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Economic Assessment of the Recreational Value of Ecosystems: Methodological Development and National and Local Application

Antara Sen · Amii R. Harwood · Ian J. Bateman · Paul Munday · Andrew Crowe · Luke Brander · Jibonayan Raychaudhuri · Andrew A. Lovett · Jo Foden · Allan Provins

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Abstract We present a novel methodology for spatially sensitive prediction of outdoor recreation visits and values for different ecosystems. Data on outset and destination characteristics and locations are combined with survey information from over 40,000 households to yield a

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A. Sen (✉) · A. R. Harwood · I. J. Bateman · P. Munday · A. A. Lovett
Centre for Social and Economic Research on the Global Environment (CSERGE),
School of Environmental Sciences, University of East Anglia (UEA),
Norwich Research Park, Norwich NR4 7TJ, UK
e-mail: a.sen@uea.ac.uk

A. Crowe
The Food and Environment Research Agency,
Sand Hutton, York, UK

L. Brander
Division of Environment, The Hong Kong University of Science and Technology,
Kowloon, Hong Kong

L. Brander
Institute for Environmental Studies, VU University, Amsterdam, The Netherlands

J. Raychaudhuri
School of Economics, University of East Anglia, Norwich, UK

J. Foden
Environment and Ecosystems, Centre for Environment, Fisheries and Aquaculture Science (Cefas),
Lowestoft, Suffolk, UK

A. Provins
Economics for the Environment Consultancy (Eftec), London, UK

trip generation function (TGF) predicting visit numbers. A new meta-analysis (MA) of relevant literature is used to predict site specific per-visit values. Combining the TGF and MA models permits spatially explicit estimation of visit numbers and values under present and potential future land use. Applications to the various land use scenarios of the UK National Ecosystem Assessment, as well as to a single site, are presented.

Keywords Recreation · Recreational value · Ecosystem services · UK National Ecosystem Assessment · Meta-analysis · Spatially sensitive

1 Introduction and Methodological Overview

Outdoor recreation is one of the major leisure activities of the UK population. A recent survey estimates that 2,858 million outdoor recreational visits were made in England during 2010, entailing direct expenditure of over £20 billion (Natural England 2010). The spatial distribution of these visits is highly non-random, a reflection of the distribution of population, location of recreational sites, availability of substitutes (and complements) and travel time and other costs involved in visiting the sites. Thus, dependent on outset and site characteristics, every destination will attract different numbers of visitors; moreover, the value derived from such visits will also vary according to site attributes. In order to reflect the complexity of spatial- and ecosystem-sensitive recreational behaviour, we develop and implement a two-step statistically driven model of open-access recreational visits and their associated values in Great Britain. We generate valuations compatible with other economic assessments in the UK National Ecosystem Assessment (2011).[1] The intended wider contribution of our paper is to present a general tool for recreation planning and environmental decision-making, providing economic values which are consistent for making comparisons with the costs of recreation provision (including opportunity costs).

In the first step of our analysis, we develop a trip generation function (TGF) which models a dependent variable defined as the expected number of visits from a given outset area to a given site. This is modelled as a function of several independent variables including the characteristics of the outset location (including socioeconomic and demographic characteristics of the population and the availability of potential substitute sites), the characteristics of the destination site (habitat type) and the travel time (and hence cost) of the journey. We estimate the TGF using a novel, large sample, annual in-house survey which provides information on the outset and destination locations. This data is combined with information on spatially referenced variables obtained from multiple sources (including digital road networks, Census data, etc.) and generated or manipulated in a Geographic Information System (GIS). The estimated model is used to predict the number of visits for the current land cover of Great Britain. The TGF is then applied in turn to each of the UK National Ecosystem Assessment (NEA) Scenarios (Haines-Young et al. 2011) to assess the economic impact of potential future land cover changes.

In the second step of our analysis, we develop a trip valuation meta-analysis (MA) model to determine the recreational use value of predicted visits. The MA model is estimated from the study of approximately 300 previous assessments of the value of an outdoor recreational visit. The MA model examines the determinants of these recreational visit values which include the

[1] The analyses and results reported in this paper are a subsequent development of the more preliminary analyses summarised in UK NEA (2011). Due to data limitations, we do not consider Northern Ireland in this study.

influence of the dominant ecosystem type at each of the visited sites (ecosystems are classified by the NEA habitats and are defined on the basis of land cover), study characteristics (i.e., valuation method and valuation unit) and the geographical location of the visited site. This step of our analysis allows us to generate an ecosystem-specific value for each visit.

Bringing these two steps together allows us to estimate, for both the current situation (baseline) and any future land use (be it the various national-level scenarios considered under the UK NEA or a more simple prospect such as the establishment of a single recreational site): (i) the number of visits to each site (adjusted for location, ecosystem type, travel time, population distribution and characteristics and the availability of substitutes and complements); (ii) the value per visit for that site (adjusted for the ecosystem type) and, by drawing these together for all sites; (iii) the spatially- and ecosystem-sensitive annual value of visits across Great Britain. This two step TGF–MA framework can be used by a decision-maker to estimate the recreational benefits (or costs) of transitioning to a future land cover which can then be compared with the direct and opportunity costs of affecting that transition. Further, the highly disaggregated nature of the recreational visit numbers and values allows the decision-maker to consider any desired resolution, for example from predictions at a 1 km $\times$ 1 km site-level to aggregations at a national-level and all intermediate scales. Figure 1 provides a schematic overview of our two step methodology.

Many previous studies have analysed the demand for recreational sites (e.g. Creel and Loomis 1990; Englin and Shonkwiler 1995; Gurmu and Trivedi 1996; Ovaskainen et al. 2001; Curtis 2002; Martínez-Espiñeira and Amoako-Tuffour 2008; Jones et al. 2010). All of these studies estimate recreational demand and benefits for single habitat recreational sites using on-site survey data. One contribution of our paper is the development of a flexible, interdisciplinary and readily transferable methodological framework relying upon off-site household survey data which can be applied to estimate recreational demand and values for any area, spatial unit and habitat mix. We use data from the nationally representative Monitor of Engagement with the Natural Environment (MENE) survey for modelling recreational demand. MENE is a major new household survey undertaken by Natural England, Defra and the UK Forestry Commission to provide baseline and trend information on how people use the natural environment in England.

The remainder of this paper is organised as follows. Section 2 describes the data and the empirical methodology for building the TGF. Section 3 provides a comparable discussion for the MA model and then combines the results from the TGF and the MA models to generate the spatially- and ecosystem-sensitive annual value of visits for the baseline year 2010. Section 4 applies this methodology to generate valuations for the UK NEA national-level scenario analyses. As a contrast, Section 5 presents a case study for determining the recreational benefits of converting an existing urban fringe farmland to an open-access recreational woodland site. Section 6 concludes with an evaluation of the potential utility of this research.

2 Visit Numbers: Trip Generation Function

This section describes the specification of the TGF, discusses data sources and presents estimation results.[2]

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

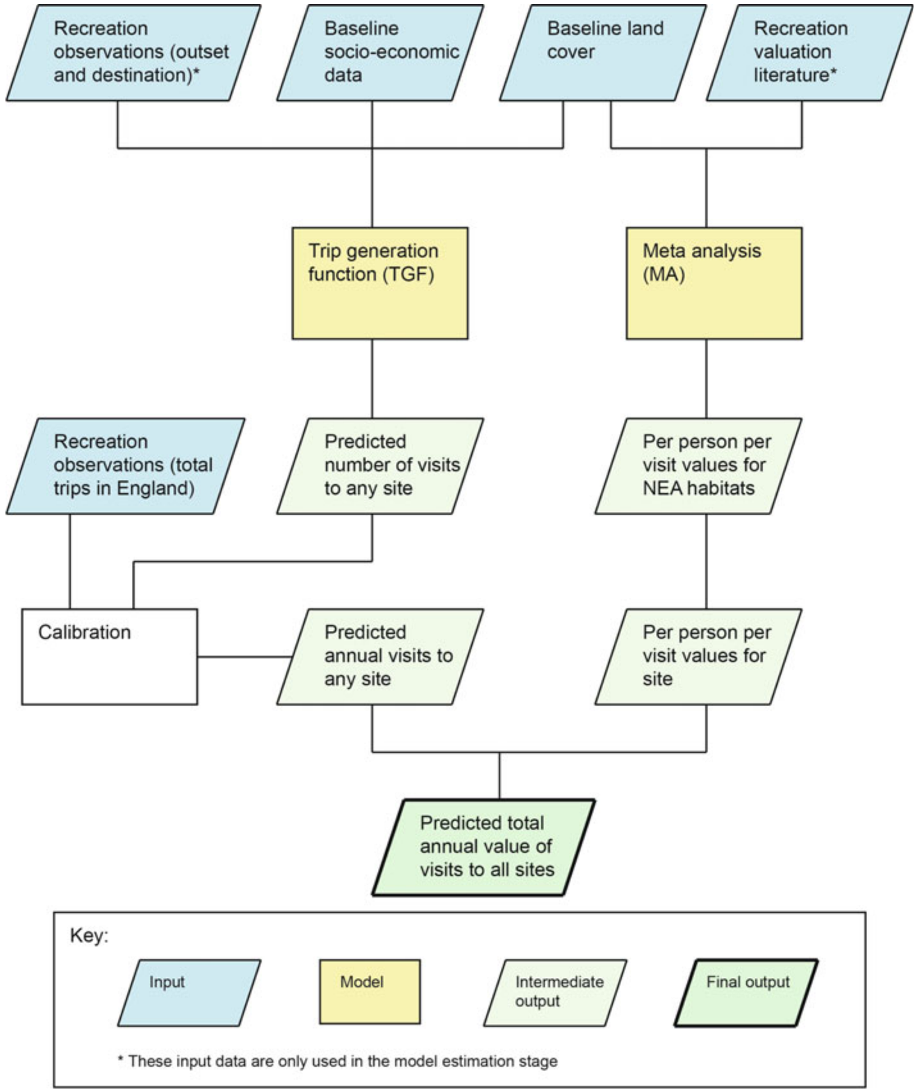

Fig. 1 Schematic representation of the linked TGF–MA methodology

2.1 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 the population in the outset area; the availability and accessibility of potential substitute or complement sites near to the outset locations and the land cover characteristics (ecosystem) of the destination site itself. Therefore, we assume that the total number of visits to any given destination site is influenced by a variety of factors operating at both the outset and the destination. We control for some of these observed factors (e.g. ecosystem type) by including them explicitly in our regression model. However, there may be certain unobserved site-specific factors that influence visit numbers to any site (e.g.

the presence of unknown site facilities may exert a significant impact on visit numbers to woodland sites, see Jones et al. 2010). 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 standard errors and inefficient parameter estimates. Thus, given the hierarchical nature of our data, with a dependent variable of discrete visit numbers clustered within destination sites, we estimate the TGF using a Poisson regression model with random intercepts. We assume that the site-specific error terms follow a multivariate normal distribution. The model is estimated using maximum likelihood techniques in which the marginal likelihood is approximated by a numerical integration approach; the adaptive Gaussian quadrature method (Rabe-Hesketh and Skrondal 2008, pp. 381).

The estimating equation for the TGF is specified as follows:

$$ln(\mu_{ij}) = \gamma_0 + \gamma_1 W_{ij} + \gamma_2 X_{ij} + u_i$$

where i denotes a series of independent sites with site i consisting of j visits. The expected number of visits to a specified site i is denoted by μ_{ij}. The fixed part of the model consists of W_{ij} (which includes travel time to a site and variables describing site characteristics, namely, the percentage of various land uses at site i) and X_{ij} (variables describing outset area characteristics, namely, substitute availability measured as the percentage of substitute habitat coverage within a set radius of the outset and outset area socio-economic and demographic variables measured as percentage of the population that is retired, percentage of the population from non-white ethnic groups, median household income and total population of the outset area). We allow for diminishing marginal utility between the number of visits to any site and the size of the recreational ecosystems (within that site and surrounding the outset area) by specifying logarithmic transformations of both the substitute availability and the site habitat variables in our model. Given that the dependent variable in our model is the logarithm of the expected number of visits to a site, the coefficients of both the substitute availability and the site habitat variables can be interpreted as elasticities. The random part of the model consists of u_i (the site-specific random intercept terms which capture the unobserved heterogeneity between different sites) which are assumed to be normally distributed with mean zero and variance σ_u^2.

2.2 Data

Observations of outdoor recreational visits were taken from the MENE 2009–2010 survey (Natural England 2010). This takes a representative sample of English adult residents, interviewing one individual in a selected household for diary records of their recreational trips in the week running up to the interview date. One of these trips is then selected at random and the geographic location of the destination is recorded. We use data for the full survey period from March 2009 to February 2010 inclusive so as to avoid seasonality bias. This data amounted to some 48,514 interviews of which 20,374 undertook a recreational trip during the diary week encompassing visits to more than 15,000 unique locations across England.

Although the MENE dataset is unsurpassed in its combined scale and spatial detail, we omit some visit records due to incomplete location information. Further, to enhance the subsequent transferability of findings, we omit a substantial tranche of visit records for respondents who did not start trips from their home address. To remove a potential source of bias in the remaining dataset we carried out an analysis of potential ‘boundary effects’. MENE records trips originating from English households taken to English destinations only. Visits taken to recreational sites located beyond the borders of England are either not recorded or deleted from the final MENE database during post-processing. Such a sampling scheme is likely to artificially depress visit 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 defined a buffer zone extending approximately 13 km into England from these borders. We omit all destination sites located in this buffer zone, which corresponds to rejecting around 251 visit records. Finally, to focus on the bulk of day trips we omit respondents who made unusually long one-way trips to destination sites (10 % of respondents travelled greater than 60 min and were therefore omitted). In sum, these omissions reduce the total size of our visit dataset to around 40,907 observations.

Records of zero visits are also important for valid model building. To account for this, we record two categories of zero visits in our estimation dataset: (i) non-visits reported by a respondent in the sample week to the observed MENE sites and (ii) non-visits to all other 1 km $\times$ 1 km grid cells that are potential destination sites but are not visited by any MENE respondent. The estimation dataset for the TGF therefore includes positive visit records as well as zero visit records resulting from all possible combinations of outset (observed in MENE) and destination sites across the entire country. This results in a final estimation dataset of over four million observations for the TGF. For our analysis, respondents were grouped by outset area and destinations are referenced to 1 km $\times$ 1 km Ordnance Survey (OS) grid cells or sites (defined subsequently).

The MENE survey records highly accurate visit outset locations (the full postcode of each visiting household). However, in order to enhance the transferability of our model, we first convert the household postcodes to OS grid reference locations, precise to 1 m resolution for the first house in the postcode[3] and from these grid locations link the postcodes to their corresponding UK Census Lower Super Output Area (LSOA).[4] Allocating household locations to their corresponding LSOA enables linkage to corresponding socio-economic and demographic variables.[5] LSOA-level measures of median gross annual household income are taken from the 2008 Experian Mosaic Public Sector dataset.[6] LSOA boundaries are drawn in part to ensure homogeneity of area socio-economic and demographic characteristics. Therefore the approximation of household characteristics by LSOA-level data is both reasonable and greatly enhances the transferability of functions across all areas of England. Transferability is also enhanced through our treatment of the destination site locations. These were assigned to the standard OS 1 km $\times$ 1 km grid cell in which they are located, yielding a more manageable dataset in which data are grouped from over 15,000 destinations to 7,575 unique grid cells or sites. Travel times from population weighted centroids of all LSOAs to destination sites were calculated using the OS Meridian road network.[7] This is a GIS dataset consisting of motorways, A-roads, B-roads and minor roads. Data from Jones et al. (2010) were employed to make allowance for varying average road speeds and urban versus rural congestion.

The environmental characteristics of destination sites are defined by linking their grid cell locations to habitat proportions derived from the 25 m resolution Land Cover Map 2000 data

[3] We use GeoConvert at MIMAS which queries the 2010 UK National Statistics Postcode Directory © Crown Copyright 2006. Source: National Statistics/Ordnance Survey. Extracts are Crown Copyright and may only be reproduced by permission.

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

[5] Linkage achieved using Casweb (http://casweb.mimas.ac.uk). Census output is Crown copyright and is reproduced with the permission of the Controller of HMSO and the Queen’s Printer for Scotland.

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

[7] © Crown Copyright/database right 2011. An Ordnance Survey/EDINA supplied service. Calculation of travel time is via cost weighted distance functions and details are provided in Sen et al. (2012).

(Fuller et al. 2002). These were grouped to conform to the NEA ecosystem categories of: (i) broadleaved woodland; (ii) coniferous woodland; (iii) coast (littoral and supra littoral); (iv) enclosed farmland; (v) freshwater body; (vi) mountain, moorland and heathlands; (vii) estuary (sub littoral); (viii) semi-natural grassland; and (ix) urban and suburban.

The number of visits to a specific site from any given outset location will be lower when that outset area is well served by other local substitute sites (Jones et al. 2010; Bateman et al. 2003). To incorporate this within our TGF analysis a series of GIS derived variables were generated. These assessed the availability of substitute resources by defining circular zones around each LSOA and calculating the percentage of each ecosystem type in that area.[8] The radii of the circles defined around each LSOA were varied to allow subsequent empirical investigation of the optimal size of the surrounding area which captures the substitution effect.[9] Using a selection criterion to compare models employing differently generated substitution variables indicated that a measure constructed using a 10 km radius around each LSOA population weighted centroid provided the best fit to the MENE visitation data. Therefore, this measure of substitute availability is included as an explanatory variable in the TGF.

2.3 Results

Table 1 reports the best-fitting TGF.[10] As expected, a negative relation with travel time is one of most significant predictor of visits. However, numerous other relationships are observed. The impact of land use (percentage of a given ecosystem habitat within a 1 km $\times$ 1 km grid square) is clearly important in determining visits to a potential destination. Coastal and freshwater sites exert the greatest attraction, followed by mountain and woodland sites and with urban locations having a negative impact upon visits (although of course the latter will often have the lowest travel times which boosts their attractiveness). Similarly substitute availability around a potential outset location also influences visit numbers. As expected these are negative relationships such that, for example, locations with high availability of attractive freshwater resources at that location tend to yield relatively lower counts of visits to other potential destinations. Interestingly urban locations also yield relatively lower counts suggesting that the residents of such locations might be less willing to travel to other destinations than those in rural locations. Relationships with socio-economic and demographic factors are as expected with wealthier and retired groups taking more visits and, as noted elsewhere

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

[9] Radii of 1, 2.5, 5 and 10 km are used for defining substitution availability measures around outset locations. The 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 indicates that a measure of the coverage of each land use/habitat type within a 10 km radius of the LSOA population weighted centroids provides the best fit to the MENE visitation data.

[10] Various functional forms were tested 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 in Table 1 provides the best fit to our data. Details regarding the alternative model specifications tested are presented in Sen et al. (2012). The site-level variance component is parameterised as the log of the variance [labelled in (σ_u^2) in the table]. The standard deviation is also included in the table and is labelled as σ_u. When σ_u is zero, the site-level variance component is no longer important and the panel Poisson estimator is similar to the pooled Poisson estimator. The likelihood-ratio test (included at the bottom of the table) formally compares the pooled Poisson estimator with the panel Poisson estimator. We find that σ_u is significantly greater than zero, so that a panel Poisson estimator is preferred.

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)
Land use variables measured at destination		
Log (%Coast at site)	0.158***	(5.950)
Log(%Freshwater at site)	0.0716***	(3.859)
Log (%Other marine at site)	0.0693*	(2.392)
Log(%Mountains at site)	0.0421*	(2.394)
Log (%Woodland at site)	0.0414***	(3.905)
Log (%Grasslands at site)	0.00233	(0.207)
Log (%Urban at site)	−0.224***	(−20.86)
Substitute availability variables measured at outset		
Log (%Coast substitute availability)	−0.0215**	(−2.632)
Log(%Freshwater substitute availability)	−0.0637***	(−6.181)
Log (%Other marine substitute availability)	−0.0325***	(−5.261)
Log (%Mountain substitute availability)	−0.000589	(−0.058)
Log (%Woodland substitute availability)	−0.0622**	(−2.900)
Log (%Grasslands substitute availability)	0.0276	(0.968)
Log (%Urban substitute availability)	−0.441***	(−26.82)
Demographic variables measured at outset		
Log(Median Household Income) (in pounds)	0.430***	(13.19)
% Retired	0.00527**	(2.735)
% Non-white ethnicity	−0.00846***	(−8.623)
Total population of outset area (no. of people)	0.000290***	(6.963)
Constant	−4.458***	(−12.78)
$\ln(\sigma_u^2)$	−0.873***	(−22.29)
σ_u	0.646***	(52.606)
Observations	4,034,290	

Likelihood-ratio test of $\sigma_u = 0$: chibar2(01) = 2076.91Pr $\geq$ chibar2 = 0.000
Dependent variable is logarithm of the expected count of visits from an LSOA to a site. Enclosed farmland is set as the base case for both the 'substitute availability' and the 'site characteristic' variables. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(Bateman et al. 2003; Centre Henley 2005), non-white groups revealing lower engagement in outdoor recreation pursuits. Finally the positive relation with outset area population, while hardly surprising, should be treated with caution. LSOA are defined such that population does not vary greatly between these areas.

2.4 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 to decision-makers for examining the consequences for recreational visits of future land cover changes. To move towards the establishment of such a tool, we first use our estimated TGF to predict visit numbers to all

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

	Great Britain	England	Scotland	Wales
Mean no. of visits	19,475	22,338	14,911	13,394
Median no. of visits	11,528	15,236	3,480	7,288
Total no. of visits (000's)	3,930,000	2,860,000	813,000	259,000

recreational sites in Great Britain under its current land coverage (baseline) and then predict the consequences of alternative land cover configurations envisaged for Great Britain in 2060 on visit numbers (NEA Scenarios, as described in Section 4 below).

In order to determine our baseline we effectively need to use our TGF to predict visits from all outset locations to all destination locations and gross up from our one week diary of our sample to an annual measure for the population. Information for the latter calibration exercise is taken from Natural England (2010) which estimates a total for England of some 2,857 million visits over the 12 month survey period. Table 2 presents post-calibration descriptive statistics for the annual visits to Great Britain and its constituent countries as predicted from our TGF.

3 Visit Valuation: Meta-analysis and Generation of Spatial- and Ecosystem-Sensitive Annual Values

Existing literature on the valuation of open-access recreation activities is substantial, encompassing a wide variety of ecosystems with a large number of estimates to justify the investigation of a MA of prior studies. An initial review of several hundred studies identified a subset of 297 value estimates within 98 relevant studies[11] for which links to ecosystem type and various other relevant variables were clearly defined. Value estimates were made comparable using purchasing power parity indices described in the Penn World Table (Heston et al. 2009) and adjusted to a common price base (2010) using the gross domestic product deflator for the UK.[12]

Informed by prior MA studies (Bateman and Jones 2003; Brander et al. 2003; Lindjhem 2007), the general form of our model was specified as follows:

$$\begin{aligned} y_i = \beta_0 + \beta_1\,(\text{habitat type})_i + \beta_2\,(\text{study chars})_i + \beta_3\,(\text{valuation unit})_i \\ + \beta_4\,(\text{valuation method})_i + \beta_5\,(\text{study country})_i + \varepsilon_i \end{aligned}$$

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 type at the study site; study chars refers to a set of variables describing characteristics of the valuation study such as sample size; the variable valuation unit controls for changes in the category and unit used for the 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.

[11] References for the full set of studies used within the MA are given in Sen et al. (2012).

[12] The data on purchasing power parity indices were obtained from the Penn World Table, Version 6.3 available at http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.phpt and data on the gross domestic product deflator were obtained from the HM-Treasury web page at http://www.hm-treasury.gov.uk/data_gdp_fig.htm.

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

Variable	Variable definition	Coefficient	*t* stat
Good characteristics			
Coastal and marine	1 = recreational site valued is coastal or marine; 0 = Grasslands	0.944**	(1.67)
Freshwater and floodplains	1 = recreational site valued is freshwater and floodplain; 0 = Grasslands	0.170	(0.32)
Wetlands	1 = recreational site is wetlands; 0 = Grasslands	0.895**	(1.64)
Mountains and heathlands	1 = recreational site valued is mountain or heath; 0 = Grasslands[a]	1.184	(0.90)
Woodlands and forests	1 = recreational site is woodlands and urban forests; 0 = Grasslands	0.775*	(1.42)
Urban fringe	1 = recreational site is greenbelt & urban fringe farmlands; 0 = Grasslands	1.248***	(2.29)
Study characteristics			
Survey year	Discrete variable: 1 = survey year is 1975…29 = survey year is 2008	0.0437***	(2.21)
Sample size	Sample size of study	−0.00547****	(−3.13)
Valuation unit			
Per household per year	1 = unit is per household per year; 0 = per person per trip	3.043*****	(9.21)
Per person per year	1 = unit is per person per year; 0 = per person per trip	2.164*****	(6.22)
Other valuation unit	1 = unit is per household/ per person per day/ per month; 0 = per person per trip	2.434*****	(6.85)
Use value only	1 = use value study; 0 = study of combined use and non-use	−0.0373	(−0.14)
Valuation method			
RPM and mixed	1 = revealed preference or mixed methods; 0 stated preference methods	0.685****	(2.89)
Study country characteristics			
Non-UK countries	1 = study conducted overseas; 0 otherwise (UK)	0.703****	(2.80)
Constant		−0.420	(−0.71)

Sample size = 297 observations obtained from 98 studies
R^2 (adj.) value is 0.72. The dependent variable is the logarithm of recreational value/person/trip (£; 2010 prices)
* $p < 0.20$, ** $p < 0.10$, *** $p < 0.05$, **** $p < 0.01$, ***** $p < 0.001$
[a] Grasslands include urban recreation parks, urban greenways, semi-natural grasslands and non-fringe farmland

3.1 Results

Following investigation of an appropriate functional form (detailed in Sen et al. 2012) our MA model is specified as a log-linear regression model. The model was estimated using OLS with cluster-robust standard errors, clustered at the study level. This estimator is robust to model misspecification and correlation of multiple value estimates within any particular study (cluster). The regression results are described in Table 3.

In order to obtain habitat-specific recreational values for use in our analysis we need to choose values for the non-focal variables in our MA model. The variables Use value only and RPM and mixed were set as if values were derived from stated preference studies of

Table 4 Estimated annual value of British recreational visits (£/yr) for the baseline year 2010

	Great Britain	England	Scotland	Wales
Mean value of visits	33,366	35,540	30,855	26,065
Median value of visits	18,761	22,750	8,700	13,027
Total value of visits (000's)	6,732,000	4,546,000	1,682,000	503,900

While urban greenspace is included in our analysis, buildings, roads and similar developed land is given a recreational value of zero. Islands and remote areas with travel times greater than 60 min are also excluded. Farmlands away from the urban fringe are assigned the grassland value in our analysis

recreational use value as these provided conservative lower bound values. The sample size variable was set equal to its mean value while the survey year variable was set to the most recent year in our dataset to represent state-of-the-art methodological developments in study design. Resulting value estimates indicated that per person per trip value was highest for greenbelt and urban fringe farmlands (£5.36), followed by mountains, moors and heathlands (£5.03), marine and coastal (£3.96), woodlands and forests (£3.34), freshwater and floodplains (£1.82) with grasslands delivering the lowest values (£1.54).

The habitat-specific recreational values provided by the MA allow us to estimate ecosystem sensitive average per person per trip values for each 1 × 1 km grid square across Britain. This is achieved by multiplying the proportional coverage of the different habitats in each grid square by their corresponding recreational values and summing for all habitats. This per person value is then multiplied by the predicted number of trips to each 1 × 1 km grid square as estimated by the calibrated outputs of our TGF. The product of these two estimates gives the estimated annual recreational value of each grid square. Summing across all grids gives our predicted annual value of recreational visits in Great Britain for the baseline year of 2010 (i.e. under the current land use) as detailed in Table 4.

4 Application 1: Predicting Recreational Value Under Alternative Future Scenarios

While the prediction of the current level and distribution of recreational values is interesting, the major use of the methodology is as a planning tool; to examine the consequences of implementing alternative policies. We demonstrate this facility by applying our TGF–MA methodology to the six[13] UK-NEA future scenarios (Haines-Young et al. 2011). These scenarios envision different alternative futures for the UK by 2060 arising from changes in land use and in the socioeconomic and demographic characteristics of the UK population. Table 5 summarises the various changes in these variables envisioned under each scenario (full details presented in ibid. and Bateman et al. 2013). This indicates that most scenarios suggest increases in population and income, both being factors which will boost the value of outdoor recreation. Similarly, most scenarios postulate changes in land use which are likely to further increase these values, the one exception being the WM scenario which reduces valuable habitats such as heathland and increases the built environment. Some of the scenarios, most notably NW, appear over optimistic in terms of increases to all the factors conducive to high recreational values.

The various changes envisioned under the UK-NEA scenarios were fed through the TGF–MA analysis to yield corresponding estimates of response in recreational values. The spatially explicit basis of the methodology provides outputs for each 1 × 1 km grid square across Britain.

[13] Each scenario was further varied according to whether a low or high greenhouse gas emission future was envisioned. For purposes of brevity, in the present paper we focus only on the high emissions variant of each scenario, with low emission variants presented in Bateman et al. (2011a).

Table 5 Summary of trends in the UK-NEA scenarios (abstracted from Haines-Young et al. 2011)

Variable	Baseline (2010)	Scenario[a]					
		WM	NW	GF	GPL	LS	NS
% urban	6.7	↑↑	≈	↑	≈	≈	≈
% heathlands	13.8	↓↓	↑↑	↑	↑	≈	↓↓
% grasslands	15.9	↓↓	↑↑	↑	↑↑	↑↑	↓↓
% conifer	5.3	≈	↑↑	↓	↓	↓	↑↑
% broadleaf	6.3	≈	↑↑	↑	↑↑	≈	↑
% farmland	43.5	≈	↓↓	↓	↓	↓	≈
% other	8.3	≈	≈	≈	≈	≈	≈
Δ population	–	↑↑	↑	↑↑	≈	≈	↑↑
Δ real income	–	↑↑	↑↑	↑	↑↑	≈	≈

Variables starting “%” refer to percentages of the total area of Great Britain
↑↑ = proportionally large increase from baseline
↑ = proportionally small increase from baseline
≈ = no substantial change from baseline
↓ = proportionally small decrease from baseline
↓↓ = proportionally large decrease from baseline
[a] Scenario names: WM, World Markets; NW, Nature at Work; GF, Go with the Flow; GPL, Green and Pleasant Land; LS, Local Stewardship; NS, National Security. Δ = change

Figure 2 maps the resulting spatial distribution of changes in recreational values between the baseline year 2010 and these scenarios while Table 6 sums these estimates at the national level and calculates the per capita equivalents.

The spatial trends depicted in Fig. 2 immediately illustrate one simple yet vital finding; gains are always largest near to population. This is hardly surprising given the importance of travel costs in determining visitation behaviour, yet it shows that, in determining spending on recreation, the most important criterion is location. The numeric results of Table 6 suggest that the potential for increases in recreational value is substantial (although we question the feasibility of certain changes envisioned, particularly with respect to scenario NW which includes scenario values for some of the underlying variables that fall substantially outside the range of our estimation dataset). However, both this table and Fig. 2 show that policies which prioritise conventional measures of income growth alongside major increases in population and urban building at the cost of the natural environment (i.e. the WM scenario) lead to substantial losses in recreational value, losses which can be avoided by protecting the environment. This contrasts the GF or GPL scenarios (as well as the rather optimistic NW scenario) where income and population increase but at a more modest pace and the natural environment is conserved and enhanced. However, note that these later scenarios all imply losses in market priced agricultural production. Bateman et al. (2013) considers the trade-off between these various values.

5 Application 2: Recreational Value of Establishing New Urban Fringe Woodland[14]

The two step methodology developed in this paper can be also used to provide economic analysis support for the targeting of recreation funding within the context of local planning.

[14] Further details in eftec (2011) with an earlier application given in Bateman et al. (2011a).

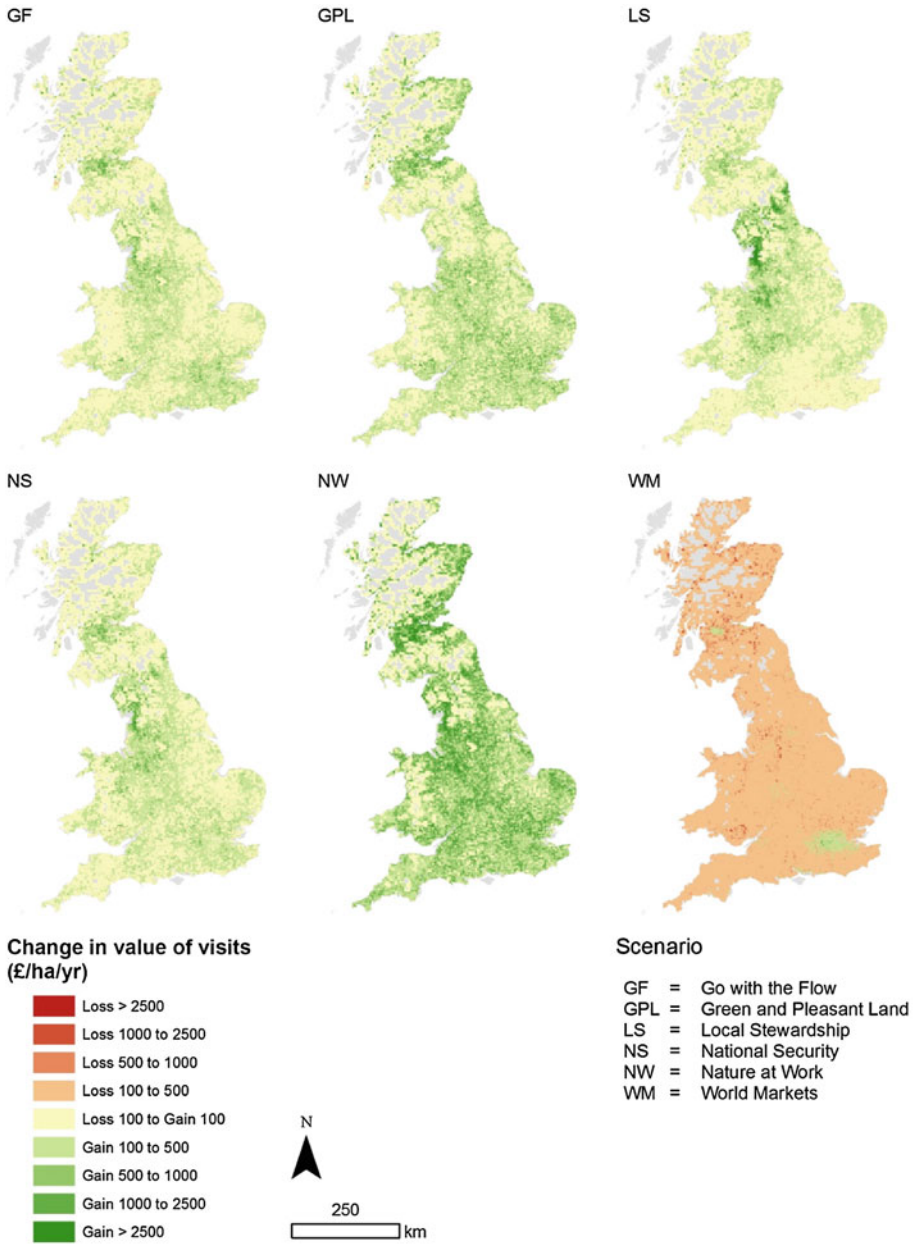

Fig. 2 Changes in recreational values between the baseline year 2010 and the six UK-NEA scenarios (£/ha/year)

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 to those regions which exhibit the largest excess of demand over current supply. Indeed prior research has shown that the distribution of population (demand)

Table 6 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

Region	Total baseline (million £)	Change GF (million £)	Change GPL (million £)	Change LS (million £)	Change NS (million £)	Change NW (million £)	Change WM (million £)
England	4,546	2,142	3,917	3,347	2,466	9,056	−1,024
Scotland	1,682	632	1,453	583	688	3,280	−856
Wales	504	179	340	289	291	1,014	−285
GB	6,732	2,953	5,710	4,219	3,445	13,350	−2,165
GB population (millions)	55.4	72.4	62.8	62.0	67.5	65.6	74.5
GB per capita values (£ p.a.)	121	13	77	55	30	185	−60

set against the availability of substitutes (supply) provides a useful first pass indicator of where additional sites are most likely to best address the problems of excess demand for recreation sites (Jones et al. 2010). 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 England. This work identifies the town of Northampton in central England as having particularly poor access to areas of environmental quality. Enhancement of environmental attributes in this area is therefore likely to represent a highly efficient use of available resources; an issue which is of particular interest given the ongoing budget austerity across the nation. Accordingly this area was selected for further study.

Whether or not a prior analysis of national efficiency is undertaken, once a particular region has been selected for investment, the recreational value tool that we develop 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). Within our case study area of the environs of Northampton, analysis identified a particularly suitable area for recreational development on the northern edge of the town where a finger of intensively farmed agricultural land protruded into the urban area, surrounded on three sides by residential buildings. Such an area obviously has high recreational potential given the high accessibility of a substantial population all facing very modest travel and time costs to access the area. For illustrative purposes we consider the conversion of 100 ha of this agricultural land into open-access woodland. While woodland generates multiple benefits (including timber production, net flux of greenhouse gases, water quality impacts, etc. and incurs opportunity costs of foregone agriculture) we only consider recreational benefits assessment in this paper.

The change in visitor numbers generated by the creation of the new woodland is assessed using the TGF to yield the predictions mapped in Fig. 3. This figure shows both the substantial increase in visits at the new site and the expected (but relatively minor) reduction in visits to surrounding sites, an effect which decays with increasing distance.[15] The increase in the number of predicted visits to the new woodland is approximately 215,000 per annum for which our MA model predicts an ecosystem-specific average value of £3.34 per visitor per trip, yielding a gain in recreation value of roughly £0.71 million p.a. However, the new site draws nearly 32,000 visits away from other local sites, most of which are a mix of urban

[15] Note that we hold the substitute coverage variables for the 151 LSOAs that intersect the 5 km × 5 km cell which contains the new woodland site constant at their baseline levels. This assumption is made to ensure that the new site does not act as a substitute for itself and this is crucial for local application of our methodology.

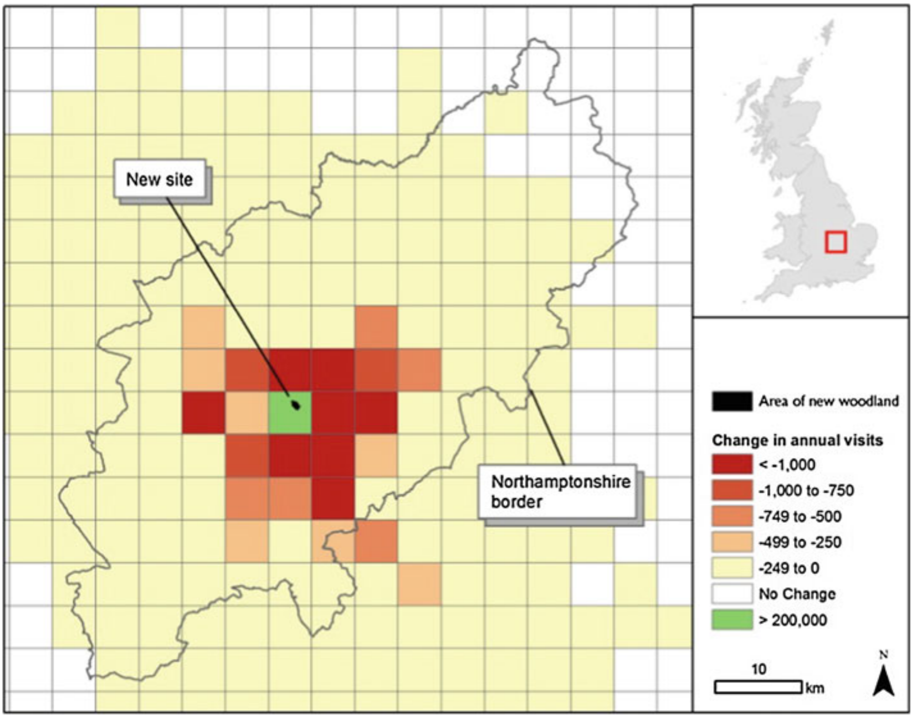

Fig. 3 Spatial distribution of the estimated change in annual visits to a new woodland

fringe farmland, floodplain and grasslands for which we estimate an average value of £2.91 per trip implying a transfer of about £93,000 each year. Adjusting for this transfer value suggests that the new site generates a net increase in recreational value of approximately £0.62 million per annum. This can then be set against the other benefits and costs generated by such an investment.

6 Conclusion

The intended contribution of our paper is to provide a method for national and local recreation planning which is compatible with wider environmental decision-making. This is achieved by developing a two stage methodology, the first part of which applies the spatial analytic power of a GIS to a major new national data source detailing both the outset and destination locations of trips. Findings reflect prior expectations regarding the importance of travel and time costs, site characteristics, substitute availability and socioeconomic and demographic factors in determining the pattern and level of recreational demand. Our second stage values predicted trips via the simple expedient of a meta-analysis of prior literature, emphasising the influence of the ecosystem characteristics of destination upon per visit values. The resultant outputs reflect the underlying economic relationships determining trips and conform well to expectations.

The flexibility of the methodology is demonstrated through applications at both national and local scale. These illustrate the suitability of the approach for use with policy and planning at both levels while outputs are compatible with conventional cost-benefit decision analysis. This latter facet points the direction for future research. An obvious extension would be to develop modules of standard GIS software to bring the methodology onto the desktop of planners and policy makers. Given that, in the UK, much local planning is already routinely conducted using GIS technology this seems an obvious route to ensure that economic analysis is moved out of the realm of academic research and into everyday decision making.

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