direct or indirect) made of a given product or service. Non-use values may take various forms (Krutilla, 1967; Pearce et al, 2006). An existence value can be derived from the simple knowledge of the existence of the good or the service. In the context of the environment, individuals may place a value on the mere existence of species, natural environments and other ecosystem. If an individual derives wellbeing from the knowledge that other people are benefiting from a particular environmental good or service, this can be termed altruistic value. Such values accrue during an individual’s lifetime, but vicarious valuation can also occur inter-generationally. The effect on wellbeing of knowing that one’s offspring, or other future generations, may enjoy an environmental good or service into the future, such as a biodiversity-rich forest being conserved, is termed bequest value. Environmental non-use values are thought to be substantial. For example, Hanley et al. (1998) found significant non-use values in a study of Environmentally Sensitive Areas (ESA) in Scotland, whereby people were willing to pay for improvements in the management of ESAs even though they did not and were not planning to visit them.

However, due to their non-market nature and their disconnection from actual uses, the valuation of non-use benefits is complex. Stated preference methods are thought to be the only economic valuation techniques capable of measuring non-use values but substantial doubts exist about the accuracy of such valuations (e.g. Cameron, 1992; Larson, 1992; Harrison, 1995). Moreover, although there are many stated preference studies that estimate non-use values for environmental amenities,[20] these are typically very localized studies for very specific amenities, and therefore not suited for aggregation across goods and space. As far as we are aware, there is no national study of environmental non-use values.

Here we follow a very different approach and propose using *legacies to environmental charities as a simple and observable market indicator of environmental non-use values*. Legacies can be argued to represent a pure non-use value: individuals leaving a charitable bequest to an environmental organisation in a will, for the purposes of supporting their conservation activities, will not experience the benefits of this work. Specifically we look at the *value of legacies over time of three of the largest environmental charities in the UK: The National Trust, RSPB, and the National Trust for Scotland*. We also analyse how legacies to environmental charities compare with legacies to other areas of charitable activity.

Although there is a small literature on charitable bequests (see Atkinson et al., 2009, for a review) we have not found any other study of legacies as an indicator of environmental non-use values. Indeed, despite the importance of charitable bequests, surprisingly little is known in the UK about this form of transfer of wealth at death and even less in known about the causes supported by these legacies (Atkinson et al., 2009).

Legacies are interesting proxies for non-use values in that they are observable in the market and not reliant on stated preference data. But clearly, they capture only one element of environmental non-use values, i.e. those that are reflected in the market place at the time of death. Further research is needed to ascertain the magnitude of the non-use values that are not reflected in the market.

[20] Furthermore, use and non-use values can be confounded for many environmental amenities as people's values may reflect a proportion of use and a proportion of non-use benefits.

4.2. Legacy income

How important are legacies? Atkinson et al. (2009) estimates that only 6% of all deaths in Britain in 2007 resulted in a charitable bequest (with this percentage rising considerably with the size of the estate). On average people leave bequests to 2.3 causes, with 43% leaving bequests to a single cause.

But despite the relatively small proportion of estates leaving a charitable bequest, legacies are a major source of income for charities. In 2008/09, charitable giving by individuals was almost £6 billion to the top 500 fundraising charities (Pharoah, 2010). *Legacies represent almost one quarter of this total (£1.4 billion),* with almost three quarters of charities reporting income from legacies. Legacy income has been particularly affected by the current economic downturn. While total fundraising income[21] fell in real terms by about 1% from 2007/08, legacy income saw a real fall of almost 4% (Pharoah, 2010).

Table 10 shows that, although *environmental charities*[22] *rank 7th in terms of total fundraised income, they rank 4th in terms of legacy income* (within the top 500 charities in the UK). Legacy income is an important source of revenue for environmental charities comprising almost 30% of all their fundraising income. Overall, the *total legacy income earned by environmental charities in 2008/09 was £97 million which constitutes 7% of all charitable legacies* (totalling just over £1.4 billion). Although around half of all charitable causes amongst the top 500 charities saw a fall in legacy income from 2007/08, environmental causes saw the biggest fall, suggesting that *environmental non-use values may be particularly sensitive to economic conditions*. By contrast, health, international, elderly, ex-service and

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[21] Fundraising income broadly comprises legacies, donations, events, gifts in kind and donated goods. Other (non-fundraising) sources of charitable income are trading income, statutory income and income from charitable activities.

[22] Environmental charities are those defined as having activities in biodiversity, land and other environmental conservation activities.

animal charities actually saw their legacy income increase in this period (Pharoah, 2010).

Table 10: Fundraised and legacy income by area of charitable activity (2008/09)

Charitable area	Legacy income (£million and % of total fundraised income)		Total fundraised income (£million)
Cancer	242	34%	706
Animals	223	55%	403
General social welfare	112	45%	249
Environment	97	29%	329
Hospices	82	33%	246
Blind	81	53%	152
International	78	9%	899
Children	73	19%	391
Disability	68	41%	166
Religion (international)	64	17%	373
Chest/ heart/ stroke	60	31%	196
Health Information	43	33%	132
Elderly	37	36%	102
Ex-services	32	29%	112
Hospitals	28	24%	116
Religion (welfare)	28	7%	423
Religion (missionary)	25	8%	306
Deaf	13	42%	31
Benevolent	11	22%	49
Mental health	8	19%	43
Arts and culture	7	2%	295
Other	9	5%	198

Source: constructed from Pharoah (2010)

Table 11 depicts the top 5 environmental charities according to the fundraised and legacy income earned in 2008/09. Three of these charities (The National Trust, RSPB and WWF UK) rank within the top 50 largest charities in the UK. The National Trust attracts the largest number of legacies, which constitute some 44% of their total fundraised income (Pharoah, 2010).

Table 11: Fundraised and legacy income of top 5 environmental charities (2008/09)

Environmental charity	Legacy income (£million and % of total fundraised income)		Total fundraised income (£million)	Rank within top 500 charities
The National Trust	42.8	44%	97.8	12
RSPB	26.6	41%	64.9	16
WWF UK	8.1	22%	37.4	32
The Woodland Trust	8.2	40%	20.6	58
National Trust for Scotland	4.0	21%	18.8	61

Source: constructed from Pharoah (2010)

In the remainder of this chapter we investigate in more detail *trends in legacies to three of the largest environmental charities in the UK: The National Trust, RSPB and the National Trust for Scotland*. Since the majority of charitable giving in the UK goes to a small group of the largest charities (for example, in 2005/06, over 70% of total income was generated by under 3,500 organisations, just 2% of the sector, while just 18 charities generated one eighth of the sector's income) it can be assumed that, by investigating legacies in three of the largest environmental charities, we are capturing the large majority of the total environmental non-use values accruing from the conservation of natural areas and species in the UK, that are reflected in legacies.

4.3. Analysis of environmental legacies

This section presents an analysis of trends in legacies to three of the largest environmental charities in the UK: The National Trust, RSPB and the National Trust for Scotland.

4.3.1. Case studies

Established in 1895*, The National Trust* (NT) is one of the UK's leading independent conservation and environmental organisations, acting as a guardian for the nation in the acquisition and permanent preservation of places of historic interest and natural beauty. Of relevance to our work, the NT manages around 254,000 hectares

(612,000 acres) of countryside, moorland, beaches and coastline in England, Wales and Northern Ireland, 709 miles of coastline (1,141 km), as well as 215 historic houses and gardens, 40 castles, 76 nature reserves, 6 World Heritage Sites, 12 lighthouses and 43 pubs and inns of outstanding interest and importance (NT, 2010). It currently has over 3.6 million members and 55,000 volunteers. More than 14 million people visit its 'pay for entry' properties, and an estimated 50 million visit open air properties (NT, 2010). Legacies form an important part of the NT's income, generating just under £43m in 2008/09,[23] corresponding to 44% of total fundraising income (Table 11).

The UK's *Royal Society for the Protection of Birds* (RSBP) was established in 1889. It is the largest wildlife conservation organisation in Europe with just over one million members. Their work focuses on the species in the greatest danger of extirpation and habitats in the greatest danger of clearance. This is done through advocacy and direct intervention: the organisation runs 200 nature reserves across the UK covering 142,044 hectares in 2008/09 (RSPB, 2010a). The RSPB is funded largely by membership fees and through other donations such as legacies, which provided the organisation with about £27m in 2008/09, which accounts for 41% of total fundraising income (Table 11).

The *National Trust for Scotland* (NTS) was established in 1931 and is the largest charity in Scotland with 310,000 members and 5,000 volunteers in 2009/10 (NTS, 2010). Its aim is to protect and promote Scotland's natural and cultural heritage. NTS is Scotland's third largest landowner, owning 128 properties and 76,000 hectares of countryside, including 16 islands, such as the World Heritage Site of St Kilda (NTS, 2010). The NTS enjoyed some 2 million recorded visitors to its (non-countryside) properties in 2009/10. Legacies of almost £6m were received in 2009/10 (a rise from £4m in 2008/9, Table 11).

[23] We note a discrepancy between this value for NT legacies in Pharoah's (2010) Charity Market Monitor and the value of legacies for the same year that is contained in a primary dataset of legacies provided by the National Trust (around £54m). We use Pharoah's values in the comparative analysis of bequests by cause while the trend analysis is based on NT's primary data.

4.3.2. Legacy trends

Table 12 depicts total legacies to the National Trust, RSPB and National Trust for Scotland from 1989 to present.

Table 12: Legacy income of NT, RSPB and NTS since 1989

	Total legacies (£million, 2009 prices)		
Year	**National Trust**	**RSPB**	**National Trust for Scotland**
1989	26.1		
1990	33.5		
1991	37.5		
1992	34.3		
1993/94	38.3	10.3	
1994/95	36.4	12.5	2.9
1995/96	29.2	13.3	2.8
1996/97	38.2	13.1	4.4
1997/98	41.7	13.1	4.0
1998/99	43.7	13.6	9.1
1999/00	47.1	13.6	
2000/01	48.7	19.5	6.2
2001/02	48.0	18.7	4.8
2002/03	49.0	20.6	3.0
2003/04	55.7	24.8	3.6
2004/05	54.9	14.9	5.5
2005/06	43.6	23.5	6.5
2006/07	50.8	25.2	5.0
2007/08	58.9	24.9	3.5
2008/09	54.0	26.9	4.0
2009/10		26.6	5.9

Source: data from NT, RSPB and NTS

The total value of annual legacies to the National Trust doubled in real terms over the past two decades (Table 12). This represents an increase in the number of legacies rather than an increasing legacy size: the number of legacies rose from 863 in 2000/01 to 956 in 2008/09, whilst the mean legacy remained relatively unchanged at around £56,500 in both 2000/01 and 2008/09 (in 2009 prices). This rise in the total number of legacies is despite falling both death rates and total number of deaths over the same period in the UK. As such, estates which left legacies to the

National Trust represented 0.14% of all estates in 2000/01 rising to 0.17% of estates in 2009/9. However, legacies left to the National Trust as proportion of GDP per capita fell during this period, from 358% in 2000/01 to 206% in 2008/09.

The RSPB's first legacy, for £25, was received in 1900. In 2009, a total of £26.6m was left to the RSPB in legacies. This is an increase of 192 times the £138,271 received in 1946 (in real terms). RSPB's increasing aggregate value of legacies can be explained by both the increasing mean value of the legacies (mean value £15,312 in 1996/97, to mean legacy £22,881 in 2008/09) and number of legacies (849 in 1996/97 to 1,162 in 2009). As noted above, the trend towards increasing numbers of legacies has come despite falling death rates in the UK. In 1999/00, 0.15% of all estates left a legacy to the RSPB, which rose to 0.20% of all deaths by 2008/9, suggesting an increased likelihood of leaving a legacy. Whilst mean legacy value has risen, GDP per capita has risen faster. As with the NT, mean legacies to the RSPB as a proportion of GDP per capita has fallen from 116% in 1996/7 to 84% in 2008/9.

In contrast, legacies over time to the NTS do not appear to follow any clear pattern, rising to £9.1m in 1998/99 then falling below £4 during 2002-2004 and again in 2007/08. Information on the number of legacies was not available and so mean legacies cannot be computed.

Had donors intended their legacy income to be spent on National Trust countryside, RSPB reserves or National Trust for Scotland countryside, we would have been able to estimate a legacy-based non-use value of around *£219 per hectare* of NT countryside, *£190 per hectare* of RSBP reserve and £53 *per hectare* of NTS Scottish countryside for 2008/09, respectively. However, as noted above, donor's preferences about the allocation of their legacies are not known.

4.4. Conclusions and knowledge gaps

Surprisingly little is known about charitable bequests in the UK. In this chapter, we investigate the evolution of legacies to three of the largest conservation organizations in the UK (National Trust, RSPB, and National Trust for Scotland), as an observable market indicator of non-use values accruing to UK's natural environment. We also analyse how legacies to environmental charities compare with legacies to other areas of charitable activity.

We found that despite the small proportion of estates leaving a charitable bequest, legacies are a major source of income for charities. Within the top 500 charities in the UK environmental charities rank 4th in terms of legacy income. In 2008/09 environmental charities attracted £97 million which constitutes 7% of all charitable legacies. Our results also suggest that for the two largest environmental charities (NT and RSPB) the total value of annual legacies increased significantly over the last two decades and the proportion of estates leaving a legacy to environmental causes has risen, even in the light of falling death rates. However, we also found that as people get wealthier they leave relatively less charitable bequests to these causes.

There are major knowledge gaps in this analysis. In general, very little is known about charitable bequests in the UK. Data on charitable bequests, estates and demographic characteristics of donors is not easily accessible, particularly for analysis over time. Equally, comprehensive data on charitable giving over time, from the perspective of the recipient organizations, and covering a wide range of organizations is not freely available.

5. Health

5.1. Introduction

Environmental quality and proximity to natural amenities is increasingly recognised as having substantial effects on physical and mental health, both directly and indirectly (e.g. Bird, 2004; deVries, et al., 2003; Hartig. et al, 2003; Maas et al, 2006; Maas et al, 2009; Mitchell and Popham, 2008; Osman, 2005; Takano et al., 2002; Ulrich, 1984). Broadly this can happen in two ways. Firstly, natural settings can act as a catalyst for healthy behaviour, leading for example to *increases in physical exercise*, which affect both physical and mental health (Pretty et al., 2007; Barton and Pretty, 2010). Secondly, *simple exposure to the natural environment*, such as having a view of a tree or grass from a window, can be beneficial, improving mental health status (Pretty et al., 2005) and physical health (Ulrich, 1984). Health outcomes in this respect can be disaggregated into two categories: reductions in mortality and reductions in morbidity (including physical and mental health).

In this section we present a preliminary investigation of the valuation of the impacts of marginal changes in the provision of natural habitats and green spaces on physical and mental health. We focus on both the pathways identified above: (1) *health improvements arising from additional exercise created by the provision of natural habitats and green settings*; and (2) *health benefits arising from more passive forms of contact with nature* such as viewing nature, being within natural spaces, etc.

5.2. Valuing the health benefits of created exercise in nature

Willis (2005) identifies three key steps in the valuation of the health benefits of created exercise due to additional green space provision: (1) measuring the physical and mental health impact of exercise; (2) valuing the health benefits of exercise; and (3) estimating the probability of additional exercise with changes in green space. We analyse each in turn.

5.2.1. Physical and mental health impact of exercise

The only exercise that should be directly attributed to the provision of natural settings is what Willis (2005) calls *'created exercise'*, i.e. exercise which would not have occurred otherwise. Exercise which would have occurred anyway in another setting (e.g. the gym or urban pavements) should not be included in the calculations as it is not truly additional. It is however very difficult to identify created exercise. In our calculations we follow the Willis (2005) approach and attempt to focus on created exercise.

We consider a scenario whereby *changes in countryside and parks management lead to an additional reduction of 1 percentage point in the numbers of sedentary people*[24] *in the UK.* Reduction in sedentary life and increase in exercise lead to a number of proven health benefits both directly and indirectly through their contribution to reductions in obesity (POST, 2001; Pretty et al., 2005). Health benefits include reductions in mortality and morbidity due to: (1) *Coronary Heart Disease* (CHD); (2) *Colo-Rectal Cancer;* (3) *Stroke*; and (4) *Stress, anxiety and depression* (morbidity only).[25]

We obtained up-to-date data on mortality and morbidity for CHD, colo-rectal cancer and stroke from the Office for National Statistics and National Audit Office (ONS, 2001, 2008, 2009; NAO, 2005). In terms of the number of people who suffer from depression we used data from the Psychiatric Morbidity Survey (PMS) of adults aged 16–74 conducted in the United Kingdom in 2000 (Singleton et al., 2001). This

[24] As in Willis (2005), sedentary people are defined as those taking less than one 30 minute period of moderate activity per week. It is estimated that roughly 23% of men and 26% of women are sedentary (POST, 2001).

[25] Willis (2005) considered only CHD, colo-rectal cancer and stroke in his report. We further include mental health. But regular physical activity contributes to the prevention and management of many other conditions not investigated here such as reductions in osteoporosis, diabetes, and breast cancer (Colman and walker, 2004; Pretty 2004; Bird, 2004).

reported an overall prevalence rate for depression of 26 per 1,000 people in the population, with a slightly higher rate for women (28 per 1,000) compared to men (23 per 1,000) (McCrone et al., 2007).

Following Willis (2005), we determined the *effect that a 1 percentage point reduction in sedentary behaviour in the UK would have upon the economic burden of the three physical diseases and the one mental health*[26] *condition* we are considering. We calculated the number of 'excess deaths' (and the amount of 'excess morbidity') attributable to physical inactivity by multiplying the deaths (or cases of illness) attributable to each inactivity-related disease by the Population Attributable Fraction (PAF) for that disease. The PAF represents the proportion of a disease in a population that could be eliminated if a particular risk exposure were removed from that population. In this case, the risk is lack of exercise. Specifically, PAF is a function of the proportion of the population exhibiting the risk (i.e. proportion of sedentary population), and of the relative risk of suffering the illness from those at risk (i.e. sedentary) compared to those without the risk (i.e. those who exercise).[27] We first calculated the excess mortality and morbidity for the current sedentary proportion of the population across UK adults (23% males and 26% females: POST, 2001). To find the additional benefit in morbidity and mortality of a 1 percentage point reduction in sedentary behaviour we ran the calculations again with the sedentary proportion of the population reduced to 22% for males and 25% for females.

The difference in excess cases of morbidity and mortality, from CHD, colo-rectal cancer, stroke and depression, between the two levels of sedentary behaviour, is the

[26] Mental health conditions were not assessed in Willis (2005). Here we tentatively estimate the mental health benefits of a reduction in sedentary life using the same methodology as for physical diseases.

[27] PAF = p(RR – 1) / [1 + p(RR – 1)] where PAF is the population attributable fraction, RR is the relative risk and p is the proportion of the population exhibiting the risk. We used the following RRs: 1.6 for colon cancer, 2.0 for CHD and 1.4 for stroke (all from Willis, 2005); and 2.04 for mental health problems (Sui et al., 2009).

number of deaths and cases of illness avoided by a one percentage point reduction in sedentary behaviour. These figures are depicted in Table 13.

As shown in Table 13, the majority of benefits appear to accrue to those over 75 years of age. There is however an argument for excluding this group from the sample given that it is unlikely that they will undertake physical exercise to the recommended levels (30 minutes of moderately intense exercise 5 times a week). Following Willis (2005) we also estimate results excluding the over 75s from the sample which has the unsurprising effect of considerably reducing the number of deaths and of cases of illness averted due to exercise.

5.2.2. Value of health benefits of exercise

The theoretically correct approach to estimate the economic value of human health impacts, either mortality or morbidity, is the *willingness to pay* (WTP) approach (e.g. Pearce et al., 2006; Krupnick, 2004). This is based on the trade-offs that individuals would make between health and wealth.

In terms of *valuing mortality risks*, the WTP approach involves the estimation of the individual WTP to secure reductions in the risk of death arising from CHD, stroke of colo-rectal cancer. Alternatively, one can estimate the willingness to accept (WTA) compensation for tolerating a higher risk of death. The most common methods for obtaining estimates of the value of mortality risk reductions are hedonic wage studies, survey-based stated preference studies and averting behaviour studies. For convenience, WTP for mortality risk reductions is normally expressed in terms of the value of a statistical life saved (VOSL) or the value of a preventable fatality (VPF). This implies dividing the WTP for a given risk reduction by that risk reduction to obtain the VOSL or VPF (Pearce et al., 2006; Krupnick, 2004). Hence, to give an aggregate measure of the benefits, in terms of lives saved, of physical exercise, the number of deaths avoided from CHD, stroke and colo-rectal cancer can be multiplied by the VPF. In this study, we follow this approach and use government estimates of the *value of a preventable fatality of £1,589,800* (DfT, 2007).[28] Table 14 summarises the values used in this analysis.

In terms of *valuing morbidity*, the WTP approach involves the estimation of the willingness to pay to avoid particular health outcomes, such as stroke, depression etc. Stated preference methods which ask people directly what they would pay to avoid specific symptoms, are commonly used. An aggregate measure of the morbidity benefits of increased exercise could be obtained by multiplying the unit values of the various illnesses of interest by the number of cases of illness reduced. The values used in this analysis are summarised in Table 14. The value used for CHD prevention is based on the Department for Transport's (2007) value for a slight injury, while the stroke prevention value is based on its value for a serious injury. The value we use for cancer prevention is taken from Hunt and Ferguson (2009) and reflects the existence of a 'dread' factor associated with diseases that are long and painful (e.g. Lindhjem et al., 2008; Cropper, 2000; Jones-Lee et al., 2007). Finally, the value for reduction of mental illness is based on Morey et al.'s (2007) estimate of WTP to eliminate depression.

An alternative way of valuing health effects is the *human capital/cost of illness* approach. In the case of *mortality risks*, the approach replaces VOSL or VPF by foregone earnings, although, in practice, per capita income is often used (Pearce et al., 2006, Krupnick, 2004). In the case or *morbidity*, changes in health are measured by the associated lost wages over the lifetime plus medical costs. This approach is not welfare-based as it captures solely financial costs and not the intangible effects such as pain and suffering. Hence, it is generally considered to provide a conservative lower bound to the true economic value of health effects. In Table 14, we also provide estimates of morbidity values based on the cost of illness approach. For CHD, stroke and cancer we used the same values as Willis (2005), while our mental illness values are based on McCrone et al.'s (2007) estimate of average treatment costs for people with depression.

[28] This value was estimated in the context of road transport. In addition to the human cost, it includes lost output and medical costs (HM Treasury, 2003).

Table 13: Value of health benefits arising from a 1 percentage point reduction in the sedentary population (£m, per year, UK)

	Mortality			Morbidity				TOTAL			
	Number of cases of averted deaths			Number of cases of averted illness				Including > 75year olds		Excluding > 75 year olds	
	Including > 75year olds	Excluding > 75year olds	VPF	Including > 75year olds	Excluding > 75year olds	Direct cost of illness	WTP to avoid	Direct cost of illness	WTP to avoid	Direct cost of illness	WTP to avoid
CHD	597	192	£949.1	20,871	5,919	£60.6	£287.4	£1,009.7	£1,236.5	£328.4	£415.2
Stroke	177	32	£281.4	1,092	689	£13.5	£195.1	£294.9	£476.5	£51.3	£57.7
Colo-rectal cancer	74	33	£117.7	141	78	£0.5	£40.7	£118.2	£158.3	£55.0	£251.1
Depression		--		8,259	7,466	£17.8	£44.1	£17.8	£44.1	£16.1	£39.9
Total	848	257	£1,348.2	30,363	14,152	£92.4	£567.2	£1,440.6	£1,915.4	£450.8	£763.8

An alternative approach (not followed here) would have been to use Quality Adjusted Life Years (QALYs) to try and estimate health benefits of physical exercise. QALYs are measures of health benefit that combine length of life with quality of life, where quality of life is assessed on a scale where zero typically represents death and one represents full health. QALYs are widely used in the health sector and are commonly estimated on the basis of 'time trade-off' or 'standard gamble' methods (Drummond et al, 1997). There is however no consensus about what the monetary value of a QALY is and how to calculate it (Tilling et al., 2009; Willis, 2005).[29]

Table 14: Health values used (£, 2009)

	Mortality values	Morbidity values			
	Preventable fatality	CHD	Stroke	Colo-rectal Cancer	Mental illness
Cost of illness	--	£2,903 [2]	£12,363 [2]	£3,650 [2]	£2,156 [3]
Willingness to pay	£1,589,800 [1]	£13,769 [4]	£178,640 [5]	£288,304 [6]	£5,343 [7]

Notes: (1) DfT (2007)
(2) Willis & Osman (2005)
(3) McCrone et al. (2007)
(4) DfT (2007), assumes 'slight injury'
(5) DfT (2007), assumes 'serious injury'
(6) Hunt & Ferguson (2009)
(7) Morey et al. (2007)

In summary, as can be seen in Table 14, we estimate that a *change in natural habitats that causes a 1 percentage point reduction in sedentary behaviour would provide a total benefit of almost £2 billion* (using WTP-based values), across the three physical conditions (CHD, colo-rectal cancer and stroke) and the mental health

[29] In the UK, the National Institute for Health and Clinical Excellent (NICE) appears to use a figure between £20,000 and £30,000 per QALY, based on how much it can afford to pay for a gain of one QALY, given its fixed budget, making this a cost rather than a benefit measure (NICE, 2008).

condition considered (stress and anxiety). However, if all people over 75 years are excluded from the analysis – on the basis that they are less able or likely to be physically active – then the benefits fall to just over £750 million.

5.2.3. Probability of additional exercise with changes in green space

The previous analysis indicates that there could be large economic benefits associated with increased physical exercise within the sedentary portion of the UK population. The key question left to answer is if a green living environment does indeed provide an incentive to be physically active, that is, how much true additional exercise is created with the extra provision of green spaces. As noted above, we are only interested in measuring the *health benefits of 'created exercise', that is exercise that is directly attributable to the green space and which would not have occurred otherwise*. As Willis (2005) points out, exercise that would have occurred anyway, independently of the green space provision (e.g. a person who is told by their doctor they have to exercise) and exercise that is diverted to the green space but would still have occurred elsewhere (e.g. a person who jogs in the park but would have used a treadmill in the gym instead) should not be taken into account when calculating the health benefits of exercise associated with green spaces.

Unfortunately, there are large gaps in knowledge in this area as environmental attributes appear to be among the least understood of the known influences on physical activity (Humpel et al., 2002). Indeed, we found *no consistent and reliable estimates of the proportion of physical exercise occurring in green spaces that is actually created*.

Conceptually, one could reasonably expect that exercise that is more enjoyable because of the amenity value of the surrounding environment would be more likely to be undertaken – or would be undertaken for a longer period of time. A simple example would be to have a brisk walk in a leafy park or along a pleasant river bank, vis-à-vis using a treadmill in the confines of a gym.

Indeed, there is a limited but consistent body of evidence that appears to suggest patterns of positive relationships between some environmental attributes and physical activity, such as walking or cycling (Lee and Maheswaran, 2010). For example, Pikora et al. (2003) found that attractive environmental attributes in streets (such as presence of trees, parks, private gardens and grassy verges) was one of the most important features related to walking and cycling; Giles-Corti et al. (2003) showed that walking at recommended levels is associated with having good access to attractive open spaces (although where safety is an issue the result may no longer hold); Ellaway et al. (2005) found that higher levels of greenery in residential environments are associated with being physically active; Pretty et al. (2007) indicate that people who participate in outdoor exercise programmes more often complete the programme than people who participate in indoor exercise programmes; and reviews by Humpel et al. (2002), Owen et al. (2004) and Lee and Maheswaran (2010) show that the aesthetic nature of the local environment, the convenience of facilities (such as footpaths and trails) and accessibility of places to walk to (such as parks and beaches) are often times associated with an increased likelihood of certain types of walking.

However, several other studies found no link between recreational physical activity and, for example, access to and quality of urban green spaces (Hillsdon et al., 2006) or tree-lined streets (Hoehner et al., 2005). Moreover, whilst Owen et al.'s (2004) review suggested some evidence of a positive link between environmental attributes and walking they also highlighted a number of studies where these relationships were not statistically significant. A recent large-scale study of 4.899 Dutch people by Maas et al. (2008) found that the amount of green space in people's living environment has little influence on people's level of physical activity. Specifically, people with more green space in their living environment walk or cycle less often (possibly because of reduced access to shops and facilities in areas with large amounts of green space that encourage car use). And although a positive relation between green space and gardening and cycling for commuting purposes was found, the amount of physical activity undertaken in greener living environments did not explain the relationship between green space and health.

Overall, we found *no conclusive evidence on the strength of the relationship between the amount of green space in the living environment and the level of physical activity*. Moreover, most of the evidence relates to walking and cycling: there is very little evidence on the links between environment and other forms of physical activity such as sports and gardening (Maas et al., 2008). Crucially, the findings reported above are primarily from cross-sectional studies of associations of environmental attributes with physical activity behavior and *cannot therefore support causal inference*. In the presence of local natural habitats, individuals may well substitute away from non-green exercise and towards green exercise due to the additional amenity benefits associated with exercise in green spaces, but overall may not substantially alter their total physical activity levels.

The factors that influence behavioural choices in relation to physical activity are complex and manifold and the effect of environmental attributes is not well-understood. Simply providing larger or better quality areas of green space may not necessarily lead to additional exercise. Hence, *it is not possible to accurately value, at the present time, the health benefits of created exercise due to additional green space provision.*

5.3. Valuing the health benefits of exposure to nature

There is now a substantial body of evidence suggesting the existence of a wide range of health benefits associated with green space over and above those induced by increased exercise. We first provide an overview of existing evidence and then describe a new quantitative study aimed at measuring such benefits in the UK.

5.3.1. Physical and mental health impact of exposure to nature

There is now a wealth of evidence on the health benefits derived from exposure to nature. The theoretical basis to health benefits derived from contact with the natural world is that humans have an innate affinity to other living organisms (the biophilia hypothesis as proposed by Wilson, 1984). In a recent review, Lee and Maheswaran (2010) reports *associations between contact with green spaces and a variety of psychological, emotional and mental health benefits, reduced stress and increased quality of life*. Interestingly, Fuller et al. (2007) found that the psychological benefits of contact with nature appear to increase with the species richness of urban green spaces. Moreover, research spanning over more than two decades suggests that mere views of nature, compared to most urban scenes lacking natural elements such as trees, appear to have more positive influences on emotional and physiological states, providing restoration from stress and mental fatigue (Ulrich, 1986; Kaplan, 2001) and even improve recovery following operations in hospitals (Ulrich, 1984). The Cultural Services NEA chapter provides a review of the literature on the health benefits of contact with nature (Burgess et al., 2010).

These health benefits of non-exercise related exposure to nature are likely to be substantial and pervasive, given the lack of substitutes and the size of the population potentially affected. Indeed, while it is fairly easy to substitute physical exercise in a natural setting by a trip to the gym or the pool, as discussed above, there are no obvious substitutes to a nice nature view. However, much of the literature on the psychological benefits of green space tend to be qualitative or from grey literature sources (Lee and Maheswaran, 2010). Hence, there is a lack of robust quantitative evidence on the link between health and contact with green spaces.

5.3.2. New evidence for the UK

We used newly-commissioned *geo-located survey data to estimate the physical and mental health effects associated with UK broad habitats, domestic gardens, managed areas and other natural amenities*.[30] Such work has not, to our knowledge, previously been undertaken for the UK, although other researchers have signalled its potential value (e.g. CJC Consulting, 2005, p. iii).

5.3.2.1. The survey

Data were collected by *web survey* during August 2010. The survey remains accessible at http://uk.wellbeingsurvey.org.uk/. and is also included in Appendix B. The population of interest was defined as UK residents aged 16 and above. Sampling was by pre-recruited panel. Panels do not provide a true probability sample, but permit quotas to be set on a range of attributes. Quota attributes were location (across five large regions), gender (male, female), age (16 – 34, 35 – 54, 55+), and work status (employee, other economic status). Quota calculations were based on data from the Annual Population Survey, January – December 2009. A total of 1,851 respondents completed the survey. Survey data was subject to extensive quality checking, including timing, response pattern and consistency checks, and IP address-based location verification. The survey comprised several sections.

For general and physical health, the *SF-36 Health Survey* was employed. The SF-36 is the leading general health measure (McDowell, 2006, p. 662). It comprises 36 survey items, with standardised administration and item scoring to produce several validated sub-scales. In this study we use the *physical functioning* and *emotional wellbeing* subscales as outcome variables. For mental and emotional health more

[30] The survey also estimated effects on subjective well-being, not reported here.

specifically the *Positive And Negative Affect Schedule (PANAS)* was presented. The PANAS asks respondents to rate the applicability to their state of mind of twenty adjectives, and responses are summed to form *negative affect* and *positive affect* indicators.

As a measure of physical activity, the *International Physical Activity Questionnaire* (IPAQ) was reproduced. The IPAQ includes questions regarding walking, moderate exercise and vigorous exercise behaviours in work, leisure, travel and domestic contexts. It provides a standardised scoring system to translate these into metabolic equivalence values (METs), which provide a straightforward absolute measure of physical activity. In addition to these standard items, we asked respondents to estimate the proportion of time spent in different forms of leisure-time exercise that was spent in natural environments.

Regarding local environmental characteristics, as in Section 2, we used *9 broad habitat categories* constructed from the Land Cover Map 2000: (1) Marine and coastal margins; (2) Freshwater, wetlands and flood plains; (3) Mountains, moors and heathland; (4) Semi-natural grasslands; (5) Enclosed farmland; (6) Coniferous woodland; (7) Broad-leaved / mixed woodland; (8) Urban; and (9) Inland Bare Ground. Our habitat variables were defined as the number of hectares of a given habitat within a 1km radius of the respondent’s home location. The omitted class is ‘urban’, so the model coefficients can be interpreted as describing the effect on health as the area of a given land cover is increased, whilst decreasing the area of urban land cover.

Additional nature-related items were included in the survey instrument. These included questions regarding *views of green spaces and water* from the respondent’s home, and *frequency of use* by the respondent of their garden (if applicable), of open countryside, and of non-countryside green spaces such as parks, recreation grounds and cemeteries. Respondent’s visitation frequency of National Parks (unless living *within* a National Park) was also recorded. Furthermore, using data from the National Trust, Ordnance Survey (Meridian 2) and others, we calculated the distance in kilometres to the nearest National Park and National Trust site boundaries, and to the nearest coastline, motorway, A-road and railway station.

Using the Nationwide house price data set used in Section 2, which contains around 1 million housing transactions for the UK, we calculated a house price index for each respondent's home location. This index is based on the 100 nearest property sales within a maximum of 10km, adjusted for all available housing characteristics and the month and year of sale. Using population density data from the European Environment Agency, we also calculated population density at each location (as the value in the 1km grid square containing that location).

Respondents were asked for a full home postcode, and residential location was estimated as this postcode's centroid using the latest (August 2010) release of the National Statistics Postcode Directory. Housing quality may be correlated with environmental quality, and may also mediate its effects. Several items on housing quality were therefore included. Standard demographic data were also requested, including gender, age, qualifications, work status, religiosity and income.

5.3.2.2. Analysis and results

Using the results from this new primary health survey conducted, we analyzed the *physical and mental health benefits of various forms of contact and exposure to the natural environment*, such as having a view of a tree or grass from a window, using gardens or visiting natural areas. Specifically, we used ordinary least squares (OLS) regression estimates from models in which the dependent variables are respondents' physical and mental health indicators. The explanatory variables include a number of environmental attributes characterising the place in which the respondent is located, and other variables as described above.

The three dependent variables are: the *SF-36 physical functioning subscale* (ranging 0–100); the *SF-36 emotional wellbeing subscale* (range also 0–100); and the *SF-6D preference-weighted utility score*, which is calculated from a subset of the SF-36. The SF-6D is a preference-based single-index measure of health that can be used in economic evaluations, unlike the SF-36 which is not based on preferences (see Brazier et al., 2002, and Kharroubi et al., 2007, for detailed explanation of this measure). These variables are described in greater detail in Table 15. [31]

Table 16 presents the basic models estimated for each of the dependent variables described in Table 15. Two separate models are run for each dependent variable: the 'a' models include all respondents from England, Wales, Scotland and Northern Ireland, but have only a subset of spatial variables available, while the 'b' models include all spatial variables but are limited to England and Wales. The coefficients in the table report the *change in health scores corresponding to a unit change in the explanatory variables* (scaled as indicated in the table). The asterisks indicate the level of statistical significance.[32]

The OLS results show that *physical exercise has a positive relationship with all three health measures*. However, the causality of these relations, especially in the case of physical functioning, is likely to run in both directions.

In relation to the environmental variables*, views of grassland from the respondent's home are significantly, substantially and positively linked with their emotional wellbeing and health-related utility*. Views of water do not show significant links with any of the dependent variables.

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[31] The positive and negative PANAS indicators were also investigated, giving results similar to those for the SF-36 emotional wellbeing (not shown).

[32] The statistical significance relates to the precision of the estimate, and the degree of confidence that the association is not a feature of this particular sample rather than an underlying relationship in the population. Three stars indicates that the chance of observing this estimate if there is no underlying relationship is less than 0.1%, two stars indicates 1%, one star 5%, and the cross indicates a weak level of statistical significance at 10%. No stars indicates that there is a high chance of observing this coefficient even if there is no underlying relationship, i.e. the coefficient is statistically insignificantly different from zero at the 10% level.

Table 15: Health dependent variables

Dependent variable	Description	Survey items
Physical functioning	SF-36 subscale: mean of 10 coded survey items	The following items are about activities you might do during a typical day. Does **your health now limit you** in these activities? If so, how much? • **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports • **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf • Lifting or carrying groceries • Climbing **several** flights of stairs • Climbing **one** flight of stairs • Bending, kneeling, or stooping • Walking **more than a mile** • Walking **several blocks** • Walking **one block** • Bathing or dressing yourself Yes, limited a lot = 0 Yes, limited a little = 50 No, not limited at all = 100
Emotional wellbeing	SF-36 subscale: mean of 5 coded survey items	How much of the time during the **past 4 weeks**... • Have you been a very nervous person? (–) • Have you felt so down in the dumps that nothing could cheer you up? (–) • Have you felt calm and peaceful? (+) • Have you felt downhearted and blue? (–) • Have you been a happy person? (+) All of the time = 100 (+) / 0 (–) Most of the time = 80 (+) / 20 (–) A good bit of the time = 60 (+) / 40 (–) Some of the time = 40 (+) / 60 (–) A little of the time = 20 (+) / 80 (–) None of the time = 0 (+) / 100 (–)
Health utility score	SF-6D health-related utility score	The SF-6D utility score is calculated by a transformation of SF-36 items, using a non-parametric Bayesian method, according to preference weights from a valuation exercise conducted with a representative UK sample (see Kharroubi et al., 2007). The utility value is anchored at 1 for full health and 0 for dead.

Table 16: Physical functioning, emotional well-being and utility scores OLS regressions

	SF-36 physical functioning (0 – 100)		SF-36 emotional wellbeing (0 – 100)		SF-6D utility score × 100 (0 – 100)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Demographics						
Male (0/1)	1.48	0.98	1.89*	2.17*	1.45*	1.36*
Age	-0.61**	-0.48*	-0.56**	-0.42*	-0.17	-0.091
Age^2	0.00012	-0.0012	0.0083***	0.0068***	0.0011	0.00025
Log(income)[1]	3.74***	3.88***	3.33***	3.39***	2.43***	2.59***
Living alone (0/1)	1.54	1.68	-2.23+	-1.76	-0.79	-0.42
Unemployed (0/1)	8.66***	7.65**	1.59	0.19	0.67	-0.27
Religious (0/1)	-3.59**	-3.15*	-1.03	-0.68	-2.01**	-1.97**
Exercise (IPAQ total MET-hours/week)	0.012**	0.015**	0.011**	0.011**	0.0070**	0.0076**
Housing						
Homeowner without mortgage (0/1)	3.40*	2.84+	1.98	2.40+	1.25	1.45+
Social tenant (0/1)	-9.06***	-9.07***	0.64	0.58	-2.27*	-2.16*
Housing problems (count) [2]	-4.67***	-5.24***	-4.79***	-5.09***	-3.93***	-3.99***
House crowding [3]	-3.16+	-2.86	0.48	0.65	-0.22	-0.23
Green space use and views						
Home views of grass (0/1)	2.08	1.98	5.03***	5.20***	2.33**	2.10*
Home views of water (0/1)	0.94	0.34	2.28	3.21	0.33	0.82
Weekly+ use of garden (0/1)	3.30*	3.54*	3.25**	3.70**	2.11**	2.67**
Monthly+ countryside visits (0/1)	3.08*	2.83+	1.31	0.91	1.01	0.92
Monthly+ other green space visits (0/1)	4.15**	3.44*	2.62*	2.58*	1.98**	1.75*
National Park visits per year (count)	-0.26	-0.26	0.18	0.26	-0.061	-0.0038
Land cover (ha within 1km radius of postcode centroid—base category is urban)						
Marine and coastal margins	-0.0063	-0.012	0.027	0.037	0.015	0.016
Freshwater, wetlands, flood plains	0.039	0.056	0.0095	0.0093	0.066	0.10+
Mountains, moors, heathland	-0.094	0.079	-0.034	0.0025	-0.033	-0.014
Semi-natural grasslands	0.0018	0.021	-0.019	-0.018	-0.011	0.0024
Enclosed farmland	-0.0043	0.016	-0.0019	0.018	0.0015	0.018*
Coniferous woodland	0.035	-0.031	0.033	-0.020	0.030	0.00073
Broad-leaved/mixed woodland	0.023	0.058	0.00028	0.046	0.0097	0.040*
Inland bare ground	0.075	0.13	-0.10	-0.032	-0.019	-0.0011
Distance to nearest…and other variables						
National Park boundary (km, 0 if inside)		-0.0079		0.022		0.011
National Trust site (km)		-0.086		0.026		0.033
Coastline (km)		0.0072		0.022		0.0066

	SF-36 physical functioning (0 – 100)		SF-36 emotional wellbeing (0 – 100)		SF-6D utility score × 100 (0 – 100)	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Motorway (km)		0.020		-0.014		-0.0013
A-road (km)		0.19		-0.067		0.042
Railway station (km)		-0.19		-0.18		-0.24*
Population density (1,000/km^2)		0.66+		0.67*		0.44*
Standardized house price index		0.011		-0.019		-0.0045
Countries (base category is England)						
Wales (0/1)	-4.37	-4.18	-2.50	-2.31	-2.77+	-2.47
Scotland (0/1)	-3.47		-2.30		-2.49*	
Northern Ireland (0/1)	3.44		-2.69		0.022	
Constant	65.6***	57.9***	29.2***	19.4*	45.6***	38.4***
Observations	1851	1647	1851	1647	1847	1644
Adjusted R-squared	0.181	0.181	0.135	0.141	0.112	0.118

Notes: The ‘a’ models include all respondents from England, Wales, Scotland and Northern Ireland, and have only a subset of spatial variables available. The ‘b’ models include all spatial variables but are limited to England and Wales.

[1] Income is logged to account for diminishing marginal returns. The income measure used is household income divided by weighted household size.

[2] Summed self-reported housing problems, out of: infestations, damp, mould, serious draughts, inadequate heating, low daylight.

[3] Number of rooms divided by number of residents.

Respondents who own and spend time in their own gardens at least once a week, and those who visit non-countryside green spaces such as urban parks at least once a month, are significantly better off on all three health indicators than those who do not. Monthly or more frequent visits to countryside have a significant positive link with physical functioning only (again, the causality here is very likely bi-directional).

Land cover and the other objective spatial variables are not significantly related to the health indicators, except in model (3b), in which the health-related utility score is regressed on the full set of spatial variables. In that model, *larger areas of freshwater, farmland and non-coniferous woodland within 1km of the home are all significantly positively associated with health utility*. This pattern is consistent with the findings of the hedonic pricing analysis in Section 2, although in that analysis coniferous woodland and bare ground were also significant.

To summarise, *positive links were detected between proximity of the home to specific habitat types and the SF-6D health-related utility score*, although such links were not observed between habitat types and simple aggregate physical and emotional health indicators. There appear to be *strong positive relationships between physical exercise and all three health measures investigated*, including physical health and emotional wellbeing; between *green views from the home and emotional wellbeing and health utility*; and between *regular use of gardens and green spaces and all three measures*. These findings are summarized in Table 17 (coefficients used are from the 'b' models in Table 16, including all spatial explanatory variables).

Table 17: Health changes and contact with nature: Summary findings

Explanatory variable	Difference in explanatory variable	Associated health differences		
		Physical functioning	Emotional wellbeing	Health utility score
Physical exercise	+24 MET-hours/week (e.g. +3 hours' vigorous activity)	+0.4%	+0.3%	+0.2%
Having a view over green space from your house	No view → any view	–	+5.0%	+2.1%
Use of own garden	Less than weekly → weekly or more	+3.5%	+3.7%	+2.7%
Use of non-countryside green space	Less than monthly → monthly or more	+3.4%	+2.6%	+1.8%
Local freshwater, wetland and flood plain land cover	+1% within 1km of the home (+ 3.14 out of 314 ha)	–	–	+0.3%
Local enclosed farmland land cover	+1% within 1km of the home (+ 3.14 out of 314 ha)	–	–	+0.1%
Local broad-leaved/mixed woodland land cover	+1% within 1km of the home (+ 3.14 out of 314 ha)	–	–	+0.1%

Note: Based on OLS models of England and Wales.

Table 17 shows that, for example, having a view of green space from one's house increases emotional well-being by 5% and the general health utility score by about 2%; using the garden weekly or more increases physical functioning and emotional wellbeing by around 3.5% and the heath utility score by 2.7%; and an increase in 1% of the area of freshwater within the 1 km radius of the home increases health utility by 0.3%.

It is important to note once again that *the associations we have estimated cannot be interpreted as causal effects*. There may be variables omitted from the models that cause changes in both the dependent and explanatory variables, and/or the dependent variable may itself be a cause of some explanatory variables. For example, use of green spaces may well be primarily determined by physical functioning, not vice versa.

5.3.2.3. Value of health benefits of exposure to nature

The general health measure SF-36 used in our survey is capable of detecting changes in health in a general population (Hemmingway et al., 1997). As such, it may be possible to use our survey results to tentatively estimate the monetary value of the health benefits associated with increasing the number of people making monthly visits to green spaces and having views of grass, or with increasing particular types of land cover.

In order to do that, and given that the SF-36 is not based on preferences, we first calculated a preference-weighted utility score from the SF-36 – the SF-6D health index described above, which can be used in economic evaluations (Brazier et al., 2002). Specifically, the SF-6D index can be used to generate QALYs associated with the environmental changes of interest, i.e. providing a green view, increasing use of the garden or visits to green spaces, and increasing particular types of landcover such as broadleaf woodland. As noted above, QALYs are measures of health benefits that combine length of life with quality of life, where quality of life is assessed on a scale where zero typically represents death and one represents full health (Drummond et al, 1997).

Secondly, we could tentatively assign a monetary value to the QALYs associated with the environmental changes of interest. The problem is that there is no consensus about what the monetary value of a QALY is and how to calculate it (Tilling et al., 2009; Willis, 2005). There is nevertheless an emerging literature attempting to empirically estimate the monetary value of a QALY (e.g. Tillig et al., 2009; Jones-Lee et al., 2007; Mason et al., 2009). One possible approach is to elicit monetary values for health improvements via stated preference methods that are comparable with QALY gains. Another more indirect method involves deriving a 'value of a life year' from existing empirical estimates of the Value of a Preventable Fatality (VPF) (Jones-Lee at al., 2007). Of particular interest to us is a special case of the latter approach, proposed very recently by Mason et al. (2009), that consists of estimating the value of a QALY based only on *quality of life changes*. The Mason et al. (2009) study is based on UK figures and use as an anchor the value of prevention of a non-fatal injury (which range from injuries that will last only a few days and require no hospital treatment through to permanent paralysis and brain damage). They estimate monetary values of a QALY ranging from £6,414 to £21,519. Given that the environmental changes being considered are likely to have impacts mostly on quality of life (rather than on life expectancy) these seem to be the most appropriate values to use.

Table 18 contains the very tentative results of the calculation outlined above. Specifically, the last column shows the estimated annual health benefits associated with having a view of nature, using the garden often, visiting green spaces regularly and increasing the proportion of broadleaf woodland, freshwater and farmland cover. We note that these figures are indicative only and subject to many assumptions as described above and should therefore be treated with caution.

Table 18: Tentative valuation of health benefits of contact with nature

Explanatory variable	Difference in explanatory variable	Associated difference in health utility score	Potential annual value of difference in health utility score per person
Physical exercise	+24 MET-hours/week (e.g. +3 hours' vigorous activity)	+0.2%	£12 – £39
Having a view over green space from your house	No view → any view	+2.1%	£135 – £452
Use of own garden	Less than weekly → weekly or more	+2.7%	£171 – £575
Use of non-countryside green space	Less than monthly → monthly or more	+1.8%	£112 – £377
Local freshwater, wetland and flood plain land cover	+1% within 1km of the home (+ 3.14 out of 314 ha)	+0.3%	£20 – £68
Local enclosed farmland land cover		+0.1%	£4 – £12
Local broad-leaved/mixed woodland land cover		+0.1%	£8 – £27

Note: Table values 1 QALY at £6,414 – £21,519 (Mason et al., 2009).

5.4. Conclusions and knowledge gaps

Our analysis showed that there could be large economic benefits associated with increased physical exercise within the sedentary portion of the UK population. Specifically, *a 1 percentage point reduction in sedentary behaviour would provide a total benefit of almost £2 billion* across three physical conditions (CHD, colo-rectal cancer and stroke) and one mental health condition (stress and anxiety). If people over 75 years are excluded from the analysis – on the basis that they are less able or likely to be physically active – then the benefits fall to just over £750 million. However, we could not link, in a robust manner, this reduction in sedentary population with the provision and quality of green space as we found *no conclusive evidence on the strength of the relationship between the amount of green space in the living environment and the level of physical activity*. *Hence is not possible to* *accurately value, at the present time, the health benefits of created exercise due to additional green space provision.*

In terms of the health benefits of more passive forms of contact with nature, using a new original UK-wide survey, we found *positive links between proximity of the home to specific habitat types (farmland, freshwater and broadleaf woodland) and the SF-6D health-related utility score*. We also found *strong positive relationships* between *green views from the home and emotional wellbeing and health utility*; and between *regular use of gardens and green spaces and physical health, emotional wellbeing and health utility*. For example, having a view of green space from one's house was found to increase emotional well-being by 5% and the general health utility score by about 2%; using the garden weekly or more increases physical functioning and emotional wellbeing by around 3.5% and the heath utility score by 2.7%; and an increase in 1% of the area of freshwater within the 1 km radius of the home increases health utility by 0.3%.

Overall, as noted above, we found important conceptual and methodological challenges in identifying the role of environmental factors in behavioural choices such as those pertaining to physical exercise. As such there is no robust estimate of the proportion of exercise occurring in green spaces is actually created. We would recommend conducting especially commissioned studies to investigate further people's exercise habits and ascertain what proportion of that exercise is a direct consequence of the provision of green spaces. This could be done using revealed and stated preference techniques or using experimental methods where extra green space is provided and behavioural change can be investigated before and after the provision.

Regular physical activity can prevent and ameliorate the severity of many costly conditions of which we have assessed only four: coronary heart disease, stroke, colo-rectal cancer and depression. This analysis could be expanded to include other conditions such as osteoporosis, arthritis, diabetes, other forms of cancer, etc.

Moreover, future work could usefully focus on improving the current monetary estimates of the environmental-related health effects, particularly of the mental health benefits arising from contact with nature which are, by and large, not well known.

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