Natural Environment Valuation Online Tool

Technical Documentation

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Chapter 4: Recreation Model

Land, Environment, Economics and Policy (LEEP) Institute

University of Exeter

Corresponding authors

Brett Day brett.day@exeter.ac.uk

Amy Binner a.r.binner@exeter.ac.uk

Nathan Owen n.e.owen@exeter.ac.uk

Authors

Brett Day

1. Introduction

Estimates of recreation visits and values within NEVO are derived from ORVal (Outdoor Recreation Valuation) model. The technical details of the estimation of that model can be found in Day and Smith (2018). In this document we provide a high level overview of the model, how it issued to provide estimated of recreational activity and the value of that activity, and how the model is used in NEVO Explore, Alter and Optimise calculations.

2. The ORVal Recreation Demand Model

The ORVal recreation demand model is a statistical model that can be used to predict the number of visits that are made by adult residents of England to different greenspaces. The model adjusts its predictions according to a number of factors, most particularly the socioeconomic characteristics of people, the day of the week, the month of the year, the attributes of a greenspace and the availability and qualities of alternative greenspaces.

The model is estimated from data collected in the Monitor of Engagement with the Natural Environment (MENE) survey. The MENE survey provides information on the recreational behaviour of a large, representative sample of adults (over 16 years of age) resident in England. Over the course of a week, each respondent records when they visited greenspaces and for one randomly-selected visit the exact location of that visit.

The fundamental assumption of the model is that the choices observed in the MENE data are somehow welfare-maximising. By 'welfare' we are referring to the sense of well-being or utility that an individual feels from their experiences. So when an individual is observed to have taken a trip to enjoy greenspace, we assume that the welfare of taking a trip at that time exceeds the welfare of doing something entirely different (say watching the TV or going shopping). Likewise when an individual is observed to have chosen a visit to one particular recreational site, we assume that the welfare derived from that visit exceeds the welfare that would be enjoyed from visiting an alternative site. Our model seeks to use that information to build a function which describes the welfare an individual gets from making different recreational choices. Indeed, it is this welfare function that is used in NEVO to estimate the welfare values generated by different landcovers experienced at open access greenspaces.

In the model, a large number of variables are used to capture important arguments in the welfare function. For example, the welfare that a person gets from taking a trip is modelled as depending on a person's socioeconomic characteristics, the location in which they live, the day of the week and the month of the year. In a similar vein, the welfare derived from visiting a particular greenspace is modelled as a trade-off between the benefits of enjoying time at that site and the costs incurred in getting there. In the model, those on-site benefits depend on the size, land covers, water margins, designations and points of interest that characterise a particular greenspace. In addition, the model assumes that people have a choice of how to get to a recreation site; either by car (or, more generally, motorised transport) or on foot (or, more generally, under their own steam). That travel to sites generates a cost particularly in terms of the opportunity cost of travel time but also, for driving, in terms of incurred fuel costs. Those costs are estimated for each individual for trips to each possible site using fast processing routing algorithms that calculate fuel consumption and expected travel time which can be turned into costs be multiplying through by the cost of fuel and opportunity cost of travel time taken from Department for Transport estimates (Department for Transport 2014).

While the data provides lots of information from which to estimate the welfare benefits of visiting greenspace our model is still statistical. Ultimately, we are able to use the model to make probabilistic predictions; how likely is it that a person with particular characteristics living in a particular location will choose to take a visit to greenspace on some particular day? How likely it is it that on that day a person will choose to visit each of the multitude of accessible greenspaces available to them, given the characteristics of each of those greenspaces and the costs of travelling to them?

1. ORVal Greenspace Map

The ORVal recreation demand model works in conjunction with the ORVal greenspace map, a detailed spatial dataset compiled through the combination and manipulation of a large number of primary data sources that describes the location and characteristics of accessible greenspace across England. Construction of the ORVal greenspace map is provided in Day and Smith (2016).

The ORVal greenspace map identifies some 129,575 greenspace sites in England that could form the focus of a recreational trip. Those greenspace sites come in three basic forms;

- parks which consist of areas of accessible greenspace within well-defined boundaries over which visitors usually have freedom to wander at will,
- paths which consist of accessible, walkable routes that pass through the landscape, often traversing a variety of different greenspaces and tending to restrict visitors to defined routes of passage.
- beaches.

Each recreation site is described by various aspects of its physical characteristics; particularly the site's dimensions, landcovers, designations and points of interest.

3. Predicting Visits

The Recreation Demand Model can be used to estimate and predict visits to greenspaces. In particular, the model allows us to predict how likely it is that an individual will take a trip to a particular greenspace on a particular day. That likelihood differs according to the socioeconomic characteristics of the person, the attributes and proximity of the greenspace and the attributes and proximity of alternative recreational greenspaces.

To generate estimates of the annual number of visits to a particular greenspace we draw on data from the 2011 UK census and on population estimates for 2016. For each of the more than 32,844 Lower Super Output Areas (LSOAs) in England, that data allows us to estimate the number of adults in each of socioeconomic group (where those groups are social grades AB, C1, C2, and DE). Visitation predictions for a particular greenspace are reached through the following set of calculations:

- For each socioeconomic group in an LSOA, we use our model to calculate the probability of taking a trip to the focus greenspace on a particular day at a particular time of year.
- Adding those probabilities up for each individual from each socioeconomic group in an LSOA provides an estimate of the expected number of visits from that LSOA to that greenspace on that day.
- Given visitation varies across months and days of the week, we reach an annual visitation figure from an LSOA by summing expected visitation numbers calculated for each different day of the year.

- Finally we repeat those calculations for each of the 32,844 LSOAs in and sum the results to arrive at a final prediction of the annual number of visits to a particular greenspace.

Estimating visitation rates for a new recreation site simply entails performing those calculations for the new site. Likewise, In order to estimate changes in visitation that arise from altering the attributes of a particular greenspace, we compare visitation levels estimated before and after the change in attributes.

In addition to predictions of annual visitation, the ORVal recreation demand model also returns predictions of how those visits are divided up across the two different modes 'by car' or 'on foot'.

4. Predicting Welfare

The ORVal recreation demand model can be used to estimate welfare values for greenspaces. By 'welfare value' we mean a figure describing the monetary equivalent of the welfare enjoyed by individuals as a result of having access to a greenspace. In economics this welfare value is often alternatively called an 'economic value' or a 'willingness to pay'. Welfare values are useful for decision-makers in applying cost-benefit analysis to appraise projects that impact on greenspace.

Our calculation of welfare values is enabled by the fact that the recreation demand model provides an estimate of the recreation welfare function. That function identifies how much welfare an individual enjoys as a result of beneficial attributes of a greenspace (e.g. the extent of woodland, the presence of a children's playground). Likewise, it identifies how much welfare is lost from each extra pound of cost incurred in travelling to a greenspace. The latter amount is crucial in calculating welfare values. It tells us the amount of welfare a person considers is equivalent to having one extra pound. In other words, it provides an exchange rate that we can use to convert estimates of changes in welfare into equivalent amounts of money.

Welfare values for an existing site are estimated by calculating how much each individual's welfare would fall if they were no longer able to access that site and then converting that welfare quantity into an equivalent monetary amount. Those welfare values can then be aggregated over the adult population of England and Wales for an entire year using the same sequence of steps as used to aggregate estimates of visitation.

Estimating welfare values for a new site follows the same logic. First we calculate, the welfare gain enjoyed by adding this new site to the set of greenspaces available for individuals to visit. Then we convert that to a money equivalent and aggregate to give an annual figure for the whole population. Likewise, the welfare value of a change in greenspace attributes is calculated by aggregating monetised estimates of the welfare changes expected from that change in attributes.

5. NEVO: Recreation Values and Visits in Explore

The recreation visits and values presented in the NEVO tool are based on aggregating those quantities for each greenspace in each 2km^2 grid cell.

Since some parks span cell boundaries, the visits and values for parks are apportioned to each cell in proportion to the area within each of those cells.

The apportioning of visits and values to the cells that a path traverses is somewhat more complicated. Values and visits for paths are related to the access point through which visitors enter a path network. The ORVal model assumes that the maximum distance a recreationist will walk from that access point on a day trip will be 10km. Clearly, individuals are more likely to pass along sections of the path network that are near to the access point that further away. Indeed, to capture this fact in the model, we divide each path up into 25m stretches and ascribe a series of weights to each stretch; the first 25m stretch leading from an access point is given a weight of 1 and that weight declines linearly for connected stretches of paths at greater distances until stretches at a distance of 10km or more are given a weight of 0. Imagining that each stretch can be equated to a 25m[2] area (or 0.0625 ha) we can calculate a weighted aggregate area accessible from each path access point. Formally we can write the area ascribed to path access point *p* as:

$$area_p = \sum_{s \in S_p} 0.0625 \times (1 - w_{s,p}) \quad where \;\; w_{s,p} = \begin{cases} d_p/10 \;\; if \; d_p \leq 10 \\ 0 \qquad otherwise \end{cases} \tag{1}$$

Where S_p is the set of path stretches s that are accessible from path access point p, $w_{s,p}$ is the weight ascribed to stretch s in calculating the area of path accessed from p and $d_{s,p}$ is the straight line distance in kilometres from access point p to the start of stretch s.

Since the ORVal model returns visit and value estimates associated with each access point, we use (1) to apportion those values across the different 2km[2] cells traversed by the path accessed through that location. In particular, the proportion of those visit and value quantities allocated to each cell is calculated a the weighted 'area' of path in each cell divided by the total weighted area ($area_p$).

5. NEVO: Recreation Values and Visits from Alterations in Landcovers

Alterations in NEVO that lead to changes in landcovers may have impacts on recreational visits and value flows. If users request returns from the recreational model then estimate of those changes in visits and values are returned. In the recreation model options, NEVO allows for three different assumptions regarding how changes in land uses impact on recreational;

- Alter Current Paths: Here we assume that there is no change in the set of accessible greenspaces. Further, we assume that there is no change to the landcovers of existing parks or beaches in the cell being altered. Accordingly, with this option the only recreational impact occurs through changing the landcovers through which current paths pass. The recreation model calculates how those changes in landcover impact on the recreational value and visits to those existing paths.

- Provide New Paths: Here we assume that landcover changes resulting in new woodland or new natural grass are made accessible to the public through new path access. No changes are experience on existing paths and parks. The length of the new paths is calculated as the circumference of a circle equal in size to the area of new natural grassland and woodland and the land covers accessed by that path are in proportion to the relative size of the neww grassland and woodland.

- Provide New Parks: similar to the 'new paths' option here we assume that landcover changes resulting in new woodland or new natural grass are made accessible to the public as new parks.

In the ORVal recreation demand model making these calculations for many new recreation or changed recreational sites is highly computer intensive. Accordingly, within NEVO we use a fast running approximation. The central bottle neck in the calculations is that the model needs to calculate travel costs from each new/changed site to each of the 32,488 LSOAs across England. Of course most of those LSOAs are so far from the new/changed site, that their residents experience no change in recreational value. Accordingly, in a pre-processing step, we work through each of the $2km^2$ cells in England placing a new 50 ha site made up of an equal share of woodland and grassland at the centre of the cell. We then calculate the additional welfare value generated by that new site for the residents of every LSOA. That allows us to identify the 50 LSOAs that experience the most welfare gain from changes either because of their proximity to the new site, the size of their populations, the socioeconomic characteristics of those populations or some combination of all those elements. In testing we found that in nearly all cases the vast majority of the welfare gain was experienced with those 50 most-impacted LSOAs.

To increase the speed of NEVO, therefore, we only carry out calculations of recreational visit and value changes for the 50 most-impacted LSOAs for each cell experiencing land cover change. Moreover, further time savings are achieved by storing the travel costs from each cell to its 50 most-impacted LSOAs along with other quantities for each of those LSOAs used in the visit and value estimates that can be pre-calculated for each LSOA. Restricting attention to the 50 most-impacted LSOAs and pre-calculating travel costs and other elements of the calculations results in huge speed-ups in NEVO estimation of changing recreational visits and values.

One last thing to note about the recreation calculations is that when changes are made across numerous cells creating or changing a number of sites the NEVO calculations assume those changes happen simultaneously. In other words, the residents of the set of most-impacted LSOAs are assumed to experience all of those changes. Accordingly, our calculations returns an aggregate welfare value for the residents of an LSOA for that set of changes across sites that are located in potentially numerous $2km^2$ cells. In that case, the values are allocated back to the cells in proportion to the share of visits to those change cells from that LSOA.

References

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