A spatially explicit national demand model for forest recreation in Ireland

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Abstract

Forest benefits are now commonly understood through the ecosystem service framework. Recreational visits to forests, considered an important cultural service, have been the target of a significant proportion of the non-market valuation literature to date. Such models have evolved from relatively simple travel cost models to employing GIS to develop spatial demand models. Due to restrictions on accessing private land, forests are a particularly important recreational resource in Ireland as those which are publicly owned are accessible to the public and free to use. In addition, recent policies directed at private forests have included attempts to encourage owners to open their forests to the public. This study outlines the development of a spatially explicit recreation demand model for Ireland that describes how visitation differs across the population based on population characteristics and existing recreational resources. The model combines a zero-inflated negative binomial model of annual forest visits of a random sample of individuals with a simulated population model of Ireland and spatial data on household location. The results include an estimation of annual forest visitation and the development of a demand map that highlights where forest expansion could be targeted to maximise the recreational value of afforestation.

Keywords Forestry, Recreation demand, GIS

JEL code Environmental Economics: Valuation of Environmental effects Q51

Introduction

European forest policy is increasingly following an ecosystem services approach which requires exploring the flow and nature of benefits supplied by forests (Maes et al., 2013). Understanding these services in a spatial context facilitates a better understanding of potential conflicts and complements that can be achieved in land use management. Recreation is a well-recognised benefit of forests and has been a popular target of non-market valuation studies for some time (Zandersen and Tol, 2009). The development of recreation models has by definition involved spatial variables, such as distance, but this has been extended to spatially explicit maps of expected visitation (Bateman et al., 1999). This move has facilitated more complex approaches to modelling and valuing recreational visits across different ecosystems (Sen et al., 2013). It has also created opportunities to incorporate substitute sites into models and to target land use change to maximise the value of associated services (Brainard et al. 2001; Gimona and van der Horst, 2007). Such a spatial approach to understanding the use of ecosystems is of unquestionable value. However, an essential requirement for this is the availability of data concerning the current extent and location of recreational resources. Data on the type and level of facilities they contain or their characteristics can also be invaluable to researchers seeking to explain use patterns and the valuation of resources (Scarpa et al., 2000).

Ireland has one of the lowest levels of forest cover in Europe but one of the fastest rates of forest expansion (Upton et al., 2014). Similar to other European countries, research in Ireland has begun to focus on deriving values for forest related ecosystem services. Recreation is a well-recognised forest ecosystem service in Ireland and a limited number of studies have sought to examine the use of forests by the public and the values they place on visits and access (Scarpa et al., 2000; Cullinan et al., 2011). Irish forests are managed by a number of agencies. Coillte teoranta, the Irish forestry board, is by far the biggest forest owner in Ireland, managing over 445,000 ha of land, and it operates an open access policy. However, only specific forests are advertised as recreational areas. The National Parks and Wildlife Service also manage a number of forests which are important recreational resources. A third group of public forest owners are individual local authorities, which manage a number of important recreation forests particularly on the outskirts of urban areas. Privately owned forests are not generally accessible to the public but a small number of owners promote recreation as a paid service and others may tolerate access. Recent changes to the grant paid for road building requires forest owners to allow access to roads that are grant aided under the scheme. To date, the quantification of forest recreational use in Ireland has tended to focus on individual forests or on those owned by Coillte. Although high-quality spatial data is available describing forest cover in Ireland, these data lack information as to the accessibility of forests for recreation, although some limited data are available for Coillte forests. Thus no map of forest recreational resources at a national level currently exists for Ireland. In the context of ambitious afforestation targets, increasingly diverse ownership structures and the adoption of ecosystem service focused policies, the quantification of current recreational resources and usage is essential.

The primary aim of the study is to develop a spatially explicit forest recreation demand model and map for Ireland. This involves combining a model of recreation demand derived from household survey data with a simulated population model and national household coordinates. A map of existing forest recreation resources is developed by combining open source data on recreational trails with a national data set of forest cover.

Methodology

The primary data source is a household survey conducted in 2010 of a representative sample of Irish individuals which included a question pertaining to the number of forest visits made by the individual in the previous twelve months. This differs from previous approaches to this issue in that the data are not linked to a specific location and not limited solely to users. Thus, it is possible to explore the factors which impact on generic forest visits and non-visitation across the population. The survey also included socio-demographic questions and recorded the coordinates of the respondent's household with their permission.

Distance to a recreational forest is expected to be one of the primary factors in explaining visitation rates but no comprehensive map of accessible forests in Ireland currently exists. For research purposes, a coarse map of recreational forests was derived by combining forest cover data from the Irish Forest Service with user generated data on walking paths from openstreetmap.org (© OpenStreetMap contributors). Forest polygons were intersected with the polylines describing walking paths to identify forests which are accessible to the public for recreation. The direct distance between each respondent and the closest recreational forest was then calculated. As urban areas are likely to offer more recreational opportunities and thus impact on whether a respondents visits a forest or not, respondents households were also identified as being in urban areas (based on CORINE 2006 data) or not.

Visitation data takes the form of discrete, non-negative integers and count models, such as those based on the poisson or negative binomial distribution, are recommended to model such data (Hellerstein and Mendelsohn, 1993; Haab and McConnell, 1996). The negative binomial model is similar to the poisson but is not bound by equal mean and variance and so can account for over dispersed data. Household survey data may include both users and non-users and can thus include a large number of zero observations, representing non-visitors. In the presence of excess zeros, researchers have a number of options but frequently employ a zero inflated or hurdle model approach depending on the nature of the model. Where zero observations are deemed to stem from both structural and sampling sources a zero-inflated model is preferred as it does not assume that all zeros stem from a different decision process (Ridout et al., 1998; Hu et al, 2011). The zero-inflated negative binomial model (ZINB) assumes that the decision involves two processes and distributions, one binary, such as a logit model, and one related to the count which follows a negative binomial distribution (Greene, 1994)

Of the sample of 996, 38% of respondents had not visited a forest in the previous 12 months. Respondents who made no trips in the previous 12 months were asked why they hadn’t and the reasons given were a mixture of structural (e.g. There are no forests close to my home) and sampling (e.g. I prefer to visit other places) factors. Thus a zero-inflated model was deemed to be the more suitable than a hurdle model which assumes the observed zeroes are structural in nature i.e. people who will never visit forests. A zero-inflated negative binomial model was identified as the most suitable model given the presence of excess zeros and the skewed nature of the data.

The Simulation Model of the Irish Local Economy, or SMILE, is a spatial microsimulation model for the population of Ireland which has been adapted to specific research needs (O'Donoghue et al., 2012). For this study a simulated population of adult individuals based on small area census data from 2006 was employed. Although not linked to specific household locations, SMILE is generated at the electoral division level. Using the coefficients from the visitation model, annual visitation per simulated individual in Ireland was calculated setting the forest distance to zero. This figure was then averaged across each electoral division. The geodirectory is a directory of coordinates for each building in Ireland. The average visitation per individual was assigned to each household location in the corresponding ED and the direct distance between households and the closest recreational forest was calculated. The forest distance coefficient was employed as a decay factor to examine expected current visitation amongst the population based on their simulated characteristics and proximity to a recreational forest. Thus, the simulated characteristics of individuals in each ED are combined with the distance between households and recreational forest location to generate a more accurate estimate of expected annual visitation. A generic spatially explicit demand model was then generated by calculating the expected visitation at all points on a 1km by 1km grid across the country. Thus it is assumed that visits will be made to only one location and substitute sites are currently not accounted for in the model.

Results

Table 1 displays the results of the zero-inflated negative binomial model. Age, socio-economic status, distance to the nearest recreational forest and having access to a car all had a significant impact on visitation. The results of the ZINB model can be interpreted in two parts. Looking first at the inflation section model which examines factors that impact on the observed structural zeros, age, access to a car and living in an urban area all had a significant impact. Age and its square were included in the model and the coefficients suggest that older people are less likely to make no forest visits but that this effect is non-linear. Respondents with access to a car and those living in urban areas were also found to be less likely to make no visits in the previous twelve months. The count section of the model identified age, social class, access to a car and distance to the closest recreational forest as significant variables which impacted in the number of visits made by respondents. Age again took a non-linear form but the results suggest that visitation decreases for older respondents. Social class was found to have a positive impact on visitation with A, B and C classes having higher visitation than E, D and F classes. Having access to a car had a relatively large positive impact indicating transportation may be an important issue in understanding visitation rates. Finally, distance to the closest recreational forest was found to have negative impact indicating that the further individuals live from an accessible forest the lower their visitation rates.

Table 1 Results of ZINB model

Variable	**Coeff.**	**St. Err.**
Neg. binomial		
Constant	3.291	0.586**
Age	-0.094	0.026**
Age^2	0.001	0.0002***
Socio.-Econ. A	0.892	0.289***
Socio.-Econ. B	0.641	0.185***
Socio.-Econ. C	0.521	0.151***
Closest forest (km)	-0.105	0.016***
Access to car	1.633	0.589***
Logit		
Constant	9.358	4.056**
Age	-0.539	0.206***
Age^2	0.006	0.002***
Access to car	-2.092	1.027**
Urban area	-3.105	1.218**
N_{Total}	991	
N_{Zero}	375	
LL	-2751.24	
Pseudo R^2	0.024	

* $p < 0.10$; ** $p<0.05$;*** $p < 0.01$

Figure 1 displays the total expected number of trips made by the simulated populations in each ED based on their characteristics and proximity to existing forests. Average visitation across the original sample was 11 which would result in an estimate of c.38 million forest visits annually based solely on the population. Total visitation estimates based on the model outputs are c.27 million indicating that a failure to account for differences in population characteristics and the amount of existing recreational resources would result in an overestimation of the annual number of forest visits. Figure 2 displays the average visitation across the population setting the forest variable to zero i.e. assuming a forest is located adjacent to individuals. This shows the impact of respondent characteristics, while ignoring proximity to resources, with average visitation across EDs varying between 9 and 15 per annum.

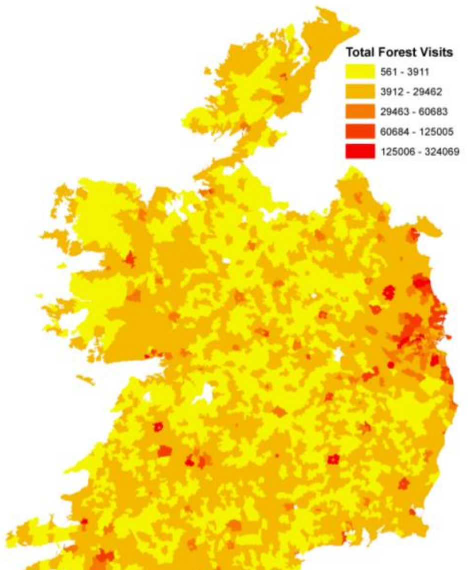

Figure 1 Total demand from each ED

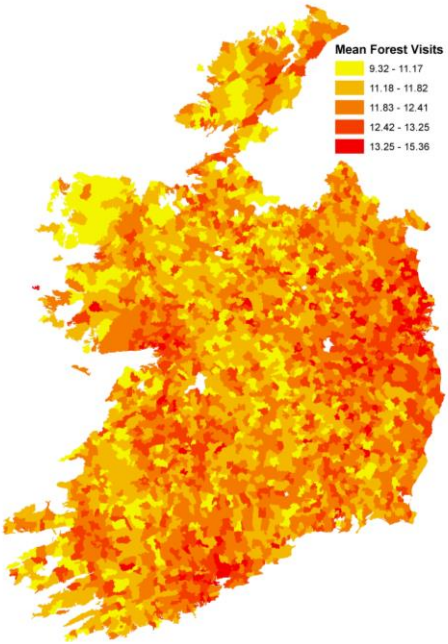

Figure 2 Mean demand from each ED based on population characteristcs

Figure 3 displays a spatially explicit potential demand model for forest recreation in Ireland. The map consists of a 1km grid of Ireland with total visitation per grid point based on the characteristics of the surrounding population and their proximity to the point. This model currently ignores existing sites but highlights where concentrations of visitation are likely to occur.

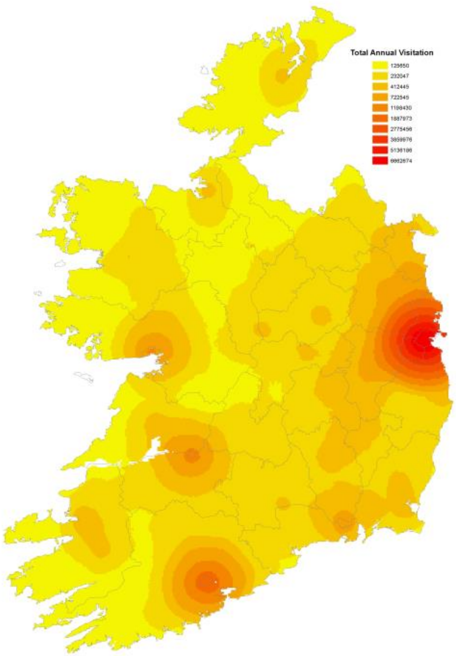

Figure 3 Spatial model of potential demand for forest recreation

Discussion

This study involves the development of a spatially explicit national demand model for forest recreation in Ireland. The results of the recreation model based on the survey data followed expectations and highlighted the importance of age, social class and having access to a car as important factors in understanding differences in visitation figures. Residents of urban areas were found to be less likely to have zero visitation, which would suggest that, in addition to the effect of higher population densities, urban forests will experience high levels of visitation in Ireland.

Initial results suggest that national forest visitation figures derived from the model are more conservative than one produced based solely on the survey sample mean. Previous authors have noted the importance of identifying the relevant population when examining demand for environmental goods (Bateman et al., 2006; Hanley et al., 2003; Cullinan, 2011). The results facilitate a more accurate estimation of the annual value of forest recreation to Ireland and suggest that a failure to account for differences in population characteristics and proximity to available recreational resources would result in a significant overestimate of annual visitation. Where mean willingness to pay estimates are transferred directly across the entire population failure to account for such differences would result in over-estimating the true value of resources. In this study the model estimation of annual visitation was almost 30% less than one based on employing a mean visitation figure across the full population. Thus this approach was found to derive more conservative estimates of visitation.

An additional benefit of developing a spatially explicit demand map is the ability to target afforestation to enhance the value of locations for recreation (Gimona and van der Horst, 2007). Figure 3 displays the demand map generated on a 1km grid across the country based on population characteristics and their proximity to each point. This map can be used a forest planning tool to identify where new forest recreational resources might be targeted and what visitation figures might be expected at each point.

A number of shortcomings of the methodology should be recognised. The household survey data are based on a question pertaining to generic forest visits in the previous

12 months and a significant assumption of the modelling process is that these visits are influenced by the closest recreational forest rather than the number of resources in a respondent's locality. Respondents were asked to only include forest visits that were undertaken from their home rather than while on holidays but respondents are likely to have visited multiple sites. Although potentially limiting this assumption does follow previous findings which suggest that distance is the most important factor in explaining the probability of visitation (Brainard et al., 1999). However, if incorrect this assumption would lead to an overestimation of the expected visitation at each point in the demand model. Related to this issue is the potential for outliers to skew the model results. Of the 996 respondents, 14 suggested that they had visited a forest 200 times or more. Although a small proportion of the sample this group may skew the model and this will be investigated in future derivations of the model.

The model is based on visitation by individuals but is averaged across populations in EDs. The average visitation by individuals is then assigned to households in the spatial analysis process. Resulting estimates may thus be conservative as it is likely that multiple visitors may exist in each household. Employing a mean number of adults per household or a more advanced simulation model may be more appropriate.

A more fundamental issue with this approach is one of equity. The potential discriminatory nature of non-market valuation methods have been noted but generally in relation to stated preference methods. The model in this paper found that higher social classes, which are associated with higher income, were more likely to visit forests. If this model was to be employed to target future afforestation based on expected visitation a further examination of the role of social class would be warranted to ascertain what factors are behind this finding.

Conclusion

This study outlines the creation of a spatially explicit forest recreation demand map for Ireland. Household survey data were combined with a simulated population model to generate annual visitation figures for simulated individuals who were then assigned to the location of households. Total demand was then modelled for each point on a

1km grid of the country. The model and spatial analysis resulted in the production of a more conservative estimate of annual visitation as it accounted for the characteristics of the population and their proximity to existing recreational resources. Thus, the importance of accounting for current resources and populations characteristics in deriving total willingness to pay figures is highlighted. In addition, the generation of spatially explicit models of demand will facilitate the targeting of future afforestation projects. This paper explores a number of issues of relevance to researchers working in the area of ecosystem service valuation including the use and availability of spatial data, the use of count models for recreation data and how count models can be combined with simulated population data to derive spatially explicit demand models.

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