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Conclusions and future directions

Introduction

This research draws upon a series of interrelated studies designed to provide an improved cost-benefit analysis of a proposed conversion of land use out of conventional agriculture and into woodland. The analysis covers a number of diverse questions and is necessarily complex. Consequently a number of conclusions can be drawn. To simplify this process, we first review the achievements of this research before considering, in the subsequent section, the problems of the study and ongoing work. This is followed by our concluding comments.

Summary of research

As reviewed in the opening chapter of this volume, woodland produces a variety of market-priced and non-market benefits and costs. The first phase of this research was concerned with monetary valuation of one of the principal non-market benefits, woodland recreation. Given the open-access nature of this good, which produces no internal return to the land-owner but is of significant social value, we were forced to rely upon non-market valuation methods. Chapter 2 reviewed these methods, highlighting the theoretical appropriateness of both the contingent valuation (CV) and travel cost (TC) techniques. The chapter also provided a theoretical analysis of the values elicited by these methods.

Chapter 3 opened with an appraisal of UK applications of these methods to the valuation of woodland recreation. This review raised a number of interesting issues; for example, studies failed to identify any significant link between recreational values and tree species. We also highlighted a number of problems with prior studies in terms of their methodology, data analysis and reporting. In an effort to identify values which could be transferred to woodlands in our study area, cross-study analyses of both TC and CV estimates were conducted. These yielded separate and significantly different valuation measures for subsequent consideration.

Concerns regarding prior applications were in part the motivation behind our own studies of recreation value, also presented in Chapter 3. Here we investigated a number of study design issues, analysing the impact which differing approaches had upon resultant value estimates. While our initial study was somewhat crude, we feel that subsequent studies provided some idea of the potential impact of design effects upon recreation value estimates. More specifically we found that CV estimates varied significantly with issues such as question ordering, the inclusion or exclusion of questions regarding recreational budgets, choice of willingness to pay format, payment vehicle and respondent type. While much of this variation can be interpreted in line with economic theory, this does raise the complex question of which value is the most appropriate for practical purposes. Our research into the TC method found that its valuations were also subject to variation according to the methodology employed. In particular we assessed the impacts of measurement effects, choice of unit values and estimation technique. Variations in estimates were found to be just as wide, or even wider, for the TC as for the CV approach. However, the chapter also presents the first of a series of GIS-based analyses which dominate the latter part of this volume. Here GIS techniques were used to improve the measurement of key variables underpinning the TC method so as to produce more accurate estimates of recreational values.

Chapter 4 opened by considering the equally important question of how many people will visit a specified woodland site. Data from our field studies were used to estimate a visit demand function which, although theoretically simple, exhibited some methodological sophistication and proved reasonably reliable in predicting visits when assessed against a subsample of sites for which actual arrivals were known. Combining this with the various recreational visit values estimated previously, we obtained a range of woodland recreation benefit values. These varied according to the valuation method used and methodological assumptions employed. From these we identified a preferred upper- and lower-bound estimate of recreation value for use in subsequent analyses.

The next three chapters switched the focus of analysis to consider tree growth and its related benefits. Throughout this we considered two species of tree: a representative conifer (Sitka spruce) and a typical broadleaf (beech). Chapter 5 assessed the costs and benefits of planting these species, producing estimates of net present value and its annuity equivalent. This necessitated a study of the appropriate discount rates for the various decision-makers under consideration (farmers and policy-makers). The chapter also provided market and shadow price assessments to facilitate investigation of the value of woodland both to the farmer and to society. This dual assessment was a feature of all subsequent chapters.

Chapter 6 presented GIS-based models of timber yield. Our methodology allowed us to use the Forestry Commission's sub-compartment database, thus permitting a very substantial increase in sample size compared to previous studies. The GIS also allowed us to incorporate data taken from the Soil Survey and Land Research Centre's (SSLRC) LandIS database detailing the environmental characteristics of a site. The high quality and extent of these data facilitated the estimation of yield models which were more robust than those previously reported in the literature. Information from Chapter 5 allowed us to convert these yield estimates into maps of timber value for both our conifer and broadleaf species.

The yield model also provided the basis for our analysis of carbon sequestration in Chapter 7. Forestry Commission models of carbon storage in timber and carbon liberation from its products were combined with information concerning soil carbon flux to produce assessments of the net impact of planting trees upon the carbon cycle. A review of the literature on valuing carbon storage was used to provide a monetary evaluation of the results from this model which, as before, involved analyses for both of our selected tree species.

Chapter 8 shifted attention from woodland to agriculture. The GIS-based models of agricultural value presented utilise farm-level rather than parish or other aggregated data. This methodology permitted the inclusion of the environmental characteristics of individual farms as explanatory variables in the value functions. A cluster analysis was used to identify homogeneous sectors within the farm database and separate modelling exercises were conducted for the two principal sectors – sheep and milk production. Finally a shadow pricing exercise provided comparisons with estimated levels of farm-gate income.

All the preceding analyses were synthesised in Chapter 9 which provided a cost-benefit appraisal of converting land out of the two agricultural sectors considered and into either of the woodland types considered. Net benefits were calculated from both farm-gate and social perspectives. Comparison of predicted values with the actual very low numbers of conversions led us to conclude that sheep farms were using a risk-weighted discount rate of about 6 per cent. While this rate meant that the level of woodland grants and subsidies made conversion unattractive from the farmers' perspective, our analysis showed that conversion from sheep farming to conifer woodland would generate substantial net social benefits which would justify the relatively modest increase in grants and subsidies necessary to induce such conversion. The scope for conversion from sheep production to broadleaf woodland was reduced by the long rotations of such tree species although some conversion was still justified (see the discussion of this issue in the following section). A particularly important finding was that the optimal location for conversion out of sheep farming was not, as in general planting practice, in remote upland areas but, rather, near heavily populated, high accessibility, lowland locations. However, when we turned to consider milk farms we found little economic justification for conversion to either conifer or broadleaf woodland.

Problems, progress and plans

Prior to presenting our final conclusions it is essential that we draw the reader's attention to several problems and omissions in this research and highlight, in mitigation, certain ongoing work addressing some if not all of these problems.

This was a relatively ambitious project covering a wide range of analyses all of which have scope for improvement. One such area is the need for further consideration of the impact of statistical error in a multimodel system. In particular, while actual versus predicted tests were conducted on recreational demand and timber yield estimates, to date such a validation analysis has not been performed for our agricultural models.

A number of issues arise from our analysis of recreation values. One point, which is more of a finding than a criticism, is that our CV and TC studies have raised significant concerns over the impact of study design, implementation and data analysis upon resultant valuation estimates. While this is an interesting research finding it does raise questions regarding the use of such values in our subsequent cost-benefit analysis. We have attempted to address these issues by using upper- and lower-bound estimates in this analysis but feel that this is a less than ideal solution. In summary, more research into the understanding and control of design effects is necessary.

Another valuation issue concerns the limitations of the recreation benefits transfer analysis presented here. While the GIS-based definition of the variables used is reasonably sophisticated, encompassing factors such as population distribution and accessibility, other factors such as site characteristics were omitted. However, in mitigation, our most recent work (overviewed in Chapter 4) shows that these omitted factors do not radically alter the relative distribution recreation values away from that predicted by the simpler models used in this analysis. This suggests that our overall conclusions are not in error here.

A further issue is that, like most studies, the present analysis becomes dated even while it is under construction. This is particularly true of our agricultural model which relies upon data from the early 1990s. In Chapter 8 we reviewed the intervening period from then to the present day, noting that the latter half of the 1990s saw substantial falls in Welsh agricultural incomes. Although, as noted in Chapter 5, timber prices have also fallen during this period the overall effect seems likely to have been either neutral or shifting marginally in favour of timber. Such moves imply that our predictions of the economic potential for land use change out of agriculture and into multipurpose woodland can be defended as conservative estimates of the present-day position.

A final issue we would highlight is that, while our study attempts to significantly extend the analysis of costs and benefits, we have omitted certain items. Of these the more important omissions include sporting revenues (which in some locations may be highly significant; see McGilvray and Perman, 1991), livestock shelter, and externalities such as biodiversity and habitat value (Jenkins, 1984, 1986; Good, 1987; Good *et al*., 1991; Peterken, 1993; Garrod and Willis, 1994; Woodhouse *et al*., 2000; Cowling and Heijnis, 2001), acidification impacts and landscape amenity effects (Campbell and Fairley, 1991; Dillman and Bergstrom, 1991; Lavers and Haines-Young, 1993; Fleischer and Tsur, 2000). Some have argued that values associated with the benefit streams issues, such as biodiversity and habitat values, may be better incorporated into decision-making by attempting to harmonise CBA with non-economic appraisal systems such as multicriteria analysis (MCA) and some commentators have attempted to bring these approaches together (Turner *et al*., 2000). We have not attempted such a harmonisation of appraisal approaches, partly because of time constraints, but principally because of the present lack of a consistent theoretical framework for such analyses.

Many of the concerns raised above are already the subject of ongoing research. Considering those externalities which are omitted from our analysis to date, one area of ongoing work is the assessment of landscape amenity. Funding from various authorities[1] has supported the development of a GIS-based hedonic pricing (HP) model of such values. The viewshed calculation capabilities of a GIS (which allow the analyst to measure the extent and type of view observed from any given point taking into account the natural terrain and man-made visual intrusions and obstacles) make it the ideal tool for compiling map databases of an area, thus obviating the need to rely on the crude distance-based measures typical of most HP models of landscape amenity. This work is now well advanced (see Lake *et al*., 1998, 2000a,b; Bateman *et al*., 2001a) and seems promising. A related development has been the increasing scope for creating realistic 3D visualisations of landscapes from GIS databases. Our initial research (Lovett *et al*., 2001; Appleton *et al*., 2002) leads us to believe that such techniques would be highly appropriate for enhancing contingent valuation, conjoint analysis and other expressed preference valuation techniques so that they might be more readily applied to the valuation of future and planned landscapes.

A further area of ongoing research examines the biodiversity and habitat values of woodland, and the implications for these values of implementing the optimal policy changes implied by the present study. This work combines our various datasets with those from the British Trust for Ornithology (BTO) to use certain bird species as flags for the wider biodiversity implications of policy change. This research is still under development but initial results (Bateman *et al*., 1997c; Woodhouse *et al*., 2000; Dolman *et al*., 2001) and other papers using GIS techniques (Gurnell *et al*.,

[1] Including the Economic and Social Research Council (ESRC), Commission for the European Community (CEC), Ordnance Survey and the Scottish Executive.

1996; Swetnam *et al.*, 1998) suggest that this will provide a powerful tool for identifying the wider effects of the decision on which tree species to use in conversion schemes. Our findings confirm the expected superiority of broadleaves over conifers as providers of desirable biodiversity outcomes, a factor which has the potential to reverse the apparent economic superiority of softwoods over hardwoods observed in Chapter 9. As discussed in Chapter 8, an important complicating factor here is that recent decreases in agricultural incomes have been accompanied by an increase in stocking densities and consequent overgrazing and ecological damage across many areas of Wales. However, as noted previously, such trends will only serve to enhance the net benefits of conversion from conventional agriculture into multipurpose forestry, thus tending to make the results presented here appear somewhat conservative.

One area in which we have to date achieved little more than a review of the literature (Bateman, 1992) is the incorporation of the acidification effects of woodlands, particularly those composed of conifers. Here, while some evidence is contradictory, the general consensus is that conifers can cause acidification damage to watersheds. There is considerable scope for addressing this issue. First, the literature is extensive, particularly with reference to Wales (see, for example, the numerous papers contained in Edwards *et al.*, 1990). Second, there is a burgeoning literature concerning the valuation of acidification impacts.[2] Finally, a number of previous studies have shown that a GIS provides the ideal tool for catchment analysis (see, for example, Adams *et al.*, 1995). This should make the future analysis of acidification impacts reasonably tractable.

Conclusions

As discussed earlier this research has addressed a number of objectives. However, we choose to emphasise two general points as its principal features, one methodological, the other empirical.

Principal methodological feature

The principal methodological achievement of this research is, we believe, the improved incorporation of spatial and environmental variables into a variety of economic models through the medium of GIS. This enhances the researcher's ability to model spatial complexity within a variety of economic analyses (Lovett and Bateman, 2001).

[2] This includes two large ongoing studies, one led by Alan Krupnick at Resources For the Future (RFF) in Washington, D.C., the other conducted by the authors and others at CSERGE, UEA, as part of the CEC EMERGE project.

A number of examples of this methodology are presented here. For example, the GIS is employed to incorporate road infrastructure characteristics and the distribution of population in our model of woodland recreation demand. The software is also used to manipulate and integrate environmental data into our analysis of agricultural values. Similarly, the GIS provides an ideal medium for combining a variety of diverse data which had not previously been linked, such as the integration of SSLRC LandIS and Forestry Commission sub-compartment databases in our analysis of timber yields. A further feature of this methodology is that the resultant maps provide easily interpretable results which can readily be used by decision-makers to analyse the impact of policy changes, and they also provide information on the most appropriate sites for targeting policy initiatives.

The flexibility and analytical power of a GIS makes it, we feel, the ideal tool for incorporating and analysing the spatial complexity which is such an important part of the real world but is often so conspicuously absent from many economic analyses.

Principal empirical feature

This research presents a cost-benefit analysis of the agriculture/forestry trade-off in one large area of the UK. The results of this analysis have, we feel, important consequences for future policy. Accepting the caveats set out above, we feel that the research has highlighted the potential for generating substantial net social benefits by converting some sheep farms to multipurpose woodland. Furthermore, the identification of optimum conversion sites, facilitated by the methodological advances discussed above, indicates that planting policy to date has been diametrically opposed to that which is required to maximise economic benefits in that it has been concentrated in remote upland areas rather than accessible lowland locations. However, our analysis has also shown that levels of woodland grant and subsidy are insufficient to induce conversion (a result which reflects real-world observations). Nevertheless, our results indicate that only modest increases in these grants and subsidies would be necessary to create the financial incentive for land use conversion and thereby release the economic net benefits arising from such change.

In essence, our analysis has highlighted the marked difference between the market appraisal of the status quo and its social value. By including externalities in our analysis we have shown that the situation is one of poorly targeted government intervention leading to market failure, a situation which can readily be remedied by linking transfer payments to the total economic value of goods rather than to their market price.

Finally, while we recognise that the research presented in this volume is not fully comprehensive with respect to the full complexities of land use change, we do believe that it represents a significant improvement on the current state of decision analysis. Furthermore, we feel that the methodology developed here is readily amenable to extension and that future research may develop this into a practical decision support system of considerable assistance to policy- and decision-makers as well as being of interest to academics and users of the land alike.