Economic Assessment of the Recreational Value of Ecosystems in Great Britain

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Abstract

We present a novel methodology for spatial- and ecosystem-sensitive estimation of recreational visit numbers and their values across Great Britain. Drawing upon an extensive and spatially explicit survey of current recreational behaviour, data are combined with highly detailed information on population characteristics, transport infrastructure and GIS generated measures of the availability of potential substitutes and complements. Analysis yields a readily transferable model of visit behaviour which is valued using a meta-analysis of the recreation valuation literature. The impacts of changes envisaged under the various UK National Ecosystem Assessment scenarios for future land use are then analysed and corresponding visits and (real) values estimated. A second analysis demonstrates the application of the methodology to assessment of a proposed single site. We conclude by considering limitations and future potential for this methodology.

Keywords: *Recreational visits; recreational values; ecosystems; substitutes; complements; UK National Ecosystem Assessment; meta-analysis; GIS; spatially sensitive.*

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1. Introduction and methodological overview

The United Kingdom National Ecosystem Assessment (UK NEA) attempts to assess trends in the services derived from UK ecosystems and to value changes in various related goods arising under a number of plausible scenarios. One of those ecosystem related goods was open-access recreation and this paper describes the various analyses undertaken and valuations obtained for this good.

Outdoor recreation forms one of the major leisure activities for the majority of the population in the UK. According to recent estimates some 2,858 million visits were made during 2010 involving an associated expenditure of some £20.4 billion (Natural England, 2010). The spatial distribution of visits and values is highly non-random, being determined in part by push factors such as the distribution of population and pull factors such as the location of desirable sites, the availability of substitutes and complements and the quality of the transport infrastructure. This means that a given resource located in different areas will generate very different numbers of visits and values. In order to address this issue and generate valuations compatible with other assessments in the UK NEA (2011)[2], we develop and implement a two-step statistically driven model of open-access recreation visits and associated values. The intended wider contribution of our paper is to provide a novel methodology that can be used as a general tool for recreation planning and environmental decision-making while providing economic values which are consistent with comparisons to the costs of recreation provision (including opportunity costs).

[2] Note that the analyses and results reported in the present paper are a subsequent development of the more preliminary analyses summarised in UK NEA (2011).

In the first step of our analysis, we develop a trip generation function (TGF) which models a dependent variable defined as the count of visits from a given, relatively small, outset point[3] to a given destination as a function of several independent variables; these include the characteristics of the outset location (including population socioeconomic and demographic characteristics, the availability of potential substitutes, etc.), travel time to the destination (taking into account the road network and its variable quality) and characteristics of the destination site (including its ecosystem type, the availability of surrounding potential substitutes and complements, etc.). The TGF is estimated using two sources of data: (i) a new annual in-house survey which provides information on the dependent variable and (ii) independent spatial and thematic variables generated and manipulated in a geographical information system (GIS). Once estimated on survey sample data, the TGF is then used to predict the number of visits per week to all 1 km square cells across the current land use of Great Britain[4]. The model is then applied in turn to each of the UK NEA scenarios for future land use with changes in estimated visitation being calculated by comparison with those for the current land use.

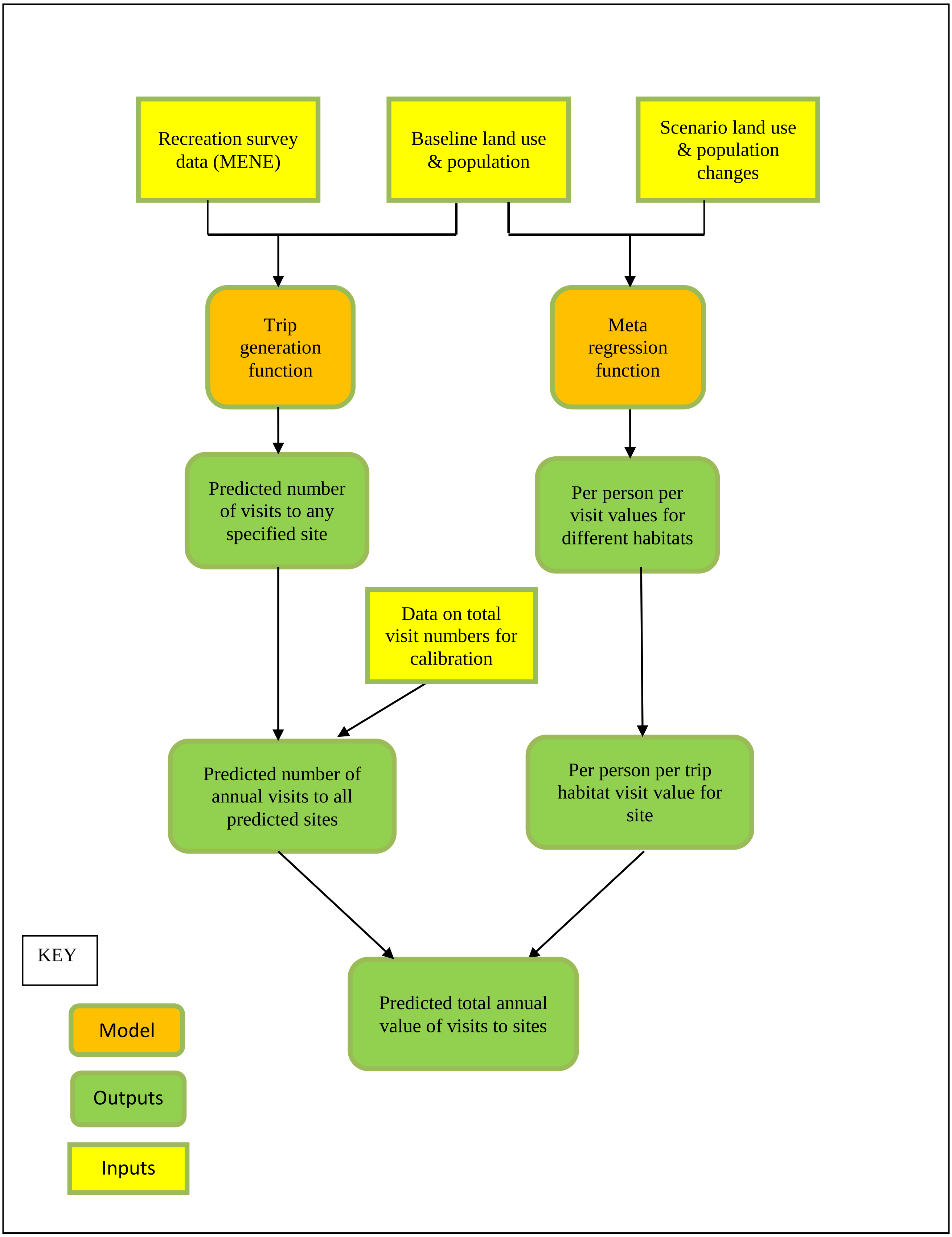
In the second step of our analysis, we seek to determine the value of predicted visits. For this purpose, we develop a trip valuation meta-analysis model (MA). This step of the study analyses nearly 300 previous estimates of the value of a recreational visit, examining the determinants of those values which include the influence of the ecosystem type of visited sites. This allows us to generate an ecosystem-specific value of each visit.

[3] As discussed in detail subsequently, our survey data covers the entirety of England for which outset locations are defined as the population weighted centroid of UK Census Lower Super Output Areas (LSOA; for full details see http://www.neighbourhood.statistics.gov.uk). These are small areas of around 400 to 600 households which, particularly in urban areas, mean that the influence of residential location on visits can be accurately modelled. Within the subsequent extrapolation of our model to predict visits across Great Britain we define potential outset points as LSOAs for England and Wales and comparable Census Data Zones (DZ) for Scotland.

[4] Note that due to data limitations, we do not consider Northern Ireland in this study.

Bringing our two step methodology together allows us to estimate, for the current land use and the future land use described under any given UK NEA scenario, i) the number of visits to each 1km cell across Great Britain (adjusted for location, ecosystem type, road network, population distribution and characteristics and the availability of substitutes and complements); ii) the value per visit for that cell (adjusted for the ecosystem type specified under that chosen scenario) and, by drawing these together, iii) the spatially and ecosystem sensitive total value of visits and how that value varies from that obtained under current land use. This provides the decision maker with vital information on the recreational benefits (or costs) of moving to that future scenario; information which can then be compared with the direct and opportunity costs of effecting that move. Furthermore, the highly disaggregated nature of the information provided by this methodology allows the decision maker to consider any desired decision area, ranging from the single 1 km grid square cell, through any user defined region, right up to and including the national level. Figure 1 provides a schematic overview of this methodology.

Figure 1: Schematic representation of the recreation valuation model.



The remainder of the paper is organized as follows. Section 2 describes the data and the empirical methodology developed for building the TGF while Section 3 provides a comparable discussion for the MA model. Section 4 combines the TGF and the MA models in order to obtain the spatially and ecosystem sensitive total value of visits for the baseline year 2010. Section 5 details the national-level scenario analysis summarised above, while Section 6 presents an application of the methodology for a single site appraisal. This case study outlines adjustments to our method for application in the context of local policy. Section 7 concludes with a discussion of the limitations, caveats and future development potential of our work.

2. Trip generation function

This section describes the development and estimation of the TGF, discusses data sources and presents results[5].

Model specification

The TGF predicts the number of visits made from each outset location to any given recreational site as a function of: the travel time to the site (in minutes), socioeconomic and demographic characteristics of population in the outset area and the land use (ecosystem) characteristics of the destination site together with the surrounding availability and accessibility of potential substitutes or complements near to outset locations.

Given the hierarchical count nature of our dataset, with a dependant variable of discrete visit numbers clustered within both outset UK Census Lower Super Output Areas (LSOA) (level 1) and destination sites (level 2), we estimate our TGF using a multilevel Poisson regression

[5] In the interests of brevity further details are presented in Sen et al., (2012).

model. This assumes that the dependent variable is influenced by a variety of factors operating at both the outset and destination levels. We control for some of these factors (e.g. ecosystem type proportions; see subsequent details) by including them explicitly in our regression model. However, there may be certain unobserved factors that influence visit numbers (e.g. the unobserved presence or absence of bike trails might alter the attractiveness of certain woodland sites). If this is the case then we can no longer assume that the regression residuals are independent. Failure to account for this intra-unit correlation will lead to an underestimation of the standard errors and inefficient parameter estimates. This is allowed for by specifying a random effects Poisson model in which the site-specific error terms follow a multivariate normal distribution (Rabe-Hesketh and Skrondal, 2008). The model is estimated using maximum likelihood techniques where the marginal likelihood is approximated by a numerical integration approach, in this case the adaptive Gaussian quadrature method.

The estimating equation for the TGF is as follows:

$$ln\ (y_{ij}) = \gamma_{00} + \gamma_{01} W_j + \gamma_{10} X_{ij} + u_{0j} + r_{ij}$$

where y_{ij} is the number of visits from a given outset area i to a specified site j. The *fixed* part of the model consists of W_j (variables describing site characteristics such as the percentage of various land uses at the site) and X_{ij} (variables describing outset area characteristics such as substitute availability, measured as the percentage of substitute habitats within a 10km radius of the LSOA population weighted centroid, and outset area socio-economic and demographic variables measured as percentage retired, percentage non-white ethnicity, median household income and total population of outset area). We allow for diminishing marginal utility between the number of visits to any site and the size of recreational ecosystems (within that site and surrounding the outset area) by specifying logarithmic transformations of both substitute availability and site habitat variables in our model. Given that the dependent variable is the logarithm of the number of visits to a site, the coefficients of both substitute availability and site habitat variables can therefore be interpreted as elasticities. The *random* part of the model consists of u_{0j} (the site-specific random intercept terms which captures the unobserved heterogeneity between different sites) and r_{ij} (the usual regression error term). The random effects u_{0j} are assumed to be normally distributed with mean zero and variance $\sigma^2 u$ (sig2u).

Data

Observations of recreational visits were taken from the Monitor of Engagement with the Natural Environment (Natural England, 2010), a new annual survey of household recreation behaviour in England which samples continuously around the year asking households for diary records of their recreational behaviour in the week running up to the interview date. The interviewer then selects one trip at random and records full details of destination location alongside details of outset location for that trip. Responses for the period from March 2009 to February 2010 (inclusive) were provided to this study amounting to some 48,514 household interviews covering the entirety of England. These data contained some 20,374 non-zero visit records to more than 15,000 unique destinations across England.

Although the MENE dataset is almost unique in its combined scale and spatial accuracy, nevertheless a number of records had to be omitted, principally because of incomplete locational information. Further omissions arose from our objective to develop a transferable methodology which required that we omit a substantial tranche of observations from respondents who did not start their trips from their home address. Neither of these omissions biases our sample but to remove a potential source of bias in the remaining dataset we carry out an analysis of 'boundary effects'. MENE recorded trips originating from England taken to English destinations. Visits taken to sites located outside of England, *viz.* to Scotland and Wales, were not recorded or deleted from the final MENE database during post-processing. Such sampling is likely to artificially depress visitor numbers to sites that lie close to the England-Scotland border and the England-Wales border. Statistical analysis of the incidence of this boundary effect resulted in the definition of a buffer extending approximately 13 km into England from these borders. In the buffer zone all destinations were omitted (251 respondents). Finally, to focus on the bulk of day trips, we omitted some 10% of respondents who made unusually long one-way trips of over 60 minutes. In sum these omissions reduce our total dataset to some 40,907 observations.

For the purposes of valid model building, the zero visits are just as important as the positive visit records. To take account of this, we recorded two categories of valid zero visits in our analysis: i) non-visits in the sample week to the observed MENE sites (i.e. a respondent chose site x in preference to sites a, b, c etc. and thus site x is recorded as a positive visit and all remaining sites were non-visits); ii) non-visits to the rest of England (i.e. 1 km grid square cells that could be potential sites but were not visited by any MENE respondent). Thus for purposes of estimation of the TGF, we considered all possible combinations of LSOAs and 1 km grid square cells in England. This resulted in an estimation dataset of over four million observations.

The MENE survey records outset locations in terms of household full postcodes which are highly accurate spatial data. However in order to enhance the subsequent transferability of our findings we first convert these to Ordnance Survey (OS) grid reference locations, precise to 1 metre resolution for the first house in the postcode, (we used GeoConvert at MIMAS which queries the 2010 UK National Statistics Postcode Directory[6]) and from these link to their corresponding UK Census LSOA[7]. This permits ready access to socio-economic and demographic variables through CASWEB[8]. Given the large sample size, approximation of household characteristics by LSOA data is both reasonable (especially given the relative population homogeneity built into the design of LSOA boundaries) and greatly enhances the transferability of findings for decision analysts operating without access to direct recreational survey data. Further replicability was achieved by defining trip origin as being LSOA population weighted centroids and calculating travel times to destination sites using the OS Meridian road network[9], a GIS file consisting of Motorways, A-roads, B-roads and minor roads used in other recreation modelling exercises (e.g. Jones et.al 2010)[10]. Replicability and transferability was also enhanced through our treatment of destination sites locations which were similarly converted to the standard OS 1 km square grid simplifying the visit destinations to some 7,575 unique grid cells or sites as illustrated in Figure 2.

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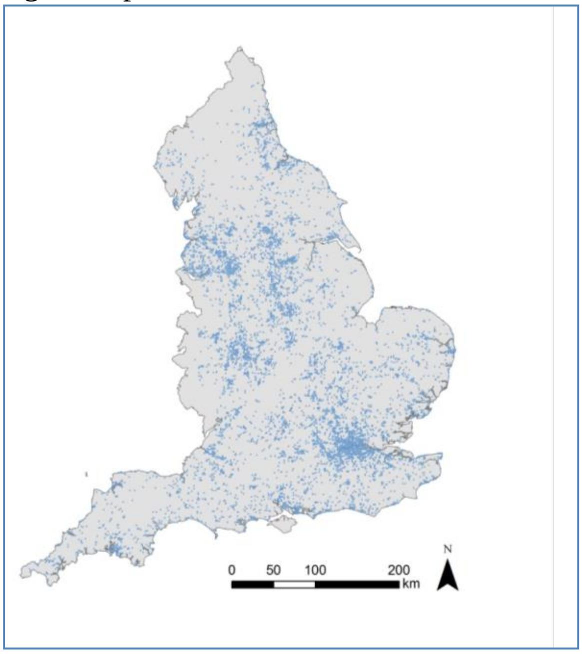
[7] Data provided through EDINA UKBORDERS with the support of the ESRC and JISC and uses boundary material which is copyright of the Crown

[8] Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland.

[9] ©Crown Copyright/database right 2011. An Ordnance Survey/EDINA supplied service.

[10] Calculating travel times from all LSOA outsets to all 1 km square grid cells across GB (as per our subsequent transfer of results) was computationally unmanageable. Therefore, while outsets were held at LSOA level, for the purpose of establishing travel time, each site was assigned to a 5km square cell. For futher details see Sen et al. (2012)

Fig 2: Map of visited sites from MENE



The environmental characteristics of destinations are defined by linking their grid cell locations to habitat proportions derived from the 25 metre resolution, UK-wide, Land Cover Map 2000 data (Fuller, et al., 2002). Habitat categories here are (1) broadleaved woodland; (2) coniferous woodland; (3) coast (littoral and supra littoral); (4) enclosed farmland; (5) freshwater body; (6) mountain, moorland and heathlands; (7) estuary (sub littoral); (8) semi-natural grassland; and (9) urban and suburban. Demographic indicators at LSOA-level[11] were extracted from the 2001 Census of UK population (CASWEB)[12]. These provided measures of ethnicity, households with dependent children and retired population[13]. LSOA level measures of median gross annual household income were taken from the 2008 Experian Mosaic Public Sector dataset[14].

[11] For prediction, statistics for Scottish outset zones (DZ) were calculated by aggregating data from Output Areas.

[12] Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland.

[13] Previous studies like Jones et.al (2003) indicate that these demographic variables significantly influence visit numbers from any outset area

[14] Source: the Experian Limited Demographic Data, ESRC/JISC Agreement.

The number of visits to a specific site from some given outset location will be lower when that outset area is well served by other local substitute sites. To allow for this, we assessed the availability of substitute resources around each potential outset location across the country. This was achieved by defining circular zones around each LSOA and calculating the percentage of each land use and habitat type in that area[15]. This measure of substitute availability is then included within the trip generation function. The radii of these circles were varied and the analysis repeated to identify the optimal size of surrounding area for capturing this substitution effect[16].

Results

Table 1 reports the best-fitting TGF[17]. Enclosed farmland is set as the base case for both the 'substitute availability' and 'site characteristic' variables.

[15] Zonal Statistics ++, a module of the 'Hawths Tools' plug-in for ArcGIS (Beyer, 2004), was used to query the habitat types in the cells entirely within the search radius. These were converted into percentages of the total search area (1 km cells entirely within the search radius which was itself varied as described subsequently).

[16] Radii of 1, 2.5, 5 and 10 km are used for defining substitution availability measures around outset locations. Resultant measures are used within a variety of model specifications including travel time from the population-weighted centroid of each LSOA to the nearest substitute site and interactions between travel time and the proportion of the above circles taken up by substitutes. An AIC criterion comparison of different models indicate that a measure of the density of each land use/habitat type within a 10km radius of the LSOA population weighted centroids provides the best fit to the MENE visitation data.

[17] We tested various functional forms for the TGF, for example by including interactions between travel time and the various land use types. An AIC criterion comparison of different models indicates that the TGF below in Table 1 provides the best fit to our data. Details regarding the alternative model specifications tested are presented in Sen et.al (2012).

Table 1: Trip Generation function

	Coefficients	t-stat
One-way trip travel time from outset to site		
Travel time (in minutes)	-0.180***	(-159.0)
Substitute availability variables measured at outset		
Log (Urban substitute availability)	-0.445***	(-27.08)
Log(Freshwater substitute availability)	-0.0627***	(-6.085)
Log (Woodland substitute availability)	-0.0596**	(-2.780)
Log (Other marine substitute availability)	-0.0328***	(-5.322)
Log (Coast substitute availability)	-0.0218**	(-2.675)
Log (Mountain substitute availability)	-0.00127	(-0.125)
Log (Grasslands substitute availability)	0.0277	(0.971)
Land use variables measured at site		
Log (Urban at site)	-0.224***	(-20.87)
Log(Freshwater at site)	0.0721***	(3.890)
Log (Wood at site)	0.0411***	(3.884)
Log (Other marine at site)	0.0686*	(2.369)
Log (Coast at site)	0.158***	(5.950)
Log(Mountains at site)	0.0417*	(2.369)
Log (Grasslands at site)	0.00230	(0.204)
Demographic variables measured at outset		
Median Household Income (in pounds)	0.0000133***	(12.79)
Total Population of outset area (no. of people)	0.000281***	(6.795)
% Non-white ethnicity	-0.00855***	(-8.707)
% Retired	0.00541**	(2.804)
Constant	-0.427***	(-3.558)
lnsig2u	-0.869***	(-22.84)
sigma_u	0.647***	(52.606)
Observations	4,034,290	

Likelihood-ratio test of sigma_u=0: chibar2 (01) = 2080.01 Pr>=chibar2 = 0.000

Dependent variable is logarithm of the expected count of visits from an LSOA/DZ to a site. Full definition of explanatory variables given in the main body of the paper

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Examining the relationships captured in the TGF we see that travel time is one of the most powerful predictors of visits from an outset area to a potential visit site. Here, the highly significant negative coefficient shows that as travel time increases the number of visits to the site falls. The substitute availability variables measure the percentage of each habitat type within a 10km radius of the outset area. The negative signs on all significant variables conform to prior expectations that visitors will be less likely to visit a site if there are alternative recreational sites available near their home (Jones et.al 2010). For example, the above model shows that a one percent increase in woodland area near to where visitors live is likely to lead to a 0.06 percent reduction in visit numbers to any potential site *relative* to enclosed farmlands.

A further set of variables are included in the TGF to describe the attractiveness of land use and habitat types across different potential recreational sites. These variables measure the percentage area of each habitat type in every 1km grid square cell. As expected we find that all the site habitat variables (with the exception of urban) exert a positive impact upon visits *relative* to enclosed farmlands. For example, a one percent increase in coastal areas at a potential site is likely to lead to a 0.15 percent increase in its visit numbers *relative* to farmlands. A set of socio-economic and demographic variables pertaining to the outset area are also included in the TGF. We observe significantly higher levels of engagement in recreation from retired and richer populations and lower engagement amongst ethnic groups (Jones et.al 2010). For example, a £1000 increase in median household income in the outset area is likely to lead to 1 percent increase in visits to any given site. Similarly a one percent increase in the percentage of retired people in the outset area is likely to lead to approximately a half percent increase in visit numbers to any given site.

The site-level variance component is parameterised as the log of the variance (labelled lnsig2u in the table). The standard deviation is also included in the table and is labelled as sigma _u. When sigma_ u is zero, the site-level variance component is no longer important and the panel estimator is similar to the pooled estimator. The likelihood-ratio test (included at the bottom of the table) formally compares the pooled estimator (poisson) with the panel estimator. We find that sigma_u is significantly greater than zero, so that a panel estimator is preferred.

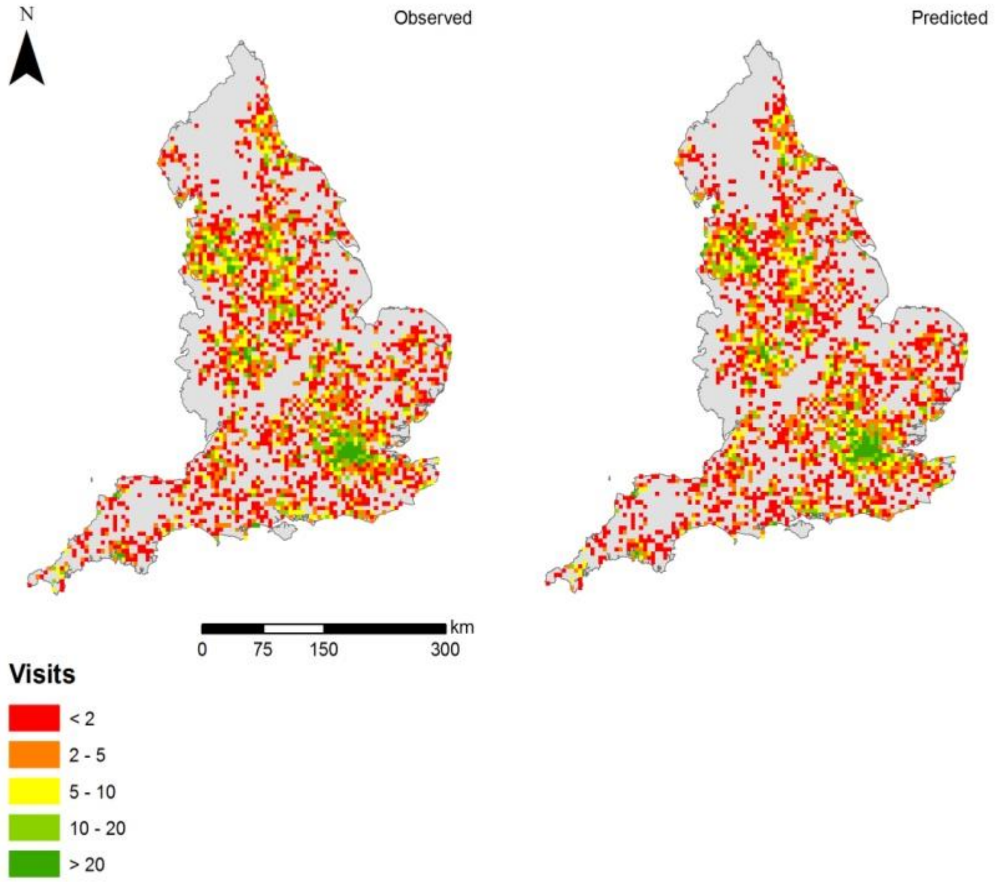
Validity analysis: Actual versus predicted visitation for the baseline year 2010

While Table 1 reports our best fitting model it does not describe the accuracy of the predictions obtained from this analysis. Figure 3 below presents a map showing the predictive ability of the estimated TGF. The left hand panel shows the actual number of visits per week for each 5 km x 5km cell in England obtained from the MENE survey. The right hand panel shows the predicted number of weekly visits to each 5km x 5km cell in England obtained from the estimated TGF above[18]. The model performance seems highly satisfactory with both the actual and the predicted maps showing relatively similar spatial patterns of recreational visits[19]. The spatial distribution of both observed and predicted visitor numbers seem to be a reflection of population density, and hence small travel distances, as visits seem to be concentrated around urban centres.

[18] We aggregate to a 5km grid square cell only for the purposes of visualisation only. Only coincident 1km^2 cells are grouped.

[19] The predicted visits obtained for the MENE sites includes *both* the fixed effects and the site-specific random effects

Figure 3: Map of actual visits vs. predicted visits in England



Transfer analysis: Predicting visits across Great Britain

While the estimated TGF provides an interesting insight into the drivers of current recreational behaviour, its main purpose is to provide a planning tool allowing the decision maker to examine the consequences of land use change upon visits. To move towards the establishment of such a tool we first need to transfer findings from our survey sample to a complete coverage of Great Britain under its current land use before extrapolating to assess the consequences of alternative land use configurations (as described in Section 4 below).

Generalisation to the entirety of Great Britain requires assessment of the recreational potential of each 1 km grid square across the nation. In order to carry out the predictions, we consider all possible combinations of every 1km^2 cell and LSOA/DZ outsets in Britain[20]. Given data on the location and characteristics of these cells and outset areas, we use the estimated coefficients of the above TGF to predict the weekly visit counts for every 1km grid square cell in Britain.In order to obtain an estimate of the *annual* predicted number of visits made to each 1km grid square cell, we calibrate the predicted per week visit figures by official estimates of the total annual number of outdoor visits to all sites in England. The information on the total annual number of outdoor visits is obtained from the MENE survey. Table 2 below presents the descriptive statistics for annual predicted visits to GB and its constituent countries.

Table 2: Predicted number of visits per annum for the baseline year 2010

	GB	England	Scotland	Wales
Mean no. of visits	19,543	22,351	15,205	13,520
Median no. of visits	11,543	15,234	3,595	7,378
Total no. of visits (000's)	3,943,219	2,857,759[21]	824,935	260,526

We now need to allow for the fact that the characteristics of sites influence the value of these predicted visits. Therefore in order to obtain the predicted values of visits per annum we turn to the meta-analysis model.

3. Valuing visits: Meta-analysis

It seems highly likely that, ceteris paribus, while different ecosystems exert differing attractiveness in terms of visit rates, they may well also exhibit differences in the marginal value of individual visits. To allow for this we require a valuation method which is sensitive to potential habitat effects.

[20] As mentioned before, we consider only those LSOA/DZ outsets which are located within one-way travel time of 60 minutes from each cell.
[21] This is the total observed number of outdoor recreational visits in England reported in MENE for 2009-2010

Fortunately the literature on the valuation of open-access recreation activities is substantial, embracing studies concerning a wide variety of ecosystems with sufficient value estimates to justify the investigation of a meta-analysis of prior studies. A review of this literature identified some 297 value estimates within 106 relevant studies[22].Our choice of studies was limited by the availability of comprehensive information regarding the various explanatory variables included in our model. A meta-analysis was duly conducted, linking estimates of recreation value to the open-access resources they relate to and various study specific and methodological variables. Value estimates were made comparable using purchasing power parity (PPP) indices given in the Penn World Table and adjusted to a common price base (2010) using the GDP deflator for the UK[23].

Following prior meta-analysis studies (Bateman and Jones 2003, Brander et.al 2003, Lindhjem 2007) the general form of our meta-analysis model is specified as follows:

$$y_i = \beta_0 + \beta_1 (habitat\ type)_i + \beta_2\ (study\ chars)_i + \beta_3\ (valuation\ unit)_i + \beta_4\ (valuation\ method)_i + \beta_5 (study\ country)_i + \varepsilon_i$$

where y_i is the per person per trip recreational value reported in study *i*; *habitat type* is a series of binary indicators denoting the dominant habitat at the study site; *study chars* refers to a set of variables describing characteristics of the valuation study such as sample size; *valuation unit* controls for changes in the category and unit used for value estimates; cross study differences in methodology are controlled via the *valuation method* variable; *study country* refers to the country in which the recreational site is located; and ε_i is the error term specific to study *i*.

Results

Following investigation of an appropriate functional form (detailed in Sen et al., 2012) our meta-analysis was specified as a log dependent model for which OLS estimation was acceptable yielding

[22] References for the full set of studies used within the meta-analysis are given in Sen et. al (2012)

[23] The data on GDP deflator was obtained from the HM-Treasury web page at http://www.hm-treasury.gov.uk/data_gdp_fig.htm

regression results as detailed in Table 3. We estimate the model using Huber-White-adjusted standard errors to correct for heteroskedasticity. Given the log dependent form of the model, coefficients on untransformed explanatory variables measure the relative change in recreational values for any given absolute change in the value of the explanatory variables.

Table 3: Meta-analysis (MA) model of recreational value estimates (£, 2010)

Variable	Variable definition	Coefficient	t-stat
Good characteristics			
Mountains & heathlands	1 = recreational site valued is mountain or heath; 0 = semi-natural grasslands (SNG)	1.184	(1.267)
Urban fringe farmlands	1 = recreational site valued is farmlands; 0 = SNG	1.248**	(3.158)
Woodlands & forests	1= recreational site is woodlands; 0= SNG	0.775*	(2.176)
Freshwater & floodplains	1 = recreational site valued is Freshwater and floodplain; 0 = SNG	0.170	(0.485)
Marine and coastal	1 = recreational site valued is Marine and coastal; 0 = SNG	0.944*	(2.268)
Wetlands	1= recreational site is wetlands; 0= SNG	0.895*	(2.134)
Study characteristics			
Survey year	Discrete variable: 1 = survey year is 1975, to 29 = survey year is 2008	0.0437**	(3.064)
Sample size	Sample size of study	-0.00547***	(-3.537)
Valuation unit			
Use value only	1= use value study; 0 = study of combined use and non-use	-0.0373	(-0.196)
Per household per year	1= unit is per household per year; 0= per person per trip	3.043***	(12.56)
Per person per year	1= unit is per person per year; 0 = per person per trip	2.164***	(8.177)
other valuation unit	1= unit is per household/ per person per day/ per month;0 = per person per trip	2.434***	(8.589)
Valuation method			
RPM & mixed	1 = revealed preference or mixed valuation methods; 0 stated preference valuation methods	0.685***	(4.214)
Study country characteristics			
Non-UK countries	1 = study conducted overseas; 0 otherwise (UK)	0.703***	(3.688)
Constant		-0.420	(-1.044)

Sample size = 297 observations 106 studies.
R^2 (adj.) value is 0.72
The dependent variable is the logarithm of recreational value/person/trip (£; 2010 prices)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We use the meta-analysis model given in Table 3 to obtain implicit habitat-specific recreational values. These are obtained by setting the sample size variable in the model equal to its mean value, survey year variable equal to 29 (i.e. the year 2008 which we assume represents the state-of-the-art methodological development and current preferences), the use value variable equal to one and the valuation method variable as RPM/mixed valuation methods. The estimated per person per trip value is found to be highest for Urban fringe farmlands (£9.76) being followed by Mountains, moors and heathlands (£9.19), Marine and coastal (£7.23), Wetlands (£6.88), Woodlands (£6.10), Freshwater and floodplains (£3.35), and Semi-natural grasslands (£2.82).

These recreational values allow us to estimate the location-specific mean per person per trip value for each 1km grid square cell in Britain. This is done by multiplying the coverage of the different habitats in each cell by their corresponding recreational values. For example, suppose a 1km grid square cell is covered by 50 percent semi-natural grassland and 50 percent farmland. In order to obtain the per person per trip value for such a cell, we multiply the coverage of semi-natural grasslands in the cell (0.5) by the per person per visit value of semi-natural grasslands (£2.82) and the coverage of farmland in the cell (0.5) by the per person per visit value of farmland (£9.76) and sum to obtain a per person per trip value of £6.29 for the 1km grid square cell. We follow this approach in order to generate an ecosystem-specific value of each visit made to all 1km grid square cells in Britain.

4. Obtaining spatially and ecosystem sensitive total values for visits

We bring together results from the trip generation function (TGF) and the meta-analysis model (MA) in order to obtain the annual predicted value of visits in Britain for the baseline year. As mentioned before, from our TGF, we obtain an estimate of the annual number of outdoor recreational visits to each 1km grid square cell in Britain. From the meta-analysis model, we obtain an estimate of the per person per trip value for each 1km grid square cell in Britain. Multiplying the two estimates together, we obtain the spatially and ecosystem sensitive total value of visits for each 1km grid square cell in

Great Britain. Adding these values across all the 1km grid square cells in England, Scotland and Wales, gives us the annual predicted value of visits in Great Britain.

Table 4 presents the descriptive statistics for annual predicted value of visits to GB and its constituent countries.

Table 4: Value of visits (£/yr) for the baseline year 2010

	Great Britain	England	Scotland	Wales
Mean value of visits	136557	154572	109451	93785
Median value of visits	78712	102023	23875	48834
Total value of visits (000's)	27,600,000	19,800,000	5,970,000	1,810,000

Note: Outdoor recreational value for GB in £ /yr (note: urban land which mainly consists of concrete buildings and city areas is given a value of zero). Reporting no value for islands and highlands because we cannot calculate travel time and hence these are not included in estimation or prediction.

5. Application 1: Predicting recreational value under alternative future NEA scenarios

The above sections show how our methodology can be used to obtain the annual predicted value of recreational visits to Great Britain for the baseline year of 2010. However, it is interesting to consider how these visit numbers and values might change under future land use changes. The NEA scenarios describe the UK in 2060 by specifying the land cover and socio-demographic changes envisaged for the UK in 2060 (refer to Haines-Young et.al 2011 for a detailed description of the NEA Scenarios). This section considers the predicted changes in annual recreational visit numbers and values under these scenarios. All of these scenarios have been further modified according to two different responses to climate change taken from the simplified UKCIP-09 Low and High Emissions Scenarios for 2050-2079. The land cover and socio-demographic changes envisaged for the UK under the twelve scenarios are then incorporated in the TGF and the MA models which help us to assess changes to recreational visit numbers and visit values under these scenarios.

For purposes of brevity, we focus only on the high climate variant of the NEA scenarios in this paper (refer to Bateman et.al 2011a for results pertaining to the low climate variant of the scenarios). In order to illustrate the applicability of our methodology we consider two extreme NEA scenarios- Nature @ Work scenario (NW) and the World Market scenario (WM). In the Nature @ Work (NW) scenario the focus is on maintaining and enhancing the output of a range of ecosystem services. This scenario emphasises the promotion of ecosystem services in multifunctional landscapes as being essential to maintaining the quality of life in the UK. In the World Markets (WM) scenario however, the focus is on unfettered economic growth through the complete liberalisation of trade. There is competition for land and this coupled with reduced rural and urban planning regulations on housing, agriculture and industry imply agricultural intensification and substantial losses in peri-urban greenspace and biodiversity. The WM scenario can be justified and is in fact of particular interest given the new planning regulations proposed by the British government in 2011. It is expected that these planning rules will facilitate the growth of urban sprawl and thus make the greenbelts and other environmentally sensitive areas more vulnerable. Under the NW scenario we expect substantial increases in freshwater sources, grasslands and woodlands but reductions in farmlands compared to the baseline. In contrast, the WM scenario is expected to be dominated by reductions in most natural habitat types but substantial increases in urban areas compared to the baseline. Although increases in income and percentage of retired population are expected to be more or less the same under both these scenarios, increase in population is likely to be considerably higher under the WM scenario than the NW scenario.

The land cover and socio-demographic changes envisaged in the NW and WM scenarios imply changes in the value of variables for both the TGF and MA models. For the TGF, these are reflected in changes in the values of the substitute availability variables, site habitat variables, median household income, population and proportion of retired population variables. By incorporating these changes in the TGF we obtain the *annual* predicted number of visits made to Great Britain for both the NW and WM scenarios[24]. For the MA model, the land cover changes under the NW and WM scenarios are reflected in changes in the habitat coverage of each 1km grid square cell. By incorporating this change in the MA model, we obtain the predicted per person per trip values in Great Britain for both the scenarios. As before, multiplying the predicted visit numbers and visit values for these two scenarios together gives us the *annual* predicted total value of visits to Great Britain for the NW and the WM scenarios. The map in figure 4 shows the changes in recreational values between the baseline year 2010 and the NW and the WM scenarios. The NW scenario displays substantial increases in the value of visits for large areas of GB. In contrast, the WM scenario shows reductions in visit values for many areas in GB. However, under the WM scenario the urban areas in and around London are expected to experience an increase in the value of visits. In both scenarios the remote uplands of Scotland, because of their inaccessibility, remain unvisited and show no change in value.[25]

[Figure 4 about here]

Figure 4: Changes in recreational values between the baseline year 2010 and the six high emissions scenarios (£/ha/year)

Table 5 summarises the national level changes in value arising between the baseline and each of the six high climate variant of the NEA scenarios. At this national level all of the scenarios generate increases in the annual value of visits except for the WM scenario. In general, we find large gains under the NW, GPL and GF scenarios and moderate increases for the LS scenario.

[Table 5 about here]

Table 5: Total (million £) and per capita (£) value of predicted annual visits in the baseline period and changes in total and per capita value of predicted annual visit under the various scenarios

[24] Note that the predicted visit numbers for these unsurveyed sites assume that the site-specific random effects are zero.

[25] As far as the other NEA scenarios are concerned, we find that the Green Pleasant Land scenario (GPL) shows substantial gains in recreational values which are followed by those under the Go with the Flow (GF) scenario. In both of these scenarios, large increases are seen in and around urban areas, while more rural areas see smaller increases in the annual value of visits. The National Security (NS) scenario also shows a similar geographic pattern to GF and GPL, but with some areas, such as the Scottish Highlands and the Pennines, experiencing a reduction in the predicted annual value of visits. Larger predicted reductions are seen under the Local Stewardship (LS) scenarios, particularly in the area south and west of London and in the urban centres, although London itself shows a substantial increase in the value of visits.

6. Application 2: Case study- Recreational value of establishing new urban fringe woodland [26]

The methodology developed above can also be employed to provide economic analysis support for the targeting of recreation funding within the context of local planning. To illustrate this we consider the problem of allocating resources for the establishment of a single recreational site within a region. Of course from a national perspective, resources should first be allocated according to those regions which exhibit the largest excess of demand over current supply and indeed prior research has shown that the distribution of population (demand) set against the availability of substitutes (supply) provides a useful first pass indicator of were additional sites are most likely to best address problems of excess demand for recreation sites (Jones et al., 2009). Mourato et al., (reported in Bateman et al., 2011b) quantify the excess demand issue through a hedonic pricing analysis of the contribution of environmental quality to property prices across the entirety of England. This work identifies the town of Northampton in central England as having particularly low values suggesting that the enhancement of environmental attributes in this area is likely to provide highly efficient usage of available resources; an issue which is of particular interest given ongoing budget austerity across the nation.

Whether or not a prior analysis of national efficiency is undertaken, once a particular region has been selected for investment, the recreational value tool developed in this paper is designed to contribute towards the optimal location of a new site within a region. The use of an automated, GIS-based approach allows analysts to consider each feasible location across any area (irrespective of its size or the resolution of analysis required). An example of such an analysis is given in Bateman et al., (2011a) and so in the example we bypass this step and solely consider the identified optimal area which in this case is located on the northern edge of the town of Northampton. Here agricultural land is surrounded on three sides by urban areas of which the southern part is closest to the town centre. This illustrative analysis considers the conversion of 100 hectare of this farmland into recreational woodland. Of course a full analysis should consider all benefits and costs, including recreation, timber

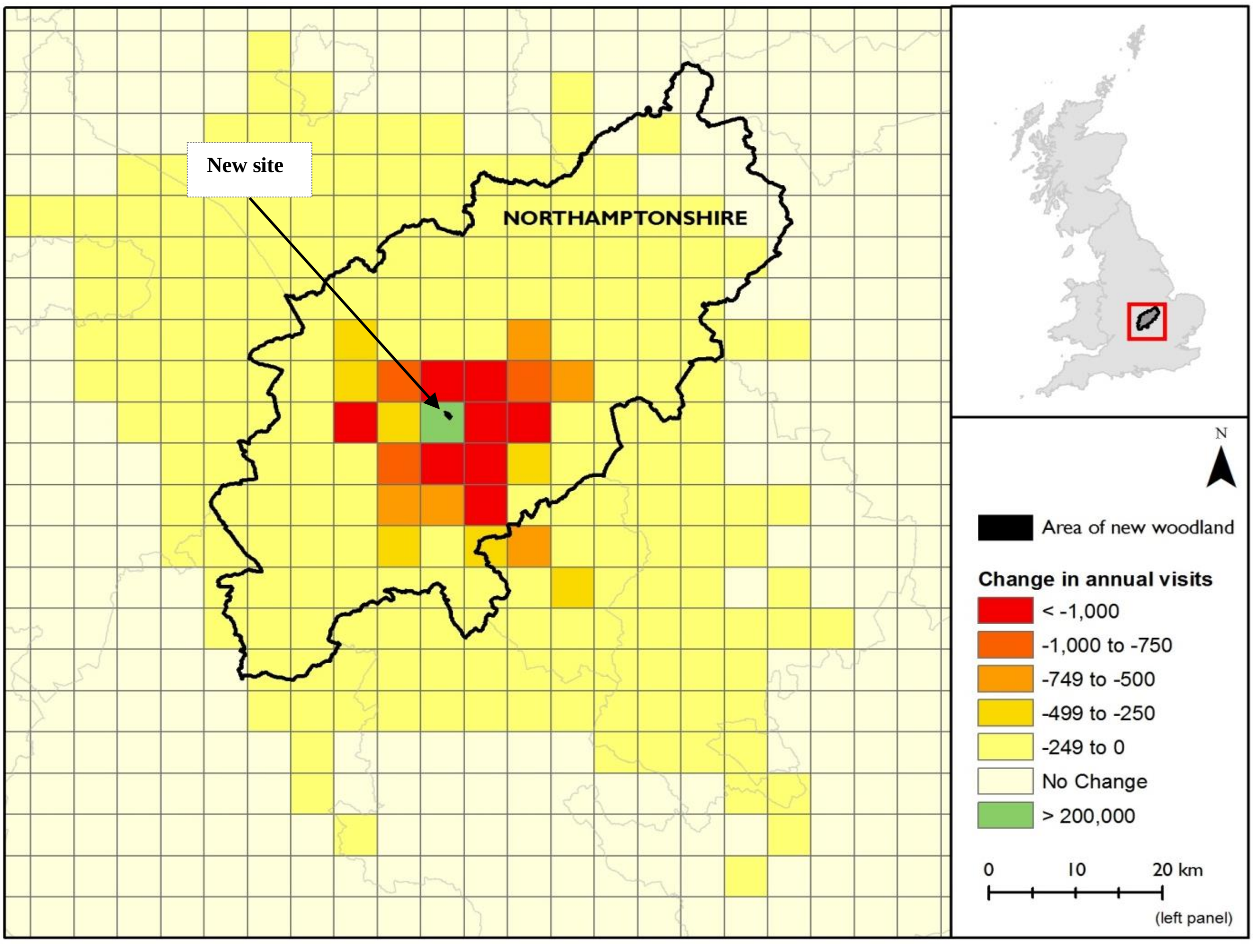
[26] This section is drawn from the eftec (2011) report. Note that visit numbers for the above case study is not based on the TGF model in this paper. Refer to the full eftec report for the relevant TGF model specification.

production, net flux of greenhouse gases, water quality impacts and the opportunity cost of foregone agriculture. Such wide ranging assessments are provided elsewhere (e.g. Bateman et al., 2003) and are omitted here in favour of a sole focus upon recreational benefit assessment via the approach developed in this paper.

The change in visitor numbers generated by the creation of the new woodland is assessed using the TGF model as described above to yield the predictions mapped in Figure 6. This shows both the substantial increase in visits at the new site and the expected reduction in visits to surrounding sites, an effect which decays with increasing distance.[27] The total increase in the number of predicted visits to the new woodland is approximately 215,000 per annum for which our MA model predicts an average value of just over £6.00 per visitor per trip, yielding a value of roughly £1.32 million each year. However, the new site draws nearly 32,000 visits away from other local sites, most of which are a mix of farmland, floodplain and grasslands for which we estimate average trip value of approximately £5.30 implying a transfer of about £165,000 each year. Adjusting for this transfer value suggests that the new site generates a net increase in recreational value of approximately £1.15 million per annum.

[27] Note that we have held the substitute density variables for the 151 LSOAs that intersect the 5 km × 5 km cell which contains the new woodland constant at their baseline levels. This assumption is made to ensure that the new site does not act as a substitute for itself.

Figure 6: Spatial distribution of the estimated change in annual visits to a new woodland.



7. Conclusion

The intended contribution of our paper is to provide an interdisciplinary method for national and local recreation planning which is compatible with wider environmental economic decision-making. We consider two applications of our methodology. *First*, we apply our methodology in a national policy context to assess the impacts of future land use changes envisaged under the various UK National Ecosystem Assessment scenarios. The spatial- and ecosystem-sensitive predictions of recreational visit numbers and their values generated by our linked TGF-MA framework provide a comprehensive assessment of the spatial diversity of current recreation values and future recreation values under various plausible scenarios envisaged for Great Britain. *Second*, we apply our methodology in a local policy context to determine the optimum location of a recreational woodland site within a specified region in England. The results obtained by applying the linked TGF-MA modelling framework to the estimation of visit numbers and associated values under both the prior and post-conversion situation serve as a useful input for conducting a cost-benefit analysis for the investment project. Hence both of these examples illustrate the versatility and applicability of our methodology for environmental policy and decision-making at any desired spatial unit and across mixed habitats. While this methodology is subject to certain shortcomings (for example, the modelling underpinning this analysis is not theoretically derived, rather it is based on a statistical analysis), nevertheless, it offers a new and spatially sensitive tool for modelling open-access recreation demand. Under our present methodology, the selection of the optimal location of a site proceeds through a process of analytical iteration. However, our future research agenda is directed towards automating this approach and allowing for error in the analysis. Similarly, at present our methodology relies upon a meta-analysis of prior studies to generate per visit values. While these are sensitive to the characteristics of visit sites, future research might utilise revealed preference datasets to examine the variation in trip values estimated through behavioural observation. The methodology is also extremely suitable for application within scenario or policy analyses and this is a major thrust of our ongoing research.

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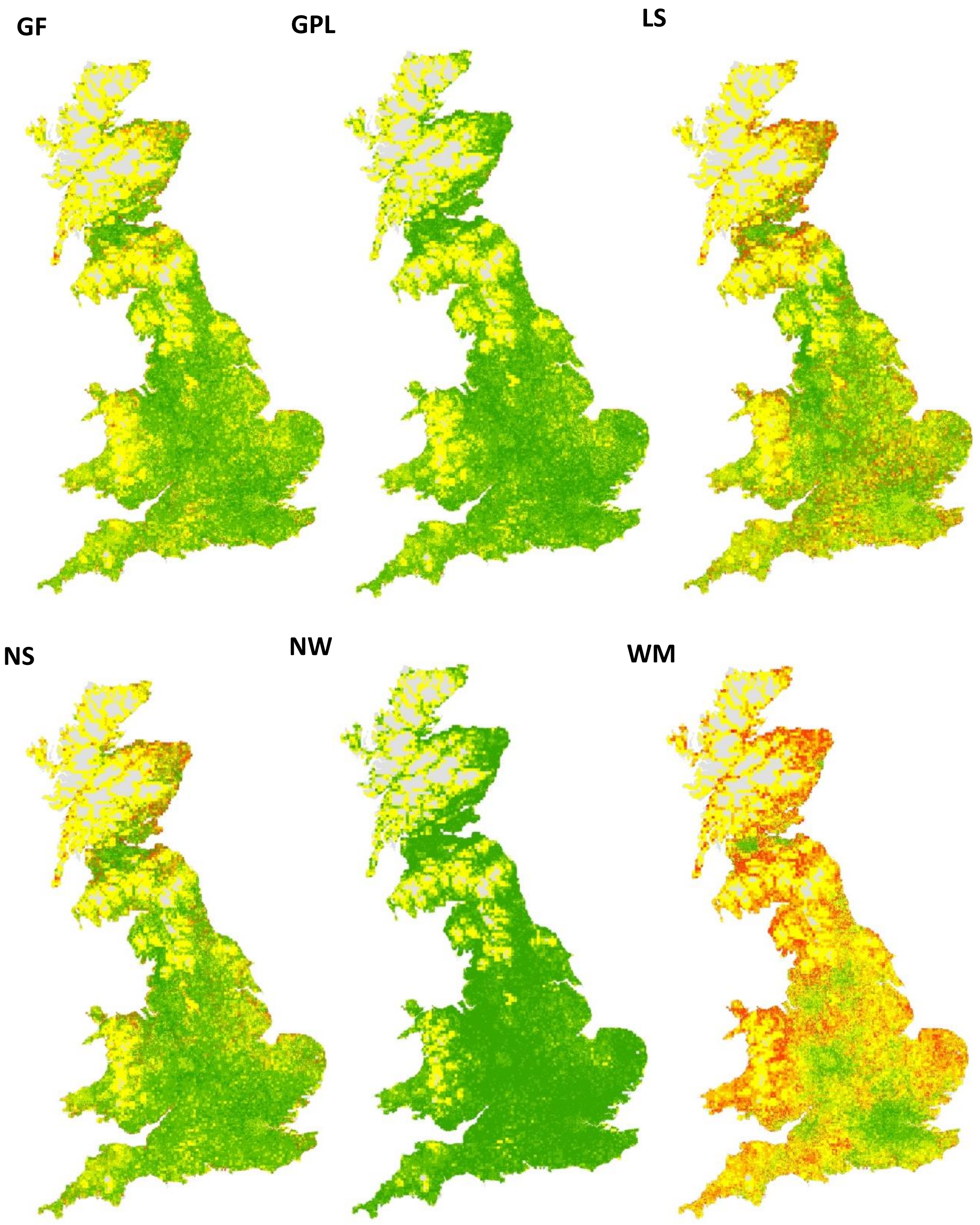
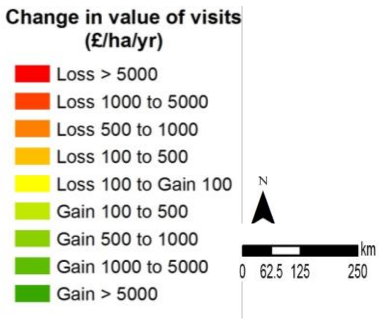
Figure 4: Changes in recreational values between the baseline year 2010 and the six high emissions scenarios (£/ha/year)





Note: Scenarios are defined as follows:

GF	= Go with the Flow
GPL	= Green and Pleasant Land
LS	= Local Stewardship
NS	= National Security
NW	= Nature @ Work
WM	= World Markets

Table 5: Total (million £) and per capita (£) value of predicted annual visits in the baseline period and changes in total and per capita value of predicted annual visit under the various high emissions scenarios

Region	Baseline (million £)	GF (million £)	GPL (million £)	LS (million £)	NS (million £)	NW (million £)	WM (million £)
England	19800	24200	46800	14600	25100	173000	532
Scotland	5970	3560	12300	564	3110	35600	-1950
Wales	1810	1190	2650	532	1650	8770	-808
GB	27600	29000	61700	15700	29800	218000	-2230
GB population (millions)	55.4	62.8	65.6	74.5	67.5	62.0	72.4
GB per capita values (£ p.a.)	498	461	940	210	441	3516	-31