Economic Assessment of the Recreational Value of Ecosystems in Great Britain[1]

Report to the Economics Team of the UK National Ecosystem Assessment

The Centre for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia

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Authors:

Antara Sen, Amii Darnell, Andrew Crowe, Ian Bateman, Paul Munday and Jo Foden

[1] We would like to thank the Monitor of the Engagement with the Natural Environment (MENE) teams at Natural England, Defra and the Forestry Commission, Luke Brander at IVM Amsterdam, the NEA Economics group members, NEA Scenarios team at the University of Nottingham and Natural England and their contractor TNS for sharing their data with us.

1. Introduction

Outdoor recreation forms one of the major leisure activities for most of the population in Great Britain. According to the most recent figures published by Natural England, even just focussing upon English recreational behaviour, there are around 2,858 million visits made every year involving a direct expenditure of some £20.4 billion per annum. Considering the location of these visits, research undertaken by Natural England shows that "during a 12 month period, 64% of adults had visited a town/city with 62% visiting a seaside town/city, 59% visited the countryside and 37% had visited the seaside coast. Across England as a whole, 40% had visited a wood/forest in the past year. A quarter (25%) of people had visited a stretch of inland 'water with boats' whilst just under a fifth (18%) had taken a trip to 'water without boats'.''

While the majority of outdoor recreation involves informal activities such as walking, nature watching and picnicking, some more distinct activities deserve mention. For example, angling is a major pastime for about 1 million licensed anglers in England and Wales. Licensed anglers fished about a total of 30 million days during 2005, about 26 million for course fishing and 4 million for game (salmon and trout) fishing (Environment Agency, 2009). Recreational fishing involves an estimated expenditure of about £1,000 million per year in England and Wales[2]. The economic gross value added from an additional 1000 days of course fishing is estimated at £15,000-19,000, varying according to region (Environment Agency, 2009).

While specific activities are clearly important, it is the general, informal activities which form the bulk of ecosystem service related recreation. Clearly these outdoor visits generate substantial recreational value and it is likely that changes to the natural environment would affect those values. Such changes in recreational values should be considered within environmental policy and decision making institutions. Here one of the major problems facing assessment is that the outdoor recreation values generated by any given resource are likely to vary substantially depending upon the spatial context. Put simply, the same resource located in different areas will generate very different numbers of visits and values.

In order to overcome this difficulty and generate valuations for the NEA, we develop and implement a novel methodology in this paper that can be used as a general tool for recreation planning and decision making. This novel methodology combines the spatial analytic capabilities of a geographic information system (GIS) with new data obtained from the Monitor of the Engagement with the Natural Environment (MENE) survey to model how the distribution of natural environment and urban resources interact with population distribution in determining recreational visit flows[3].

The methodology developed for our analysis consists of three basic elements. These are described below:

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[2] To clarify, this statement refers to expenditure, not to net economic value in terms of willingness to pay.

[3] The Monitor of the Engagement with the Natural Environment (MENE) survey was recently released by Natural England, Defra and the Forestry Commission. This is a major new database intended to provide baseline and trend information on how people use the natural environment in England. It provides an unrivalled source of data and our present analysis is, as far as we are aware, the first major empirical use of the MENE survey.

(i) A site prediction model (SPM): Normally the location of existing and policy intended recreation sites is known via secondary sources. However, the economic analysis of the NEA Scenarios described in Section 4 of this report extends to future worlds where such locations are unknown. To address this problem, we need a method to determine the location of potential recreational sites in new states of the world. The site prediction model achieves this by taking information from the MENE survey on the location of outdoor recreational sites and examines how these are related to: (i) the type of natural resources at that site (ii) the distribution of population around that site and (iii) the travel distance to the site. While the location of sites is known for England via the MENE survey, this model also allows us to predict the spatial distribution of sites for the rest of Great Britain using the model fit on England. This method avoids reliance upon secondary sources for this information, which is liable to omit informal recreation sites which are not officially recorded as such but may generate a large proportion of overall trip numbers.

(ii) A trip generation function (TGF): The trip generation function models the factors determining the number of visits from each UK Census Lower Super Output Area (LSOA) to any given recreational site[4]. The analysis takes information on the location of both LSOAs and recreational sites from the MENE survey. The outset point is defined as the point from where the respondents start their journey in order to visit the recreational sites. Since our analysis is restricted to day trips only, outset point for most of the respondents is given by their residential location. However, for simplicity, we assume that all respondents start their journey from the population-weighted centroid of the LSOA to which they belong. We examine the accessibility of environmental characteristics within and around these LSOA outset locations in order to assess the availability of substitutes which may divert potential visitors away from any given site. Allowance is also made for the population of each LSOA and its socio-economic and demographic characteristics as these may affect the propensity to undertake visits. We also incorporate measures of the environmental characteristics of sites (which could be taken either directly from MENE or from the predictions of the site prediction model) and their surroundings so as to assess their attractiveness to potential visitors.

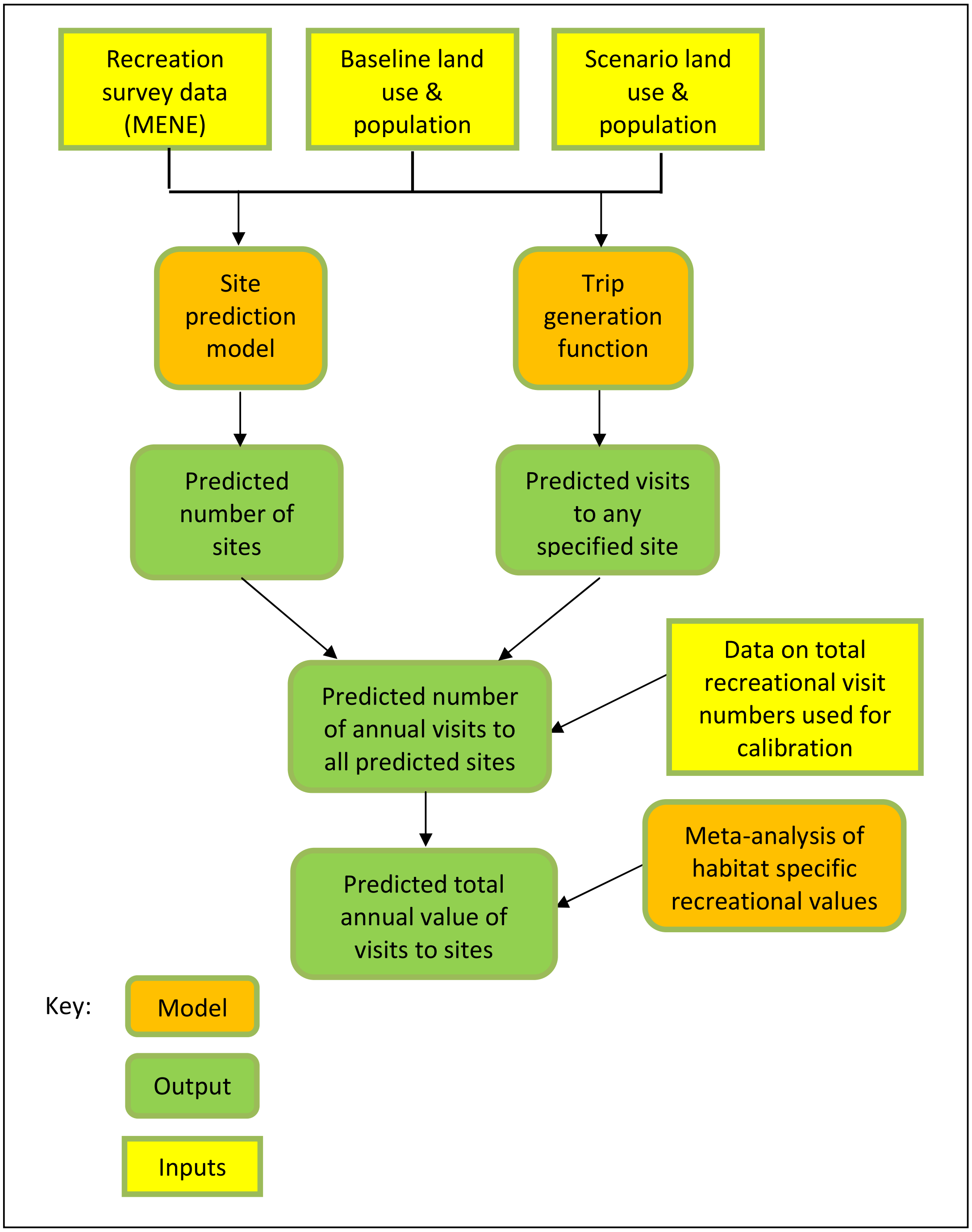
(iii) A trip valuation meta-analysis (MA): Once we know where sites are located via the site prediction model and the number of visits to each of those sites via the trip generation function, we then seek to determine the value of those visits. This stage in the study re-analyses nearly 200 previous estimates of the value of a recreational visit, examining the influence of the environmental characteristics of visited sites and the differences in the methods used to generate those value estimates.

[4] LSOAs are small areas of around 400 to 600 households which, particularly in urban areas, mean that the influence of residential location on visits made can be accurately modelled. We used population weighted LSOA centroids as the outset point for our analysis. Further details regarding LSOAs are available at: http://www.neighbourhood.statistics.gov.uk/dissemination/Info.do?page=aboutneighbourhood/geography/superoutputareas/soa-intro.htm. For our modelling of Scottish outset areas we used the Census Data Zone (DZ) unit.

Once the site prediction model is estimated using data for England taken from MENE survey, it is then used to generate the predicted number of potential recreational sites in each 5km square cell of Great Britain. The trip generation function is used to estimate the predicted number of visits per week to a site in each of the 5km square cells. By weighting the estimated number of visits per week by the number of sites per cell (as predicted by the site prediction model) we get a sense of the spatial distribution of visits. However, adjustments have to be made for the sampling strategy of the MENE survey. The MENE survey is well designed for extrapolation, with households from all areas of the country being sampled at all periods across the year, thus avoiding spatial and temporal biases. However, of course, only a subset of households can and are interviewed, and even these households are asked only about the trips that they make during the week prior to the interview. One of these trips is then randomly selected by the interviewer and the respondent is asked to give detailed information regarding this visit including outset and destination location. Any extrapolation process therefore has to make allowance for these sampling characteristics. The requisite adjustments are calibrated by official estimates of the total annual number of outdoor visits to all sites obtained from the MENE survey. Once we make these adjustments we obtain an estimate of the annual predicted number of visits to each 5km cell allowing for both the number of sites and number of visits to those sites.

The final step of our assessment is to value these predicted visits. Our meta analysis allows the value of a visit to vary according to the habitat type characteristics of the visited site. We assume that these characteristics can be proxied by information on the physical environment of the 5km cell into which a site falls. This allows us to generate a site specific value per person per visit for each trip. Multiplying this by the predicted number of trips to each site in that cell allows us to estimate its annual recreation value. The annual recreation values vary according to the natural environment of the area, the availability of substitutes, the transport infrastructures and the distribution and characteristics of the population in and around that area and hence are spatially varied. These recreation values provide a useful input to environmental policy and decision making especially in situations where we need to ensure an efficient allocation of scare resources. Furthermore, these values can be aggregated across any desired spatial unit up to and including country-level to provide an estimate of total annual recreational value under any given state of the world. Analyses of policy change or future scenarios can then be undertaken by applying our site prediction model, trip generation function and meta-analysis models to the various land use and population distributions envisioned under those policies or scenarios. Figure 1 provides a schematic overview of the methodology developed for this analysis.

Figure 1: Schematic representation of the recreation valuation model.



The schematics shown above allow us to predict where recreational sites are located, how many visits these sites generate and the value of those visits. Importantly, for decision making purposes, the models allow us to vary policy relevant elements of the analysis to examine their impacts on recreational values. Thus, for example, we can examine how new land use scenarios would alter the environmental characteristics of potential sites, making them more or less attractive to visitors and enhancing or degrading the value of any visits made.

This report is organized as follows. Section 2 describes the data that we use for our analysis. Section 3 describes the site prediction model, trip generation function and meta-analysis models and the empirical methodologies underpinning these models. Section 4 applies the methodology developed in this report for predicting the pattern and value of recreational day visits in Great Britain under the full range of population and land use change scenarios developed by the NEA scenarios team. These predictions are compared with the baseline year 2000 to estimate the changes in recreation values under each of the scenarios. Section 5 concludes with a case study which demonstrates the versatility of our methodology.

2. Data

The most crucial and novel source of data used in our analysis is the Monitor of the Engagement with the Natural Environment (MENE) survey data which was recently released by Natural England, Defra and the Forestry Commission. The data for MENE was provided by a year long, in-house, face-to-face survey. Respondents were asked about the number of visits that they had made seven days prior to the day of their interview. One of these trips was then randomly selected by the interviewer and the respondent was asked to give detailed information regarding this visit including destination location. This information on destination location was then recorded alongside information on the outset location providing the vital information required for our analysis. MENE survey results were published in September 2010 and have been used for economic analysis for the first time in this report.

The methodology developed for this study is applied not only to England where the survey data was gathered, but throughout Great Britain (See Section 4 below)[5]. A detailed description of the methodology underlining the GIS-based calculation of location and travel time variables is provided below. In summary the GIS methodology entails the following steps:

- Respondent home and visited site locations are obtained from the MENE survey database
- The environmental characteristics for both the visited site and its surroundings are defined and data is obtained using the Land Cover map 2000, provided by the Centre for Ecology and Hydrology (CEH), Wallingford, UK

[5] There is an implicit assumption here that the preferences of English respondents can be generalised across Great Britain. While we see no clear cultural case against this assumption one concern is whether the environmental characteristics of England embrace the diversity of Great Britain. Generally this is not thought to be a problem. Perhaps the weakest element of this assumption is in regard to mountains. England contains a considerably lower density of such environments and does not contain any of the high peaks of Wales and none of the major mountains of Scotland. Obviously it would be ideal to have comparable data from all UK nations. However, perhaps surprisingly, information on both outset and destination location is not collected in surveys other than MENE. Note that while our application considers all of Great Britain it could readily be applied throughout the UK or further afield provided that sufficient data is available.

- GIS is used to calculate travel times via the full road network between all potential outset points (LSOAs) and both potential and actual destination sites

- Potential substitute sites are defined including measures of the density of different land use and habitat types around each potential outset point using GIS

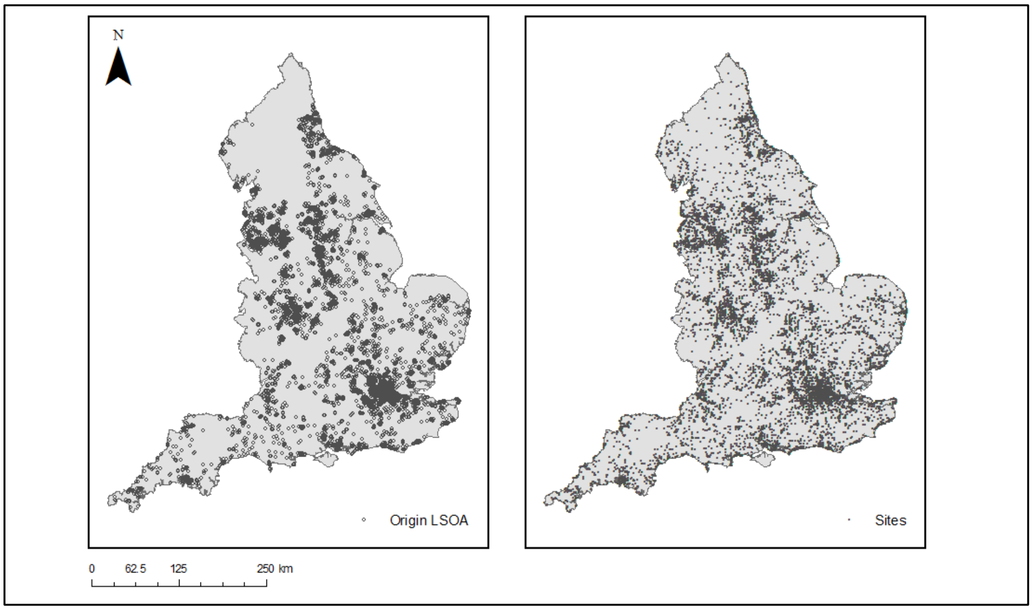
- Socio-economic and demographic variables describing each LSOA are obtained from the UK Census database 2001.

From the original MENE dataset of 48,514 respondents, we omit 5,305 respondents due to incomplete location information. We omit a further 751 respondents as they were on holiday during the interview period (only day trippers are considered in our analysis).[6] An analysis of potential "edge-effects" is undertaken to examine whether those who live near the England-Scotland border and the England-Wales border appear to have lower than expected visit rates. Such a pattern is possible given that the visits made by these people to locations outside England (i.e. to Scotland or Wales) are truncated. The truncation occurs since the MENE survey reports information on visits made to recreational sites located in England only. Our analysis indicates that a small number of respondents (approximately 150 people) are affected in this way and these are also omitted from further analysis. Of the remainder, some 27,593 respondents did not take a visit during the seven days preceding the survey although these respondents are retained within our subsequent analysis in order to adjust the model estimates for these valid zero visit observations. The destination sites are identified on the basis of the MENE questionnaire which required the respondent to name the actual place(s) that he visited seven days prior to the interview. This locational information is verified by the interviewer using a variety of secondary sources like internet search engines, online mapping websites etc. Once the interviewer has successfully identified and verified the destination location, he adds the grid references corresponding to each of the destination sites in the form of Eastings and Northings and includes this information in the survey data files[7]. We identify 8,292 distinct destination sites, each having a 1 km square grid reference from these survey data files. Figure 2 maps the location of LSOA outset areas and destination sites.

[6] Subsequent investigations further restricted our analysis to the more than 90% of day trip journeys with a one-way duration of 60 minutes or less. This restriction was imposed to avoid the very large number of zero visit outset locations imputed when we permit our analysis to allow day trip visits from any outset to any destination across the entire country.

[7] Eastings and Northings are geographic Cartesian coordinates for any point. Easting refers to the *x*-coordinate and Northing refers to the y-coordinate

Figure 2: Distribution of day trip visitor outset locations (left hand panel) and destination sites (right hand panel).



The environmental characteristics of sites are defined by linking their 1 km square grid cell locations to habitat proportions derived from the 25m resolution UK-wide Land Cover Map 2000 data (Fuller, et al., 2002)[8]. This dataset is used for its coverage and availability. Habitat categories in the Land Cover map were reclassified in order to be consistent with the NEA habitat categories. Thus the habitat categories that we consider in our analysis 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. Percentages of each habitat type in each 1 km square cell are calculated and used to define sites for the estimation of the trip generation function[9]. For prediction across Great Britain, habitat proportions are calculated at a 5 km grid square resolution.

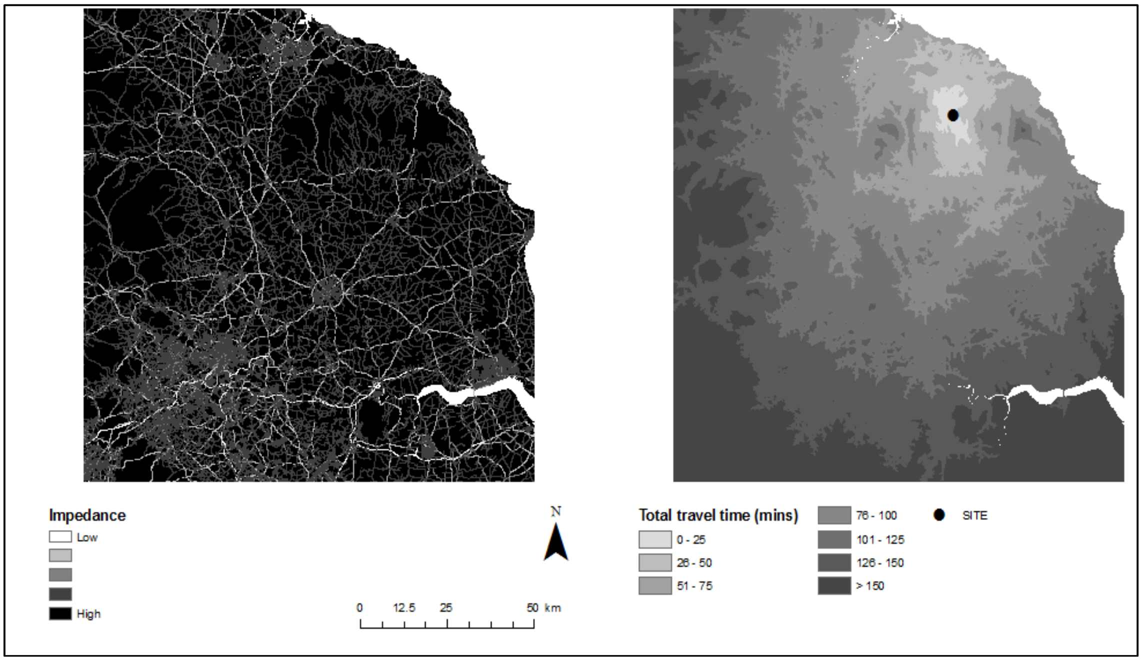
Travel times between outset and destination locations are calculated for all of Great Britain predominantly using the Ordnance Survey Meridian road network. Average road speeds are taken from Jones et al. (2010). The study by Jones et al., (2010) discriminate between road types (motorway, A-road, B-road and minor road), as well as between urban and rural contexts. The road network is converted into a regular grid of 100 × 100 metre cells with each cell containing a value corresponding to travel-time-per-unit distance. Allowances for locations off the regular road grid are made using adjustments for walking speed (Jones et al.,

[8] LCM2000 is provided by the Centre for Ecology and Hydrology (CEH), Wallingford, UK. The procedure that we use here employs a substantially greater degree of spatial accuracy than that used by the NEA Scenarios team. As a result of this, the Site Prediction Model and Trip Generation Function models reported in Section 3 below had to be re-estimated using the simplified land use map employed by the NEA Scenarios team before they could be applied to value those scenarios (see Section 4 below for the re-estimated models).

[9] This was undertaken using ESRI's ArcGIS Zonal Statistics facility.

2002).The resultant travel time map is used to calculate the minimum travel time between any outset location and any destination site[10]. An example of the resulting travel time surface or the impedance surface for a single destination is given in Figure 3.

Figure 3: Impedance surface (left hand panel) and estimated travel time bands (right hand panel) for potential outset locations around a single recreational visit site near to Pickering in the North York Moors



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. Ignoring the impact of substitutes is likely to inflate the attractiveness of more distant sites. To allow for this fact the availability of substitute resources around each potential outset location across the country is assessed. This was achieved by defining circular areas around each LSOA and calculating the percentage of each land use and habitat type in that area[11]. This measure of substitute availability is then included within the trip generation function. The radius of these circles is varied and the analysis repeated to identify the optimal size of surrounding area for capturing this substitution effect[12].

[10] An essential simplification for the Trip Generation Function analysis is that all visitors are assumed to start their journey from the population-weighted centroid of their home LSOA and to travel using the shortest time route to their chosen destination site the location of which is taken to be the geometric centroid of the 1 km grid square containing that site. A similar approach was used for the Site Prediction Model analysis although here 5km grid square centroids were used for the location of destination sites. Bateman et al., (1999) show that actual and GIS predicted routes are highly correlated and the latter provides a strong predictor of the former for modelling purpose. The calculations needed for this analysis were undertaken using the 'Cost Distance' (impedance surface) command in ESRI ArcGIS.

[11] Zonal Statistics ++, a module of the 'Hawths Tools' plug-in for ArcGIS (Beyer, 2004), is used to count the cells entirely within the search radius that are of a particular substitute type. These are converted into percentages of the total circle area (25 m cells entirely within the search radius).

[12] 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

Previous research suggests that visit rates vary across LSOAs depending in part upon the socio-economic and demographic characteristics of those areas (Jones et al., 2010). To allow for this possibility, such characteristic data is obtained for all LSOAs from the UK Census with income variables being obtained from Experian data[13]. Comparable statistics for the rest of Great Britain is also obtained for purposes of prediction.

As noted above, we expect that the probability of recreation sites being located in an area is in part a function of the size and distribution of the local population. To include this factor within the site prediction model, a spatially weighted measure of the population around any point is calculated by first taking a 1km grid square map of population and aggregating this up to the 5km grid resolution as used by the site prediction model. Population from outside any 'focal' 5km square is likely to have a non-zero but diminishing probability of visiting a site in that cell. As there is no theoretical guidance regarding the exact form of this relationship it can be determined through purely empirical means. To investigate this we first define a population weight (w) as the following inverse power function:

$$w = \frac{1}{d^y}$$

Where w = population weight
d = distance from focal cell[14]
y = empirically determined exponent

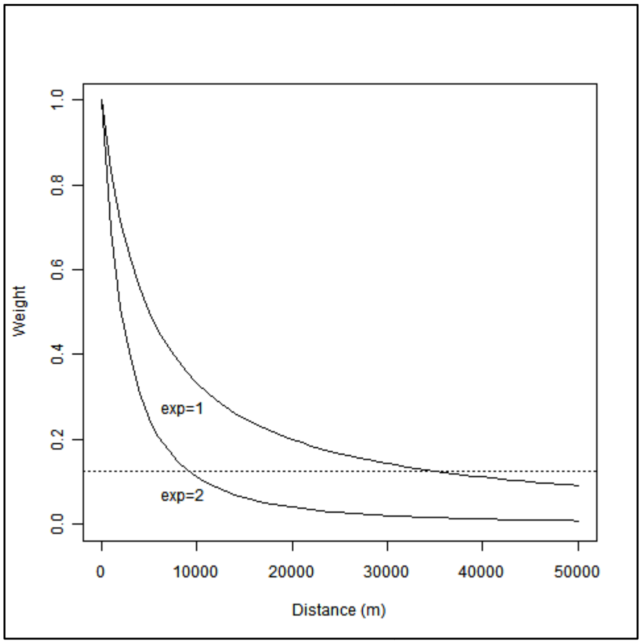
As can be seen, w is defined so that populations at a greater distance from a given location site have a diminishing impact on the probability of that location being a recreational site. The larger the value of the exponent (y) the faster this diminishment occurs. Our empirical analysis suggests that a good fit to the data on actual site locations can be found by a site prediction model containing two versions of this weight, the first with y=1 and the second with y=2. This was improved further by constraining values of w lower than 0.125 to be zero. Figure 4 illustrates the resultant weight functions.

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.

[13] This of course assumes that LSOA statistics can be used as valid estimates for the households interviewed in the MENE survey. Note that UK Census 2001 data are used for all socio-demographic variables but that the 2009 Experian data on income is employed. Experian data is held at MIMAS, University of Manchester.

[14] distance (d) is defined as d = (centroid distance from focal cell centroid (in metres)+ 5000)/5000 so that a maximum weighting of 1 is given to the population of the focal cell.

Figure 4: Weight function relating population to the probability of recreational sites over increasing distance to that potential site. Exponent values of 1 and 2 and dotted line indicating cut-off value of 0.125 are empirically determined.



3. Empirical Methodology

3.1 The site prediction model (SPM)

The first element of our analysis seeks to predict the likely location of recreational sites. While such a predictive analysis is clearly unnecessary where the location of existing or planned recreational sites are known, it is required both for extrapolation beyond the base-data area of England, and application of our models to the new worlds envisioned within the NEA Scenarios.

Two broad factors are postulated as determinants of recreational site location:

- the nature of any potential destination site (e.g. its environmental and land use characteristics);
- availability of population around that site.

We assume that y_i which is the number of observed visited sites in each 5 km square cell and hence a count variable follows a negative binomial distribution. The negative binomial distribution is basically a Poisson distribution with an omitted variable υ_i, such that e^{υ_i} follows a gamma distribution with mean 1 and variance α.

$y_i \sim$ Poisson (μ_i*) where μ_i*= exp ($x_i\beta + \upsilon_i$) and e^{υ_i} ~Gamma ($1/\alpha$, α); α is the overdispersion parameter. We consider the negative binomial model specification since the conditional variance of y_i is found to be greater than its conditional mean so that the data is overdispersed. If the mean structure is correctly specified but there is overdispersion then the estimates from the Poisson regression model are consistent but inefficient (Gourieroux et.al., 1984). The standard errors resulting from the Poisson model are also biased downwards as a result of overdispersion. The negative binomial model is an extension of the Poisson model that adds a parameter which allows the conditional variance of y_i to exceed its conditional mean. Likelihood ratio tests indicate that over dispersion parameter (α) is statistically significant, justifying our choice of the negative binomial model reported below.

The data drawn from across the entirety of England provides a good deal of variation in both of these dimensions. An analysis of competing model specifications resulted in our best-fitting Site Prediction Model as reported in Table 1. This model sets enclosed farmland as the base land use category so that the coefficients on the other land uses gives us their influence relative to the base case.

Table 1: Site Prediction model: Predicting the number of recreation sites in each 5km square

	Coefficients	t-stat	p-value
% of coast in cell	0.00769**	(2.603)	0.009
% of freshwater in cell	0.0651***	(6.128)	0.000
%of semi-natural grass in cell	0.00545**	(3.151)	0.002
% of mountains& heath in cell	-0.0149***	(-4.949)	0.000
% of estuary & ocean in cell	0.0134***	(12.27)	0.000
% of urban area in cell	0.0543***	(32.07)	0.000
% of coniferous forests in cell	-0.00631	(-1.461)	0.144
%of broadleaved forests in cell	0.0267***	(10.24)	0.000
weighted pop density (y=1)	0.000000417***	(5.541)	0.000
weighted pop density (y=2)	-0.00000486***	(-9.103)	0.000
Constant	-0.805***	(-20.62)	
Log alpha	-0.644***	(-12.22)	
Observations	5497		

Notes: Dependent variable is number of visited MENE sites in a 5 km cell. Data is for England.
Base category land use is enclosed farmland
Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
The above SPM is estimated using a negative binomial model with robust standard errors.
The number of observations refers to the number of 5 km square grid cells in England on which the estimation was based. This is less than the number of sites in the MENE dataset due to multiple sites falling within the same grid square.

Because of the negative binomial form of the model the magnitudes of the coefficients cannot be directly interpreted as the marginal effects of their influence on the number of visited sites. However, their signs do allow simple interpretation of the direction of their effects. To interpret the coefficients on the land use variables we need to recall that these show the differences in effect from the baseline which is set as enclosed farmland. Given this fact, a positive coefficient shows a land use or habitat which is more likely to yield recreational sites than does enclosed farmland (and the opposite applies for negative coefficients). This means that coastal, freshwater, semi-natural grassland, estuary, broadleaf and even urban areas yield a higher number of recreation sites than enclosed farmland. One clear exception is mountains moors and heathlands. While such habitats yield high quality recreational experiences (as evidenced in our subsequent trip generation function and meta-analysis models), they are characterised by few access points relative to their size. Interestingly, coniferous forests are found to be insignificantly different from enclosed farmland in terms of site probability, a result which is in stark contrast to the positive and significant effects found for broadleaf woodland. The coefficients for the weighted population density variables indicate a significant positive but marginally diminishing impact on the expected count of recreational sites. In other words locations near to populations are more likely to yield recreational sites than those further away.

The estimated site prediction model described above is now used to generate a predicted count of potential recreational sites in each 5km square cell of Great Britain. This count for each cell is divided by the total predicted count of sites for Great Britain to generate a weight for each cell. This weight for each cell is used in conjunction with the output from the trip generation function to estimate the total number of visits to each cell.

3.2 The trip generation function (TGF)

The trip generation function predicts the number of visits made from each outset location to any given recreational site (whether observed or predicted from the site prediction model) as a function of: the travel time to the site (in minutes), the accessibility of other potential substitute recreational areas near to outset locations, socio-economic and demographic characteristics of population in the outset area and the land use and habitat characteristics of the potential destination site[15].

The multilevel Poisson regression model is used to estimate the trip generation function. The choice of this model is motivated by nature of the data. First, since the dependent variable which is the number of visits from an outset area to any given recreational site is a count, we assume that it follows a Poisson distribution. Second, since the nature of the data is hierarchical, i.e., the data have a nested structure we use a multilevel poisson regression model instead of the standard Poisson regression model. A two level structure is assumed where the outset zones (level 1) are nested within sites (level 2). The basic assumption of the multilevel model is that the dependent variable, *viz*, the number of visits, is influenced by a variety of factors which operate at both the outset as well as the site levels. We control for some of these factors by including them explicitly in our regression model. For example, we include habitat proportions for each site as controls in the model. However, there may still exist certain unobserved factors that influence visit numbers. For example, a woodland site may be more attractive to visitors than other woodland sites because of a biking trail at that site. If this is the case then we can no longer assume independence of the regression residuals. Failure to account for this intra-unit correlation will lead to an underestimation of the standard errors and inefficient parameter estimates.

The multilevel Poisson model that we estimate is basically a random effects Poisson model in which the site-specific error terms follow a multivariate normal distribution (Rabe-Hesketh and Skrondal 2008 pp 381). The model is estimated using maximum likelihood techniques where the marginal likelihood is approximated by numerical integration methods, *viz*, the Gauss-Hermite adaptive quadrature method.

The estimating equation for the trip generation function is as follows:

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

[15] This is defined as each LSOA within 60 minutes one way travel of a potential site.

where i denotes outset areas and j denotes sites and y_{ij} is the number of visits from a specified small area Census unit i (LSOA in England and Wales; DZ in Scotland) to a specified site j. The fixed part of the model consists of W_j (which includes variables that describe site characteristics) and X_{ij} (which include variables that describe the outset area characteristics). The random part of the model consists of u_{0j} (the site-specific random intercept term and hence captures the unobserved heterogeneity between different sites) and r_{ij} (the usual error term). The random effects u_{0j} are assumed to be normally distributed with mean zero and variance σ^2u. The table below reports the best-fitting trip generation function.

Table 2: Trip generation function: Predicting visit numbers from an outset location to a site destination

	Coefficient	t-stat
Travel time from a LSOA/DZ to a site	-0.0594***	(-106.3)
Coast substitute availability	-0.0115***	(-4.156)
Urban substitute availability	-0.0211***	(-32.99)
Freshwater substitute availability	-0.0633***	(-5.109)
Grassland substitute availability	-0.0225***	(-10.16)
Woodland substitute availability	-0.0168***	(-8.446)
Other marine substitute availability	0.000710	(0.738)
Mountain substitute availability	0.0148***	(3.725)
% of coast in site	0.00940***	(6.504)
% urban in site	-0.00219***	(-4.464)
% of freshwater in site	0.0102***	(4.220)
% of grasslands in site	0.00158	(1.343)
% of woodlands in site	0.00286**	(2.948)
% of estuary and ocean in site	-0.0156***	(-11.89)
% of mountain & heath in site	0.0226***	(10.54)
% non-white ethnicity	-0.00580***	(-6.537)
% Retired	0.00642***	(3.678)
Median Household Income	0.00000874***	(9.414)
Total Population of outset area	0.000225***	(5.899)
Constant	-3.195***	(-37.84)
lnsig2u		
Constant	-0.737***	(-21.76)
Observations	4141089	

Notes: The dependent variable is the number of visits from a specified small area Census unit (LSOA in England and Wales; DZ in Scotland) to a specified site.
t-stat is given beside the coefficients in parenthesis
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
The substitute availability variables are calculated as the percentage of a specified land use type within a 10km radius of the outset point.
Enclosed farmland is set as the base case for both the 'substitute availability' and 'site' characteristic variables.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: lnsig2u = natural logarithm of the variance of the random intercept term in the multilevel model. The random intercept term captures the unobserved heterogeneity between the different sites.
Estimated using a Multilevel Poisson regression model

Examining the relationships captured in the trip generation function we see that by far the most powerful predictor of visits from an outset area to a potential visit site is the travel time involved. Here the highly significant negative coefficient shows that as travel time increases the number of visits falls. This is an important result as it underlines the vital importance of space in optimal decision making-location is a major driver of value. The impact of the availability of substitutes is also strongly in line with prior expectations with all substitutes working to reduce visits to more distant sites with the exception of mountains where (as discussed previously) access to sites is limited by the available road infrastructure relative to the size of such areas[16]. A set of variables is included in the trip generation function to describe the attractiveness of land use and habitat type across different potential visit sites. By specifying all site habitat variables to contrast with a baseline of enclosed farmland we see that most of the habitat types exert a positive impact upon visits (i.e. they are considered more attractive than enclosed farmlands). Mountains, coasts, freshwater sites and woodlands exert significant positive effects in attracting visitors. Notice that while mountainous outset locations are associated with a low substitute availability effect, nevertheless they have a positive effect as destinations for visits from other areas. A set of socio-economic and demographic variables pertaining to the population in the outset area are also included in the trip generation function. We observe significantly higher levels of engagement in recreation from retired and richer populations and lower engagement amongst ethnic groups.

The estimated trip generation function allows us to predict the number of visitors that would arrive at a site located in any given 5km square cell of Great Britain. However, as we have already seen from the site prediction model analysis, the distribution of sites across the country is far from uniform. Therefore by multiplying the predictions of visit counts in a given cell (obtained from the trip generation function) by the expected number of sites in that cell (obtained from the site prediction model analysis) we obtain an estimate of the total number of visits in each grid square which is fully adjusted for the characteristics and location of that cell. The resulting spatial distribution of predicted visits can readily be mapped for decision support purposes or aggregated up to any desired area including country or Great Britain level. However, we now need to allow for the fact that the characteristics of sites may influence the value of any predicted visits. For this we turn to the meta-analysis model.

3.3 The valuation meta-analysis (MA)

The literature on the valuation of outdoor recreation activities is substantial and a review of this literature reveals some 193 value estimates within 98 relevant studies[17]. We conduct a meta-analysis of these studies and explain the value estimates as a function of both the resources that they are concerned with and to various variables which describe the study characteristics and populations used to provide these estimates. To improve comparability across studies all the value estimates from non-UK studies are adjusted using purchasing power parity data and all estimates are converted to common GBP (2010) prices.[18]

The estimating equation for the meta-analysis is as follows:

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

[16] Note that the other marine category does not include coast and generally picks up the effect of less accessible marine areas. But this is insignificantly different from the enclosed farmland base category.

[17] References for the studies used in the meta-analysis can be obtained from the author upon request.

[18] We use the purchasing power parity (PPP) adjusted exchange rates listed in the Penn World Table for the conversion (http://pwt.econ.upenn.edu/). Using the GDP deflator for the UK (http://www.hm-treasury.gov.uk/data_gdp_guide.htm) we then convert all the values to 2009 prices.

where y_i is recreational value (willingness to pay/consumer surplus value), *habitat type* is the land use type of the recreational site valued, *study* is the characteristics of the valuation study, *valuation unit* is the unit in which the original study records the recreational value estimates, *valuation method* is the method used for the valuation of the good, *study country* is the characteristics of the country in which the recreational site is located and ε_i is the error term specific to study j.

The OLS regression results are presented in Table 3 below. Since the Breusch-Pagan test for heteroskedasticity indicates that the model is heteroskedastic we estimate the model using the Huber-White-adjusted standard errors. The coefficients of the above semi-log regression model measure the relative change in recreational values for any given absolute change in the value of the explanatory variables. For explanatory variables which are expressed as logarithms, *viz,* population density and the sample size, the coefficients are interpreted as the percentage change in recreational values given a small percentage change in the explanatory variables. The adjusted R^2 value is 0.75 which implies that about three quarters of the variation in recreational values is explained by variation in the explanatory variables included in the meta-analysis model.

Since the meta-analysis dataset consist of some studies which report multiple value estimates, we re-estimate the above model using cluster-robust standard errors. Each study is considered to be a cluster. The cluster-robust standard errors adjust for within-study correlation of value estimates but assume zero correlation across different studies. The regression results for this model are not reported in this report but are available from the author. The model estimates using the cluster-robust standard errors, as expected, remain the same when compared to the model estimates using the Huber-White-adjusted standard errors, with changes pertaining to the standard errors alone[19].

[19] Some of the variables *viz,* Grasslands, farm & woods, use value only and Open-ended format become statistically insignificant when we move from the OLS model estimated using the Huber-White-adjusted standard errors to the OLS model estimated using cluster-robust standard errors.

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

Variable	Variable definition	Coefficient	t-stat
Good characteristics[1]			
Mountains & heathlands	1 if recreational site valued is mountain or heath; 0 otherwise	1.771*	(1.834)
Grasslands, farm & woods	1 if recreational site valued is Grasslands, farm and woodlands; 0 otherwise	0.579*	(1.886)
Freshwater, marine &coastal	1 if recreational site valued is Freshwater, marine &coastal; 0 otherwise	0.222	(0.763)
Designated site	1 if recreational site is holds some official designation; 0 otherwise	0.0225	(0.121)
Study characteristics			
Published	1 if study published in peer-reviewed journal or book; 0 otherwise	0.133	(0.468)
Survey year	Discrete variable: 1 = published in 1975, to 29 = published in 2008	0.0360	(1.364)
Log sample size	Logarithm of sample size	-0.493**	(-2.143)
in-person interview	1 if survey mode is in-person; 0 otherwise	0.130	(0.469)
Use value only	1 if use value study; 0 otherwise	0.372*	(1.787)
Substitutes considered	1 if substitute sites included in the valuation study; 0 otherwise	-0.117	(-0.570)
Valuation unit[2]			
Per household per year	1 if value in terms of per household per year; 0 otherwise	2.825****	(8.583)
Per person per year	1 if value in terms of per person per year; 0 otherwise	2.090****	(6.251)
Other valuation unit	1 if value in terms of per household/person, per day/ month; 0 otherwise	2.101****	(4.648)
Valuation method[3]			
RPM & mixed valuation	1 = revealed preference or mixed valuation methods; 0 otherwise	1.494**	(2.335)
Open-ended format	1 = stated preference using open-ended WTP elicitation format; 0 otherwise	-0.363*	(-1.838)
Payment vehicle-tax	1 = payment vehicle is a tax; 0 otherwise	0.351	(1.316)
Study country characteristics			
Log of population density	Population density of state/country in which the site is located	0.360	(1.206)
Non-UK countries[4]	1 = study conducted overseas; 0 otherwise (UK)	1.193***	(3.215)
Constant		-0.110	(-0.123)
Observations		193	

Dependent variable is logarithm of recreational value (WTP or consumer surplus) (£, 2010)
1. Omitted land use base case = urban environments
2. Base case for valuation units is per person per visit
3. Base case for valuation method is close-ended stated preference methods
4. Non-UK countries considered: North America, Western Europe, Australia and New Zealand.
Estimated using OLS with Huber White standard errors * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

The estimated model detailed in Table 3 conforms well to prior expectations. Most of the methodological variables are statistically insignificant which suggests that framing issues observed in many individual studies may be less of a problem when studies are pooled within a meta-analysis. Interestingly, although the site prediction model highlights that mountain areas provide a lower density of recreational sites, the meta-analysis model suggests that visits that are made to such areas yield relatively high per visit values.

The methodology developed in Sections 2 and 3 is flexible and can be readily applied to a variety of policy questions. In Section 4 below we apply the method to valuing the variety of changes envisioned in the NEA scenarios. However, this approach can also be applied to more commonplace decision contexts such as the simple question of how to optimise the recreation value generated by a limited budget. Such a question is addressed in Section 5 of this report so as to demonstrate the versatility of the methodology.

4. NEA Scenario Analyses

This section applies the methodology developed above for predicting the pattern and value of recreational day visits in Great Britain under different scenarios. These predictions are compared with the pattern and value of visits for the year 2000 (taken to be the baseline by the NEA scenarios team) to calculate the changes in recreation values under each scenario.

4.1 Methodology: Although we follow the basic methodology outlined in the previous sections we have had to make a few adjustments in order to extend that approach to the valuation of recreation under the NEA Scenarios, as follows:

- LSOA/DZ populations were calculated for 2060 in accordance with the population trends envisaged by the NEA Scenarios

- The NEA Scenarios team employ a 1km grid resolution to define their maps of the baseline and scenario land use whereas we employ a 25metre resolution map in our development of the methods described in Sections 2 and 3 above. For consistency we re-estimate site prediction model (SPM) and trip generation function (TGF) using map information from the NEA Scenarios team (including recalculation of the explanatory variables used in those models). These re-estimated models are reported as Tables 4 and 5. Comparison with the models reported in Section 3 above shows that these are more or less similar with relatively minor changes in parameter values.

Table 4: Site probability model (SPM)[20]: Predicting the number of recreation sites in each 5km grid square

	Coefficients	t-stat
% of coast in cell	0.0210**	(2.699)
% of freshwater in cell	0.0613***	(6.160)
% of grasslands in cell	0.00490**	(3.220)
% of mountains and heath in cell	-0.0169***	(-5.267)
% of other marine in cell	0.0110***	(11.16)
%of urban in cell	0.0542***	(32.17)
% of coniferous forests in cell	-0.00582	(-1.358)
% of broadleaved forests in cell	0.0267***	(10.29)
weighted pop density (y=1) in cell[21]	0.000000407***	(5.407)
weighted pop density (y=2) in cell	-0.00000460***	(-8.695)
Constant	-0.811***	(-20.40)
Log alpha		
Constant	-0.627***	(-12.04)
Observations	5526	

The dependent variable is the number of visited MENE sites in a 5 km cell.
For full definition of variables and discussion of relationships see the NEA Economics chapter
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
The model is estimated using a negative binomial model with robust standard errors.

Table 5: Trip generation function (TGF): Predicting the number of day visits to a site

	Coefficients	t-stat
Travel time from LSOA to site	-0.0628***	(-110.6)
Coast substitute availability	-0.0233*	(-2.151)
Urban substitute availability	-0.0219***	(-34.75)
Freshwater substitute availability	-0.0827***	(-6.349)
Grasslands substitute availability	-0.0215***	(-9.797)
Woodland substitute availability	-0.0177***	(-8.887)
Sea/ocean substitute availability	-0.00198*	(-2.164)
Mountain substitute availability	0.0120**	(2.971)
%coast in site	0.0226***	(11.12)
%urban in site	-0.00222***	(-4.617)
%freshwater in site	0.0113***	(4.812)
% grasslands in site	0.00160	(1.477)
%woodlands in site	0.00364***	(3.896)
%of sea in site	0.0233***	(9.804)
%mountain/heath in site	0.0181***	(7.980)
% non-white ethnicity	-0.00546***	(-6.162)
% retired	0.00645***	(3.661)
Median Household Income	0.0000104***	(11.19)
Total Population of outset area	0.000227***	(5.902)
Constant	-3.101***	(-36.30)
lnsig2u		
Constant	-0.912***	(-25.47)
Observations	4047387	

The dependent variable is the number of visits from an LSOA/DZ to a site
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
The above model is estimated using a multilevel Poisson regression model

[20] Tests indicate that the overdispersion parameter (alpha) is significant, justifying our choice of the negative binomial model.

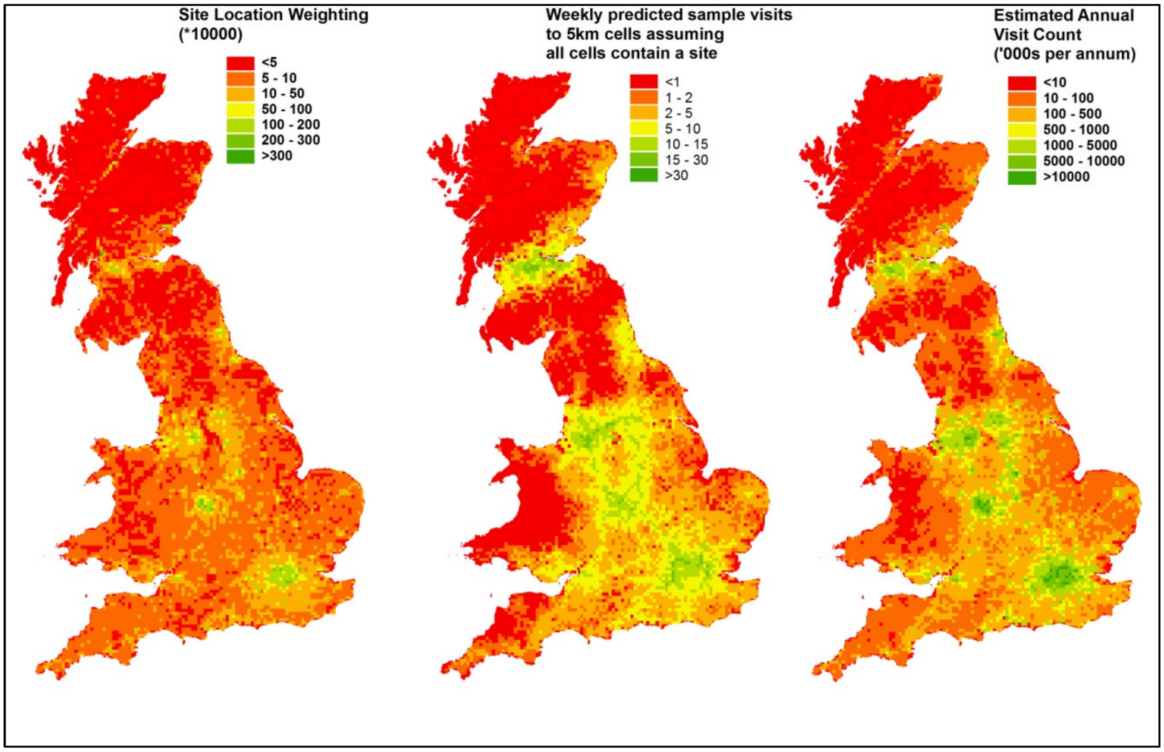
[21] Weighted population density variables (weights=1.0 and 2.0) are only included in the model based on statistical significance

4.2 Distribution and value of recreational visits under the Baseline

In order to establish a comparative baseline for our subsequent scenario analysis we take data from the most recent UK Census (2001) on the distribution and socioeconomic and demographic characteristics of the population, and combine this with the most recent CEH land use map (2000), Ordnance Survey information on the road network and data on travel times (Jones et al., 2010). This allows us to generate the range of variables required for the site prediction model and trip generation function analyses including the characteristics of outset locations and potential destination sites, travel times, substitute availability, etc.

Estimation of the site prediction model provides us with the predicted distribution of sites across Great Britain under the baseline conditions, as illustrated in the left hand panel of Figure 5. As per expectations, the immediate observation regarding this distribution is that it reflects at least in some noticeable part, variation in population density across the country. However, there are also noticeable influences from variation in land use type. This is perhaps most clearly seen in areas such as the south-west of England and the western coastal areas of Wales where, despite relatively low populations, site probability remains significant. Population pressures become the dominant factor when we consider the baseline predictions of the trip generation function as illustrated in the central panel of Figure 5. This predicts the number of visitors that there would be to each grid cell on the assumption that it does indeed contain a recreational site. Here the decay in visit rates away from population centres clearly demonstrates the vital importance of placing recreational sites in areas which are readily accessible to large numbers of people. The right hand panel of Figure 5 combines the information given in both of the previous analyses to adjust the trip generation function predictions for the probability of sites given by the site prediction model. Note that we have also at this stage adjusted from the sample data given in the central figure, to the entire population of Great Britain (Section 1 above discusses this adjustment). Hence the distribution in the right hand panel shows us the estimated total number of visits to each grid cell per annum.

Figure 5: The Baseline distribution of sites (LHS), predicted number of day visits (unadjusted for sample size) to sites (centre) and the estimated total number of recreational day visits per annum across Great Britain (RHS; adjusted for sample size).



The resulting distribution conforms strongly to prior expectations. Visit numbers reflect the very strong influence of travel time and associated costs. However, the land use and habitat types of each area clearly exert their influence. For example, prized landscapes such as large areas of south-west England, the north Norfolk coast, the western coast of Wales and the border areas of Scotland down into the Lakes all exert a pull on visitors which overcomes the fact that they have relatively low resident populations.

The total annual visitor numbers described in the RHS panel of Figure 5 can then be fed into the meta-analysis model to convert visitor numbers into values, taking into account the land use and habitat characteristics of each visited site and their corresponding specific values. Figure 6 maps the resultant values obtained from this analysis. The distribution is similar to but not identical with that shown in the final panel of Figure 5 due to the different per visit values attached to visits in different habitat types. This is perhaps most noticeable in areas such as the Scottish highlands where, although the number of visits is low relative to the vast numbers around major conurbations, nevertheless the high per visit values attached to such habitats boosts up the recreational value of such areas. Table 6 presents a few descriptive statistics regarding the number of visits and their value in the Baseline situation

Figure 6: Total value of annual predicted visits (£'000) in the Baseline scenario

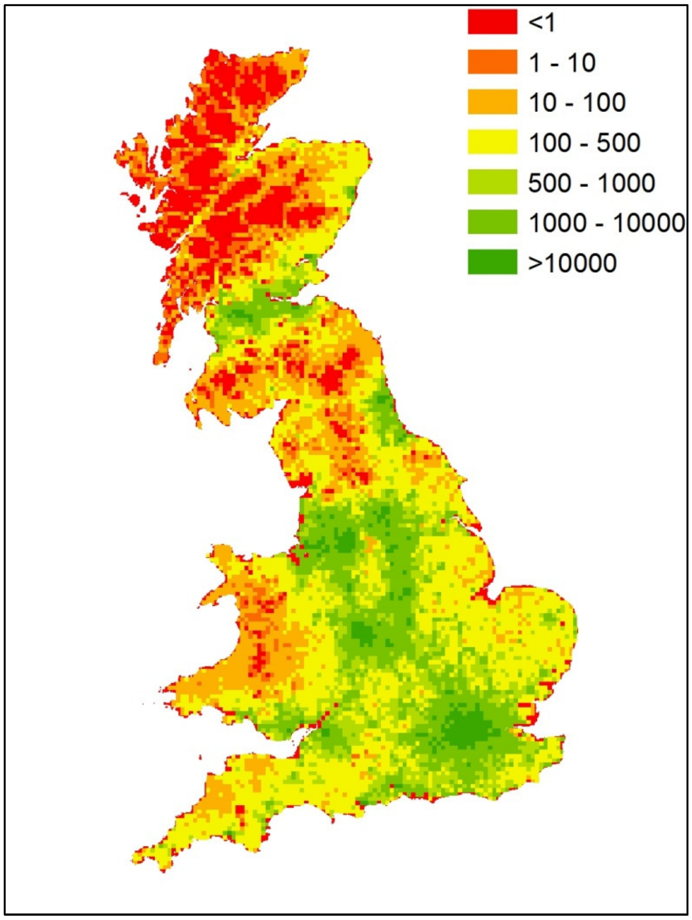


Table 6: Predicted total annual visit numbers and their total value: Great Britain and its constituent countries for the Baseline period ('000)

	Great Britain	England	Scotland	Wales
Predicted visit per annum				
Mean (No. per 5km cell)	394	559	130	94
Median (No. per 5km cell)	72	133	12	24
Country total	3,231,000	2,860,000	290,000	81,000
Value of predicted visit per annum				
Mean (£/5km cell)	1,223	1,732	414	303
Median (£/5km cell)	241	436	44	79
Country total (£)	10,040,000	8,854,000	926,000	260,000

4.3 Description of the NEA Scenarios

The scenarios envisaged by the NEA scenarios team are not the product of a modelling exercise in which trends are extrapolated and estimates of the future produced. Rather, the scenarios are hypothetical future worlds drawn in major part from a process of interaction with relevant agencies and do not reflect the consequences of policy implementations, market shifts or environmental changes.

The following paragraphs present a concise overview of the NEA scenarios. In each case, changes are calculated between a baseline (set as the situation in 2000) and the envisioned state of Great Britain in 2060 under the six NEA Scenarios.

- *Go with the Flow (GF)* essentially follows today's socio-political, economic trends and results in a future Britain that is roughly based on today's ideals with some leaning towards improving the environmental and sustainability performance of the UK. Current ideas being developed in academic, government and the media about the way forward for the UK environment have been adopted. Environmental improvements are still important in the governments vision for a future UK, but the public are less keen on adopting many global or national environmental standards (business and industry even less so). This stand-off continues to dominate and a lot of environmental progress is hindered. It is important to note that this scenario does not conform to that usually used as a baseline in an economic analysis. Typically an economic analysis would define a baseline case under which existing trends and expected shifts are modelled to generate an estimate of how the world might look in the absence of particular policy changes. Economists typically refer to these as 'business as usual' or 'do-nothing' baselines. Other scenarios which embody such drivers such as policy change can then be analysed to assess their likely impact on recreational values. This is not the case here and economists or other decision makers should not infer that the GF scenario is a 'do-nothing' baseline. The present approach is justified by noting both that it refers to a very long time horizon over which modelling would be problematic and that the scenarios listed here are to some extent either aspirational or embody fears about the future.

- *Green and Pleasant Land (GPL)* is a storyline where the conservation of biodiversity and landscape are the dominant driving forces. Whilst it is recognised that biodiversity often provides essential benefits to society, its intrinsic value is accorded a pre-eminence in policy and legislation. A preservationist attitude arises because the UK can afford to look after its own backyard without diminishing standards of living. Tourism and leisure is consequently boosted by this drive and increases its share of overall UK GDP – and by the decline in popularity of many of late-20th century holiday destinations because of climate change (e.g., France, Spain and Italy). The countryside is very much a managed, cultural landscape but the focus is now on trying to maintain, protect and improve the aesthetic appeal. In general, landscape preservation often coincides with biodiversity conservation although one major source of conflict is between the importance of recognising habitat and ecosystem change and the preservation of landscapes.

- *Local Stewardship (LS)* has elements of *National Security* but is more environmentally benign under this scenario and although localism is a dominant paradigm, society is less nationalistic. Political power is devolved and many major issues are decided at a regional or local level (except crucial national aspects like defence); local timber and energy production is encouraged and there is great pride the numerous local food products. This scenario focuses on optimising resources and consumption is reduced to more sustainable (and healthy) levels - GDP is low but sustainable. The 'Tragedy of the Commons' would not be recognised in the UK; societal equity fits alongside environmental equity. People travel less and depend more on local resources; more of our food and leisure activities take place in the immediate locale. Technological development occurs in localised areas due to private innovation and a government initiative for developing sustainable technology. The implementation of the sustainable management of resources is a priority and society relies less on technological innovation. Low carbon economies spring up and there is greater use of alternative economies such as LETS (Local Exchange Trading Systems) schemes. Through local specialisation the UK becomes less homogenised - landscape become more distinct and even local economies vary considerably. Social and environmental regulation has advanced though, particularly in workers welfare and rights and in environmental protection. Although economic growth is slower compared to other storylines, the economy is more stable.

- Under the *National Security (NS)* scenario UK industry is protected from foreign investors and imports. Trade barriers and tariffs are increased to protect jobs and livelihoods in the UK; immigration is also very tightly controlled. Technological development is state funded and many industries are subsidised by the state (including agriculture). Food, fuel, timber and mineral resources are prioritised over biodiversity conservation. Climate change results in increases in global energy prices forcing many countries to attempt greater self-sufficiency (and efficiency) in many of their core industries. Britain is no exception and agricultural and other primary industries 'optimise' (rather than intensify) accordingly.

- In the *Nature at Work (NW)* scenario the conservation of biodiversity as an end in itself is less of a priority compared to maintaining and enhancing the output of ecosystem services. Adapting to climate change is also a priority, which means that some non-native species are introduced to provide food, energy or shade. A campaign of promoting ecosystem services in multifunctional landscapes as essential to maintaining the quality of life in the UK is now embedded in all walks of society (primary schooling all the way to large industry). Society accepts that some trade-offs have to be made and as a result becomes more environmentally aware. Habitat restoration and creation is seen as an important component of this campaign but the explicit conservation of species is sometimes overruled by a 'greater' ecosystem service benefit; this sometimes results in habitat conversion (e.g., semi-natural grassland to woodland). As well as carbon mitigation, an important focus is the enhancement of societies' resilience to climate change through 'ecosystem-based adaptation'. Modern technology is used were appropriate though and even genetically modified biotechnology is adopted if it can be shown to enhance ecosystem service provision. This includes the use of drought-tolerant crops to maintain production and reduce soil erosion. 'Optimal Service Provision' is important and many ecosystem services in the landscape are a result of careful examination of the trade-offs through scientific and community review.

- In the *World Markets (WM)* storyline unfettered economic growth through the complete liberalisation of trade is the main goal. International trade barriers dissolve, agriculture subsidies disappear and farming, for example, is now industrial and large-scale. Consumption in society is high which results in greater resource use and imports. There is competition for land and this coupled with reduced rural and urban planning regulations on housing, agriculture and industry mean that biodiversity is often the loser. Technological development in all industries is mainly privately funded but nevertheless is burgeoning. Food is cheap and plentiful but of low quality. As in land-based food production, food supplies from the seas are equally seen as source for exploitation without recourse to any sustainable management. Fish stocks plummet and a few species are wiped out. Most fish is imported from Asia. Desalination plants are built in areas on the east coast to meet water demand for the south and eastern counties. 'Home-grown' fossil fuel energy production is declining and has been overtaken by imports of gas from abroad and privately funded nuclear industry in the UK. Consequently, coastal areas are built upon to accommodate power plants and gas pipeline stations. Supplies of other ecosystem services increasingly become privatised.

Table 7: Mean land use coverage & population figures for Great Britain: Year 2000 Baseline and NEA 2060 Scenarios

Land use	Baseline	GF-H	GF-L	GPL-H	GPL-L	LS-H	LS-L	NS-H	NS-L	NW-H	NW-L	WM-H	WM-L
% coast	0.48	0.44	0.47	0.47	0.47	0.44	0.47	0.41	0.44	0.45	0.46	0.42	0.45
% freshwater	0.77	1.95	0.90	1.54	1.51	1.82	0.77	1.63	0.77	2.12	1.69	1.62	0.78
% grasslands	15.9	18.34	17.64	25.3	22.1	21.9	21.5	8.42	8.15	20.20	20.03	13.7	13.28
% mountains & heathlands	13.8	15.04	14.75	14.62	14.82	14.22	14.06	8.16	8.02	16.6	15.6	11.7	11.5
% other marine	7.08	7.12	7.09	7.09	7.09	7.12	7.09	7.09	7.08	7.11	7.11	7.46	7.35
% urban	6.72	7.61	8.06	6.74	6.71	6.36	6.50	6.95	6.81	6.61	6.72	14.3	14.57
% conifer wood	5.32	4.23	4.23	3.82	3.77	4.77	4.77	18.91	18.2	8.54	8.79	6.18	5.01
% broadleaved wood	6.34	9.76	9.37	11.06	11.94	7.69	6.73	6.40	7.21	10.57	10.57	5.25	5.75
% enclosed farmlands	43.5	35.5	37.49	29.25	31.53	36.6	38.06	42.04	43.22	27.75	28.85	39.32	41.2
LSOA mean population	1518	1781	1781	1543	1543	1524	1524	1660	1660	1612	1612	1831	1831
Change in total real income	0	+1.5%	+1.5%	+2%	+2%	+0.5%	+0.5%	+1%	+1%	+3%	+3%	+2%	+2%
Change in proportion retired	0	+20%	+20%	+22%	+22%	+19.5%	+19.5%	+19.5%	+19.5%	+20%	+20%	+21%	+21%

Notes: Cells are shaded so as to indicate the magnitude of change from the 2000 Baseline under each of the NEA Scenarios. Unshaded cells indicate that there is no significant change; Green cells indicate significant increases over the Baseline (with darker tones indicating more substantial increases); Red cells indicate significant reductions from the Baseline (with darker tones indicating more substantial reductions).

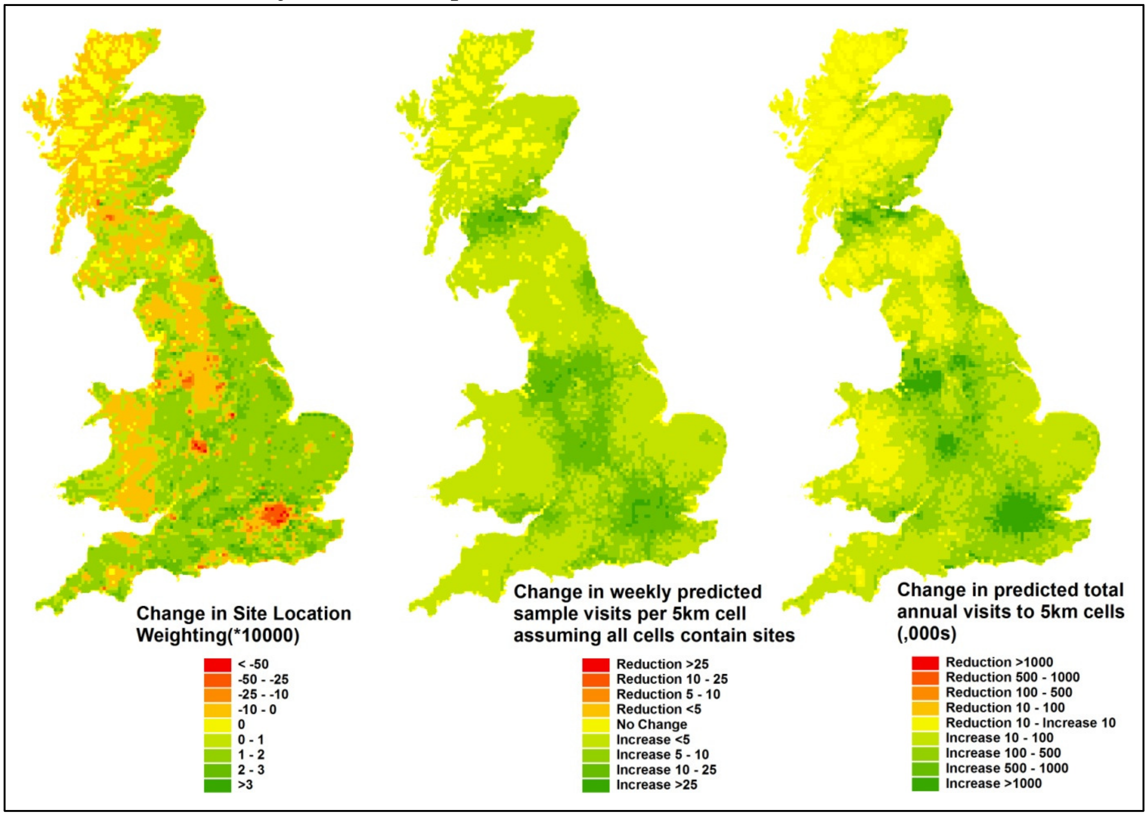
Table 7 above presents the average land use coverage and population figures for Great Britain for the baseline year 2000 and the various NEA 2060 Scenarios All of these scenarios have been further modified according to two different responses to climate change taken from the simplified UKCIP-09 Low and High Emissions Scenarios for 2050-2079. In sum then, we assess changes to all five of our ecosystem service related goods under twelve scenarios.

Recall that the GF scenario is not a conventional economic ‘business as usual’ baseline in that it does not attempt to model future trends based upon best available data (on policy and market trends and environmental change forecasts) but is rather a product of the ideologies summarised in the discussion given above. As such it does not constitute an acceptable baseline for comparison with other scenarios. Consequently all economic analyses in this report compare the situation envisioned in 2060 under each of the above scenarios with a consistent baseline for the year 2000. The valuation of changes under each scenario informs decision analysts of the trade-offs across the set of goods under consideration. Such information is clearly an important input to decision making.

4.4 Recreation valuation changes under the NEA Scenarios While Sections 2 and 3 discusses the development and estimation of our underlying models in some detail, it does not discuss their use within scenario analyses at any length. Therefore in this section we first describe a single such analysis in some detail. That methodology is then simply iterated to generate results for the remaining scenarios. Our more detailed discussions concern the estimation of values generated by moving from the Baseline situation to that envisaged under the high emissions variant of the Green and Pleasant Land (GPL-H) scenario.

The NEA Scenarios team envision the GPL-H scenario as one in which conservation of biodiversity and landscape are the dominant driving forces. There are substantial relative increases in broadleaved woodland, freshwater and grassland habitats and declines in coniferous woodland and enclosed farmland. Although overall population increase is modest, the proportion retired increases more than under any other scenario and incomes also rise substantially. Taken together these factors are expected to play out through the site prediction model and the trip generation function models to increase both the number and value of recreational visits. This is indeed what our analysis reveals as illustrated in Figure 7 which reworks the format of Figure 5, although now for the GPL-H scenario. The maps are now coloured such that decreases from the baseline are shown in red and increases are coloured in green. In both cases darker tones indicate more substantial changes from the Baseline.

Figure 7: Changes induced by a move from the Baseline to the GPL-H scenario in terms of the distribution of sites (LHS), the predicted number of day visits (unadjusted for sample size) to sites (centre) and the estimated total number of recreational day visits per annum across Great Britain (RHS; adjusted for sample size).



Considering the maps shown in Figure 7 the immediate observation is the dominance of green tones indicating increases over the Baseline. This is least true of the distribution of sites where both upland and high density urban locations witness declines. However, even here there is a noticeable increase in the prevalence of lowland recreational sites driven in major part by the increases in broadleaved woodland, freshwater and grassland habitats and declines in coniferous woodland and enclosed farmland in such areas. The contrast between high density urban locations and areas just outside those centres is particularly noticeable reflecting an increased availability of urban fringe recreational sites. This is taken advantage of by the increase in income and retirement populations reflected in the strong increase in predicted day visits. This overwhelms the reduction in intra-urban site availability to capitalise on the increase in urban fringe sites so as to generate very substantial increases in recreational values in all highly populated areas. Indeed it is only the more remote areas which do not experience increased recreational visit numbers under the GPL-H scenario. These visitor numbers are applied to the meta-analysis model to convert them into values taking into account the new habitat distribution envisioned under the GPL-H. Figure 8 maps this distribution of values which again is similar to, but not identical with that of the number of visitors, the difference being due to the variation in per visit values across habitats. Table 8 presents selected descriptive statistics regarding the change in the number of visits and their value generated by a shift from the Baseline situation to the GPL-H scenario.

Figure 8: Total value of annual predicted visits (£'000) under the GPL-H scenario

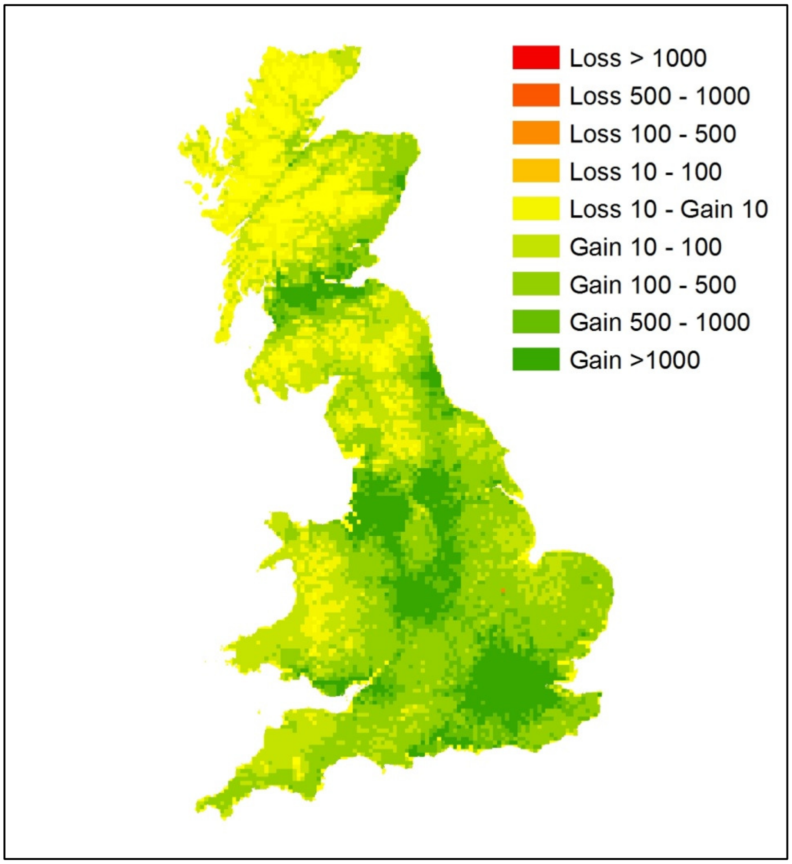


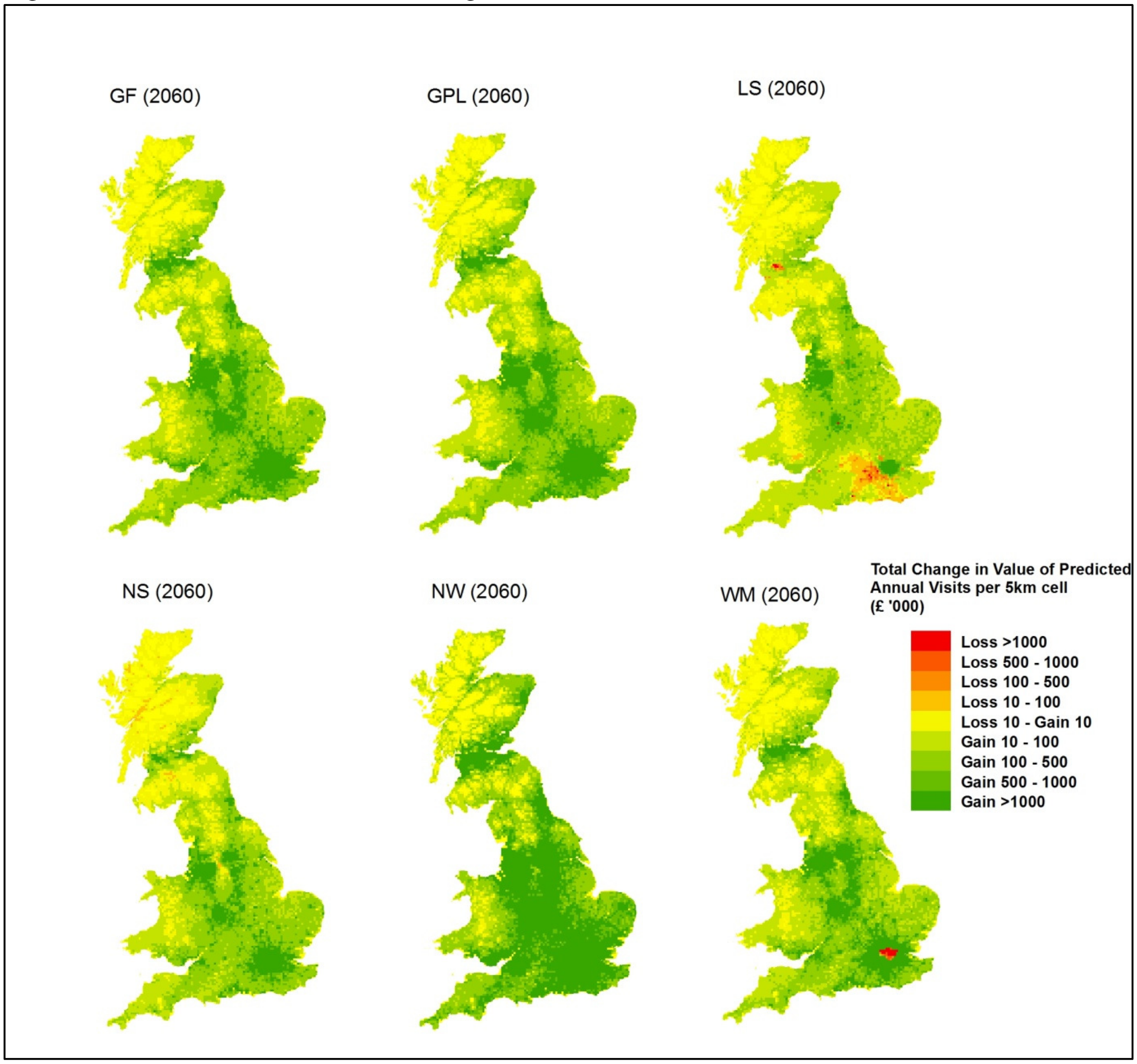
Table 8: Changes in the predicted total annual visit numbers and their total value arising from a move from the Baseline situation to the GPL-H scenario: Great Britain and its constituent countries ('000).

	Great Britain	England	Scotland	Wales
Predicted visit per annum				
Mean (No. per 5km cell)	199	277	77	54
Median (No. per 5km cell)	49	85	8	14
Country total	1,636,000	1,417,000	173,000	46,000
Value of predicted visit per annum				
Mean (£/5km cell)	628	871	249	173
Median (£/5km cell)	163	279	28	47
Country total (£)	5,156,000	4,451,000	556,000	149,000

Note: all changes are positive under this scenario analysis.

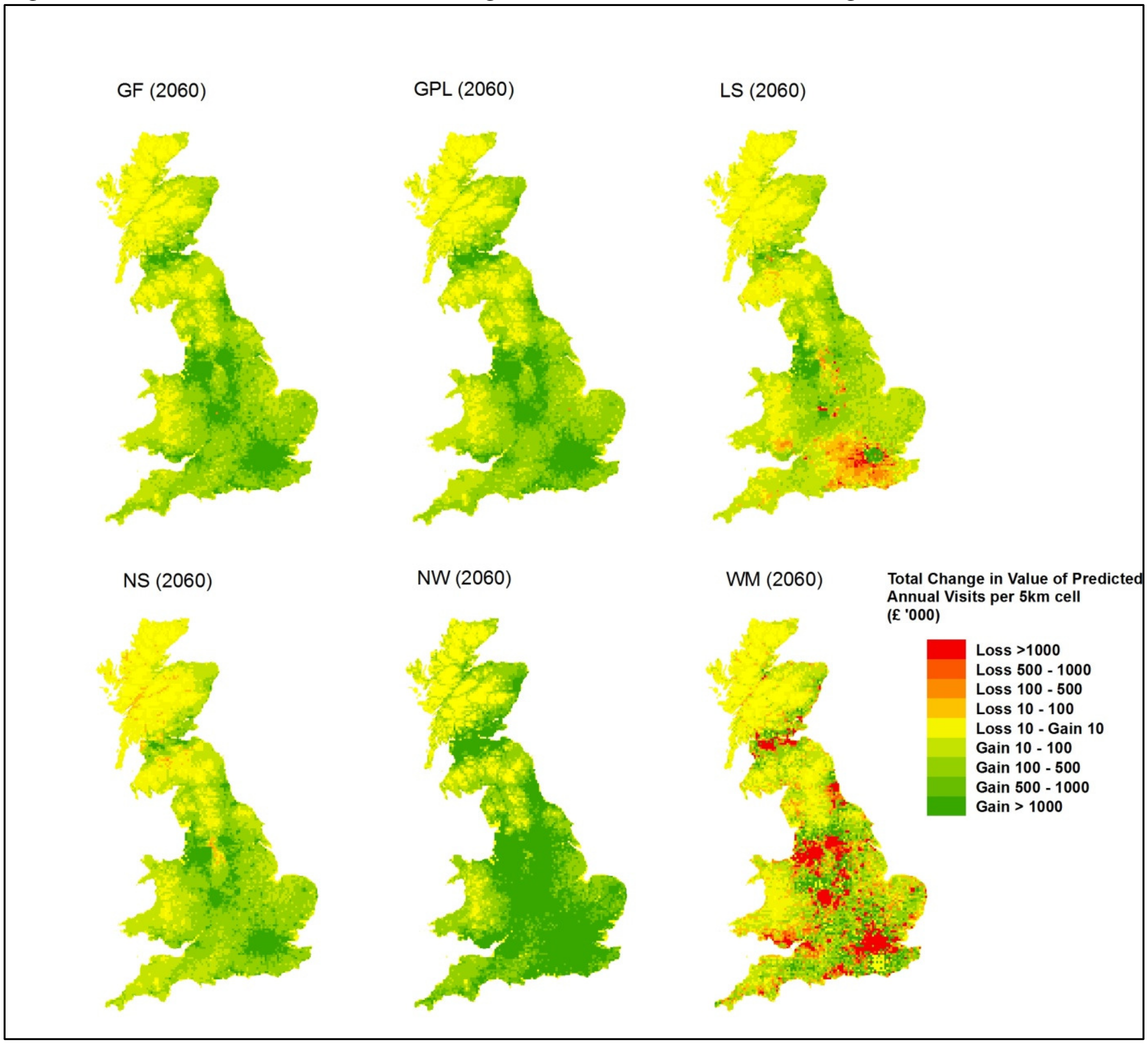
Inspection of Table 8 confirms the message of Figure 8, that the GPL-H scenario delivers a substantial increase in recreation values over the Baseline. We now repeat this analysis for each of the scenarios with the resulting distribution of values being mapped in Figure 9 for their low emission variants while Figure 10 repeats this for the high emission scenarios.

Figure 9: Total recreational value changes from the Baseline to all low emissions scenarios



Note: Scenarios are as follows:
GF = Go with the Flow
GPL = Green and Pleasant Land
LS = Local Stewardship
NS = National Security
NW = Nature at Work
WM = World Markets

Figure 10: Total recreational value changes from the Baseline to all high emissions scenarios



Note: Scenarios are as follows:
GF = Go with the Flow
GPL = Green and Pleasant Land
LS = Local Stewardship
NS = National Security
NW = Nature at Work
WM = World Markets

In general the maps shown in figures 9 and 10 are dominated by increases in visit values. The NW scenario displays the most substantial increases in the value of visits for large areas of GB both at high and low emissions. These gains are followed by those under the GPL scenario which are a little higher than those under GF. 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 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 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. The WM scenarios probably show the greatest difference both in comparison to the other scenarios and also in the response to high and low emissions. In both high and low scenarios London shows a very large decrease in value of visits with similar decreases in predicted visit value also seen in other urban centres across the country. However, in the low emissions scenario the urban areas outside of London are expected to experience an increase in the value of visits. In all cases the remote uplands of Scotland, because of their inaccessibility, remain unvisited and show no change in value.

Table 9 summarises the national level changes in value arising between the baseline and each of the scenarios. At this national level all of the scenarios generate increases in the annual value of visits except for the WM-high emissions scenario. In general, we find large gains under the NW, GPL and GF scenarios and moderate increases for the LS scenario.

Table 9: 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	Baseline (million £)	GF (million £)		GPL (million £)		LS (million £)		NS (million £)		NW (million £)		WM (million £)	
		high	low	high	low	high	low	high	low	High	low	high	low
England	8854	3624	5048	4451	5327	898	1400	3061	4125	21084	21428	-678	4398
Scotland	926	370	488	556	602	162	84	189	249	2262	2190	-61	517
Wales	260	127	174	149	174	38	52	94	119	568	547	-84	122
Great Britain	10040	4121	5711	5156	6103	1098	1535	3344	4493	23914	24165	-823	5037
Great Britain population (millions)	55.4	62.8	62.8	65.6	65.6	74.5	74.5	67.5	67.5	62.0	62.0	72.4	72.4
Great Britain per capita values (£ p.a.)	181	14	36	61	76	-1	6	17	34	337	341	-57	21

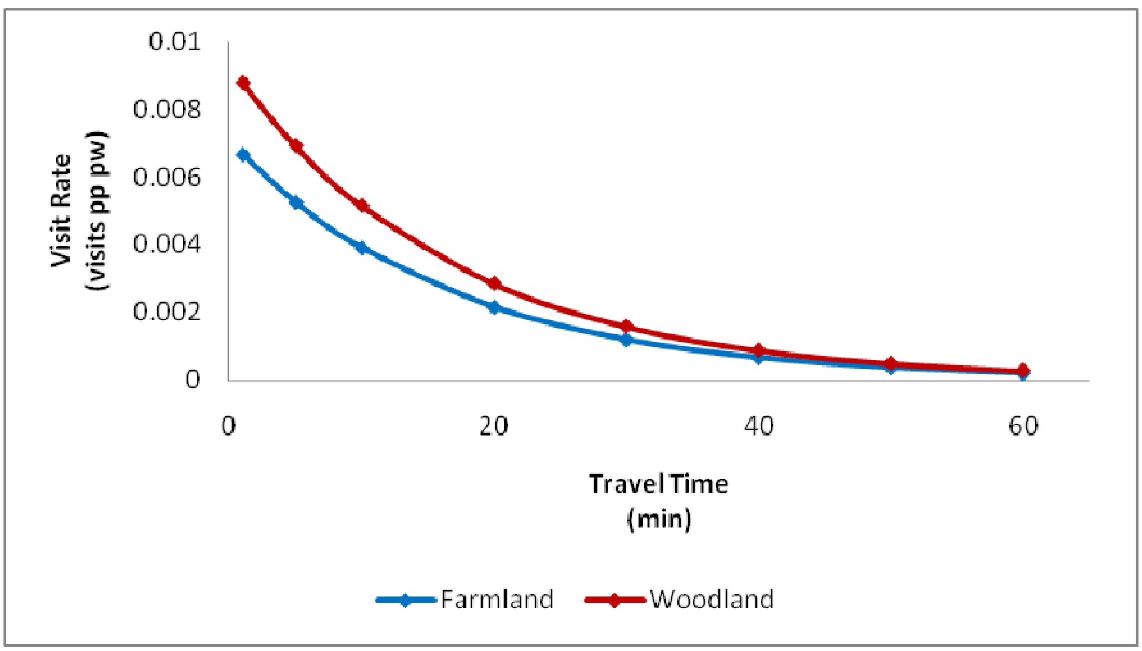
Note: Scenarios are as follows:
GF = Go with the Flow
GPL = Green and Pleasant Land
LS = Local Stewardship
NS = National Security
NW = Nature at Work
WM = World Markets

The last row of Table 9 divides the Great Britain level values under the Baseline and each scenario by the Great Britain population to obtain per capita values. These adjust the national level results for the increases in population envisioned to occur, at different rates, under all scenarios. While the NW scenario yields the highest per capita value, this analysis substantially differentiates the GPL and GF findings showing that, on a per person basis, the former more than double the value of the latter.

5. Case Study

Our case study considers a simple scenario in which a policy maker has the funds to convert a single area of farmland into recreational forest and wants to know where best to locate that forest. For this simple illustration we bypass the site prediction model (SPM), which is mainly of use when we seek to transfer findings outside England to the rest of the UK (a stage considered in the Valuing Changes in Ecosystem Services chapter). Therefore we omit this stage and move straight on to applying the trip generation function. The estimated trip generation function reported in Table 2 shows that woodland is significantly more attractive to recreational visitors than enclosed farmland (the base case for that model). However, the strong influence of travel time shows that both land uses become relatively less attractive the further away a site is from an outset location. This is illustrated in Figure 11 below which shows the predicted visitor rates for each of these land uses at different travel times.

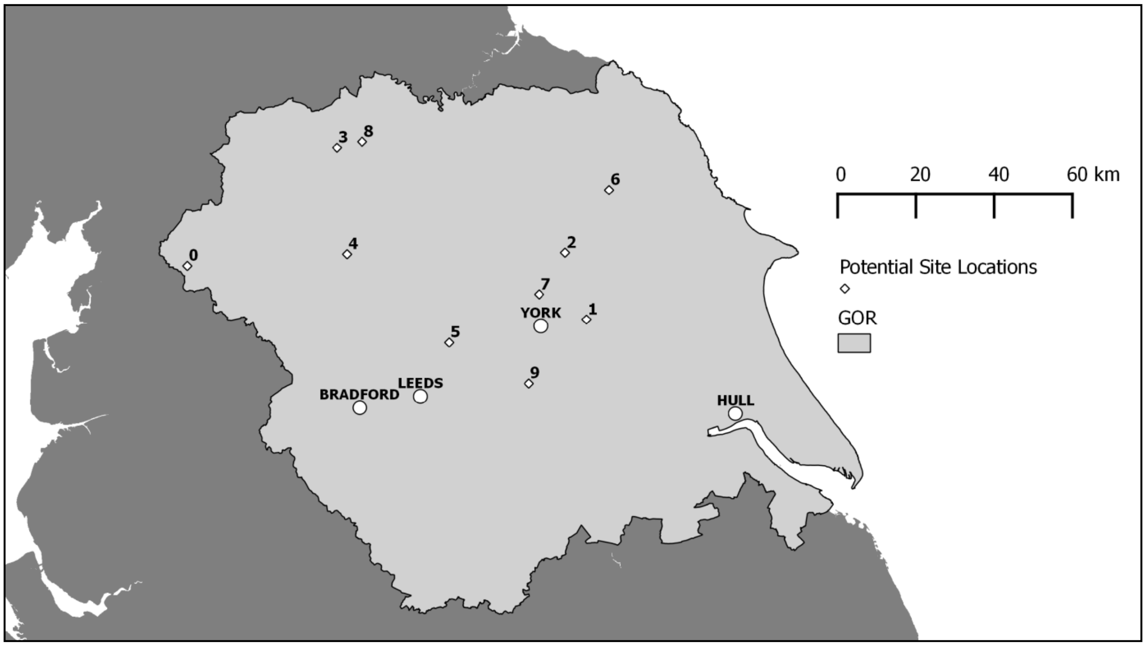
Figure 11: TGF predictions: Travel time impacts on visit rate for woodland and farmland sites



Source: Sen. et al (2011) and the SEER project.

Figure 11 demonstrates not only that woodlands attract more visitors than farmland, but also that there is a strong distance decay in these visit rates. This means that the location of sites will significantly determine the number of visitors they attract. We apply our methodology to examine how the recreational values created by converting enclosed farmland to woodland will vary depending upon the location of that conversion. For simplicity we illustrate this by considering the consequences of placing our new forest in ten randomly chosen locations across the North Humberside area illustrated in Figure 12. If we were undertaking a formal review of such a scheme then this process would be iterated for all potential sites across the entire area (a process which is rapid and straightforward given modern computing speeds) so as to identify the optimal location for such a scheme.

Figure 12: Location map for ten randomly assigned land use change locations



Source: Sen. et al (2011) and the SEER project.

For each of the randomly chosen land use conversion sites we calculate the various substitution measures needed for the TGF. These are added to data on site characteristics and the socio-economic and demographic variables included in that model. Applying our TGF visit rates to each location, first under its present agricultural land use and then under woodland, we can estimate the change in visit numbers generated by the land conversion policy. The final stage of our analysis is to use the meta-analysis model to value predicted visits to each site under the current land use which is farmland and under the change in land use which is woodland.

Table 10 presents results from the above illustrative analysis. As can be seen, in each of the ten locations considered, the number of visits increases when the land is converted into woodland. However, the magnitude of this change and the value they generate varies substantially across locations. Site P9 yields the highest increase in value from this change in land use while site P4 provides the lowest value. Clearly incorporating spatial variation into decision making is a vital aid to efficient resource allocation, particularly in a time of austerity.

Under a cost-effectiveness analysis this would conclude our assessment. However, a full economic cost-benefit analysis would supplement this recreational value with the other market and non-market benefits generated and set this against the costs of each scheme in each location. Because costs such as the loss of agricultural output values will also vary spatially, it is not necessarily the case that the site which generates the highest recreational value is necessarily the optimal location for such land use conversion. Nevertheless, given the prevailing shadow value of agriculture it seems very likely that many of these sites, if chosen, would pass benefit-cost tests (although note that there is a substitution effect here; once one new site is created this forms a substitute for, and lowers the value of, any other proposed site in the vicinity – our methodology can readily be automated to permit the capture of such effects within the decision analysis system). Why then do such sites not presently exist? This is, in part, a reflection of market failure; at present land users are not compensated for the recreational and other non-market benefits they provide and hence such services are, from a social optimality perspective, under supplied. It is the task of government to address such market failures through incentives or other mechanisms (including the removal of market imperfections and distortions which perversely often reinforce the problems of missing markets for environmental goods).

Table 10: Predicted increase in recreational visits and valuations at alternative sites conversion from farmland to woodland (£/year, 2010 prices)

Site No. →	P0		P1		P2		P3		P4	
Description	Very remote site but near to rural A road		Close to York		A little remote and with substitutes like P7 nearer to York		Slightly further from Middlesbrough than site P8		Very remote and with no nearby major roads	
Travel Bands (min)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)
1	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
10	0	0	195	643	0	0	0	0	0	0
20	162	537	541	1788	0	0	595	1967	0	0
30	241	796	3159	10444	90	298	451	1492	0	0
40	201	664	602	1991	251	830	1004	3318	33	111
50	931	3076	1042	3445	875	2891	958	3168	28	92
60	709	2342	1671	5523	290	957	822	2719	67	222
Total	**2243**	**7414**	**7210**	**23834**	**1506**	**4977**	**3831**	**12664**	**129**	**425**

Site No. →	P5		P6		P7		P8		P9	
Description	Midway between York & Leeds with good road links		Remote site but near to rural A road		Very close to York		Quite near Middlesbrough but no main road link		Midway between York & Leeds with excellent motorway links	
Travel Bands (min)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)	Extra Visits (per annum)	Value of Extra Visits (£ per annum)
1	0	0	0	0	0	0	0	0	165	545
5	0	0	261	862	0	0	0	0	130	431
10	0	0	292	965	584	1930	0	0	0	0
20	1028	3398	271	894	2705	8942	866	2862	1948	6438
30	3581	11836	361	1194	2046	6764	301	995	4574	15119
40	4601	15209	402	1327	719	2378	1389	4590	4852	16039
50	4643	15349	996	3291	1740	5752	968	3199	4718	15595
60	2183	7215	590	1949	1914	6326	1091	3608	3372	11148
Total	**16036**	**53008**	**3171**	**10483**	**9708**	**32092**	**4614**	**15253**	**19759**	**65315**

Source: Sen. et al (2011) and the SEER project.

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