NON-MARKET BENEFITS OF FORESTRY

Phase 1

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CONTENTS

Executive Summary

NON-MARKET BENEFITS OF FORESTRY

1. The aim of the study was to:
   - review existing valuation methodologies and research to determine the best approach to valuing non-market benefits (NMBs) of U.K. forestry;
   - investigate existing data to determine which topics future research might address;
   - determine which valuation techniques should be used in such research if accurate and robust values are to be obtained.

The review concentrated on the main NMBs of forestry: recreation, landscape amenity, biodiversity, and carbon sequestration. Other benefits briefly reviewed encompassed water quality, pollution absorption, health effects and preservation of archaeological artefacts.

2. Existing studies appear to derive varying values for each NMB; this variability is found not to be adequately and consistently addressed. Differences in estimated benefits for a forestry good arise because studies rarely value *exactly* the same commodity using *exactly* the same technique; and studies also vary in the types of benefits they seek to measure.

3. The two principal NMB values used by the Forestry Commission (FC) are a value for recreational visitors of £1 per visit, established in 1992 (indexed to £1.42 in 1999); and a value for biodiversity in remote coniferous forests, derived in 1996. There are some deficiencies with existing NMB values, both in their application and in their estimation. First, the value for a recreational visitor is applied without regard to the attributes or the location of the forest. Second, considerable advances in the development of techniques to measure NMBs have taken place, suggesting that more accurate and reliable estimates of NMBs for recreation, landscape amenity, and biodiversity, could now be derived.

4. The results of the full study would inform the different levels of decision-making required by the FC at:

a) a national level to assess policy (e.g. expansion of woodland area), and to ensure efficient resource allocation and correct calculation of the internal rate of return on forestry investment;

b) a strategic (regional) level to prioritise objectives;

c) forest plan and programme levels to inform management and design;

d) a project level to appraise individual WGS and other schemes.

5. Recommendations to adopt existing NMB estimates, or to update these, or to estimate additional NMB values were made with respect to recreation, landscape and amenity, biodiversity, carbon sequestration, and other NMBs.

Recreation

6. Recent work on the recreational value of forests in Northern Ireland suggests mean willingness-to-pay (WTP) values between £0.60 and £1.74 per visit, depending upon the location of the forest, its attributes and the socio-economic characteristics of visitors. Instead of adopting a single value per visit across all forests, to determine the aggregate recreational benefits of woodland, recreational values need to be more sensitive to the attributes of individual forests, the location and availability of substitutes and the characteristics of the population of visitors in the catchment area. This might be achieved with recently developed multi-attribute approaches, and with benefit-transfer techniques.

7. The EU-CAMAR data set on recreational visits to 13 Scottish forests has not been analysed. Analysis of this data would provide more accurate and reliable information on recreational values, by types of forest and their attributes. The validity of these values to forests in England and Wales could easily be tested with a comparative survey and analysis of visitors to two forests in England.

8. The effect of changes in the provision of forest attributes on the probability of site choice, the number of visitors to a forest, and welfare (change in WTP), can be more

readily estimated through recent developments in travel-cost and contingent valuation techniques. Again the EU-CAMAR data can be used to estimate these impacts.

9. The EU-CAMAR data set would permit an analysis of distance decay effects in the probability of visiting a site, and also any decrease in WTP with distance from the site. This research would thus improve knowledge about the aggregation of benefits, and provide a much more accurate estimate of the aggregate recreational benefits of existing woodland. In addition the research would also permit a more robust estimate of the recreational value of new planting and forestry expansion; and inform forest design plans for the development and management of specific forests.

Landscape

10. A number of studies have provided varying estimates of the value for woodland landscapes. These studies have been undertaken for different landscapes and in different contexts (e.g. species type; existing landscapes; and new planting over different types of landscape); hence there is no consensus on a single monetary estimate of the value that woodland contributes to landscape. The Entec (1997) study valued landscape attributes (species, shape and felling) and WTP for an 'ideal' forest design; but the attributes were generic and not detailed enough to be applied to individual forests. Existing studies suggest that landscape value is a major NMB of woodland. More research is required to investigate the interaction effects of different landscape attributes on the general landscape character and its amenity value. Developments in multi-sensory reality technology might allow respondents a greater appreciation of landscape implications of alternative management regimes and options in forest design studies. This research might also provide more information on the perceptions, preferences, and values of the general public for different woodland landscapes.

Biodiversity

11. There is limited knowledge about the general public's preferences for biodiversity in forests. The Newcastle University/ERM (1996) study provided estimates of the public's WTP for increases in different biodiversity standards ('basic', 'desired', and 'conversion to native woodland') to improve the quantity and diversity of plants and

animals in remote forests currently managed on a commercial basis with few visitors. However, less is known about WTP for biodiversity in other types of woodland; or about the value of the net biodiversity benefits of conversion to woodland from other land-uses.

12. This study recommends that further research be carried out to assess the biodiversity benefits of forestry, particularly in relation to so-called 'headline' species. This is particularly important for native woodland and other areas of non-commercial forestry, where non-market goods are the most important outputs. Such research must be informed by a greater understanding of the ability of the general public to value biodiversity and an assessment of the information required by them before robust benefit estimates can be elicited.

Carbon sequestration

13. Carbon sequestrated by forestry makes a small but significant contribution towards meeting the UK's commitment under the Kyoto Protocol. Relationships between carbon sequestration and tree species, growth rate, thinning, and rotation length are known; but there is uncertainty about changes in the carbon content of soils between agriculture and forestry and the proportion of carbon locked-up in timber products. The best current estimate for the value of carbon sequestrated is £55 per tC (2000 prices); although estimates of the value of carbon sequestration vary widely. Carbon sequestration is an important element in the NMBs of forestry; and carbon sequestrated by forestry is rising over time. More research should be devoted to assessing changes in the total value of carbon sequestration associated with different management regimes, and as an input into forest strategy and forest design. The cost of alternative options open to society for carbon abatement should be established to compare with forestry.

Other NMBs

14. Other NMBs of forestry comprise water quality, pollution absorption, health effects, and the preservation of archaeological artefacts. There is some uncertainty about the magnitude of these impacts, although valuation techniques exist to value them if they can be identified. The limited evidence available suggests that the effect

of these NMBs is small. For example, the contribution of forestry to the preservation of historic monuments and ancient field systems is through protecting land from the disturbance of mechanised agriculture. The economic value of this is only the option value of preserving the site, and option values tend to be low compared to use values. Hence, it is recommended that future research to value NMBs should concentrate on the more significant ones, namely recreation, landscape amenity, biodiversity, and carbon sequestration.

Aggregate Values

15. Aggregate estimates of NMBs are more sensitive to the accurate definition of the population of beneficiaries, than to variations in willingness-to-pay estimates of NMBs. Therefore, particular care must be devoted to the issue of correct market definition, distinguishing between visits and visitors in the analysis, and the market areas over which NMBs are aggregated.

16. Some NMBs, such as the value per MtC sequestrated, can be summed to derive an aggregate value across Great Britain. Where travel-cost and contingent valuation methods have been correctly applied, then the resulting estimates can also be aggregated in a straightforward manner, provided the population of users is well defined. For local public goods (e.g. specific woodland areas) distance decay in aggregate population values exist for recreation, landscape, and biodiversity values. This means that simple approaches to aggregation will cause major errors in the estimation of total value. Failure to account for interactions and substitution effects between specific forest sites, and also forest areas, can also lead to the over-estimate of the aggregate value of NMBs.

17. Aggregation of values should also account for declining marginal WTP for some NMBs (e.g. for additional woodland). In aggregating different NMBs it might be particularly difficult to avoid double counting. For example, recreation values will also contain some element of visitors' landscape amenity value for forests. There is no easy solution to this problem when deriving estimates of closely related NMBs. Although future research may reduce this problem, we currently recommend that only

conservative estimates of NMBs be aggregated over well-defined populations of beneficiaries.

Future research proposals

18. As non-market benefits are the most important output of much of the forested area in Britain, it is clearly a high priority for policy makers to have a more comprehensive estimate of these benefits than currently exists. These estimates will inform future management decisions regarding the FC estate and, when used in conjunction with cost estimates, can help to resolve decisions such as whether or not to replant or restore areas of native woodland.

19. With so many options existing for further research, we recommend that future efforts be concentrated in areas where maximum value for money can be obtained in terms of the increased accuracy of forestry benefit estimates. Priority areas are identified as follows:

- First, based on a review of existing studies, it appears that the correct spatial and socio-economic characterisation of potential markets for each unpriced forest good should be a major priority for a correct definition of the total NMB value.
- Secondly, a fuller exploitation of the information content of existing datasets would seem to be in order, through an integrated analysis specifically aimed at the estimation of total NMB from forestry.
- Thirdly, because of the large potential saving on the cost of new data collection, the investigation of the reliability of various multi-attribute benefit transfer techniques seems a particularly cost effective avenue of research.

20. A number of other research priorities have emerged as potentially compelling from this scoping study. These, however, for the purpose at hand, are of lesser immediate importance than those outlined above. Amongst these we list:

- Firstly, an investigation of values and perception of biodiversity issues in non-commercial forests;

- Secondly, an investigation of the extent to which forestry impacts on landscape character (external landscape values) and the perception of such an issue from the viewpoint of the community at large;
- Thirdly, since forest management decisions have long term repercussions, some dynamic aspects of the determinants of long term recreation and other NMBs ought to be investigated;
- Fourthly, more research is needed in modelling how forestry based environmental targets can be achieved. The opportunity cost of carbon sequestration by means of non-forestry policies requires investigation to compare with its benefit cost ratio for forestry.
- Finally, the Forestry Commission ought to encourage further applied studies to better characterise the management implications of some of the less well understood NMBs of forestry, such as the effects of forestry on human health, on pollution abatement, water purification and quality etc. An increased technical understanding of these issues is an essential prerequisite of any serious economic valuation effort.

Chapter 1

INTRODUCTION

1.1: Background

Forests in Britain provide a range of benefits to society in addition to supplying timber and a variety of other marketable goods. As these benefits do not generally attract a price, they are often referred to as non-market benefits (NMBs): they include open access recreation, public amenity and landscape benefits, biodiversity, and carbon-sequestration, as well as a number of other environmental and educational benefits. These NMBs can be described as 'public goods' - they can be enjoyed by everybody, and the fact that one person benefits from them does not usually affect the enjoyment of anyone else.

The open-access nature of such public goods means that it is difficult to charge people who want to enjoy them, and therefore such goods are not provided by market mechanisms which tend to be driven by profit. For the same reason these public good benefits are not reflected in the rate of return that the Forestry Commission (FC) achieves on timber sales or from the residual value of investment in planting. Nevertheless, the public-good aspects of forest management make a significant contribution to the overall welfare of society and are an important part of FC's role in providing multipurpose forestry. The continued provision of these public goods is fundamental to the FC's obligations to manage Britain's forests for the benefit of the nation and for ensuring that public expenditure on the FC represents "good value for money".

If the NMBs of forests are incorrectly valued, or if NMBs are not fully incorporated into decision making on resource allocation, or into management decisions on the structure of individual forests, then an optimally efficient allocation of resources will not be achieved, and societal welfare will not be maximised.

1.2: Aims and objectives

The specific objectives in of this research study, as set out in the original tender document, are to:

- review existing valuation methodologies and research to determine the best approach to valuing NMBs in any subsequent research studies;
- investigate existing relevant data to determine what areas future research might usefully address;
- determine relevant valuation techniques that should be used in such research to determine accurate and robust values.

The FC subsequently requested the addition of two further objectives to:

- investigate why FC clients had found some studies more useful than others, and why this was the case;
- broaden the scope of research on the applicability of techniques to FC issues outside environmental economics.

1.3: Approach

In addressing these specific issues the project will review previous research and methodologies used to calculate the NMBs of forestry. A substantial number of studies on the NMBs of forestry have been undertaken both in the UK and abroad. These have valued a variety of NMBs associated with forestry; using different economic valuation techniques. In addition scoring techniques have also been used to assess preferences amongst alternatives and forest attributes, particularly landscape characteristics.

Valuation studies rarely value exactly the same commodity using the exactly the same technique, or based on exactly the same samples of the population. Consequently different studies derive different values for what may seem to be the same good, a perspective exacerbated by many studies reporting only estimated mean or median values, rather than reporting how these point estimates might differ across different samples. There is surprisingly little information about the levels of consistency between and within non-market valuation studies. Meta-analysis (Walsh *et* al, 1989), a statistical technique which attempts to clarify the underlying results from a range of different studies, and other formal comparisons between estimated values from valuation studies (e.g. Carson *et* al, 1996) are beginning to provide some insights into this issue.

For forestry, any comparison of estimates to assess consistency of values is made more problematic by the fact that the nature or supply of the public good (e.g. open-access recreation) can vary between sites (and hence studies). Similarly the context within which the NMBs of forests have been estimated varies considerably, as does the geographic location. Both of these factors can influence the benefit that an individual derives for a particular forest and therefore the estimated aggregate value of the forest. Studies have also varied in the extent to which they have sought to measure the various types of benefit associated with forests.

Product definition is also an important consideration when assessing:

- the extent to which existing studies have measured a specific value, or whether they have implicitly valued a range of benefits; and whether or not this has led to an element of double counting; and
- whether studies have measured both use and non-use values.

A careful study of product definition is also crucial to identifying any particular ‘niches’ or aspects of NMBs that have not been valued, or that have only been valued in conjunction with another attribute. Such niche values may need to be addressed in subsequent research studies.

Existing research studies differ too in other respects. For example,

- some studies have sought to measure or value the forest stock, whilst others have investigated the welfare benefits of marginal changes to the stock;

- some studies have explicitly sought to address, model, and estimate the declining marginal value of successive increments of a forest good. For example, the recreational value of additional areas of forest, or the value of additional increments to recreational provision within an existing forest, will decline with increasing provision. Other studies have sought to assess the value of recreation in forests in terms of current provision, or at a fixed point, without estimating scope effects.

- many studies have valued forest attributes in isolation from other forests, i.e. valuing the recreation or biodiversity value of each forest as if it was the only forest providing that good, and then summing the value across all forests. However, there are economic arguments for valuing all forests simultaneously for some attributes and types of value, or sequentially if the good being supplied is part of a more general programme of supply provision.

The latter point has important implications for the aggregation of values. The aggregation issue comprises a number of dimensions. Some NMBs have greater value for the public than others. For nationwide 'public goods', the value to the individual is invariant across space. However, many public goods (e.g. open access non-priced recreation) are local in nature, and their benefits decline with distance as an increasing number of substitute outdoor recreation sites are encountered. The aggregate value of a NMB to individuals will also depend on whether it is the sole change or the sole programme to be implemented, or whether it forms part of a multi-programme package.

These issues are developed in reviews of forestry studies that have sought to value recreation, landscape and amenity, biodiversity, carbon sequestration, and aggregate benefits. But first this Report maps out valuation techniques in relation to NMBs; before proceeding to outline the theoretical limits to valuation methods as a prelude and context for the review of existing studies.

1.4: Towards a Typology of Forest Values

Forests, like other important environmental systems, perform a variety of functions and offer society a range of products, goods and services. The development of forests to satisfy these functions is dependent upon the weighting given to the NMBs forests are deemed to produce. NMBs are particularly importance in areas where forest policy aims to maximise the multiple-use benefits of forests.

Figure 1.1 (based on Turner, 2000) attempts to depict the linkages between the ecological functions of forests, the goods, products and services that they provide and the economic and ecosystem value of these tangible and intangible outputs. Turner's approach to the classification of environmental values is adopted because it makes a clear distinction between the ecological and economic functions of forests. This approach takes account of both the secondary (market and non-market) benefits that forests and woodlands provide to society and the primary values associated with the functioning of healthy forest ecosystems. These primary (or glue) values take account of the fundamental role that natural capital performs in the ecological systems upon which the continued well-being of our planet depends. For example, the genetic diversity of a forest ecosystem will determine its ability to cope with stress and shock and how well it can adapt and evolve in the face of change.

This useful dichotomy of primary and secondary values reminds the policymaker that the total value of a forest ecosystem may be greater than the economic benefits that it may generate for mankind and suggests that there are other paradigms, apart from that of neo-classical economics, which can be used in valuing forests. In a similar fashion Figure 1.1 adopts Turner's convention of treating historic, cultural and symbolic values separately from other non-market benefits. This distinction is made to reflect the deeper contribution that forests and woodlands might make to local identity and culture, contributions so deeply rooted in people's lives that conventional economic techniques may not fully identify them.

This study, however, concentrates on determining which techniques can successfully be applied to the estimation of the non-market benefits associated with forest goods and services. These techniques are discussed in more detail in a number of other texts (e.g. Garrod and Willis, 1999; Winpenny, 1992; etc.) and will not be described here. As illustrated in Figure 1.1, some techniques (e.g. contingent valuation, choice experiments, hedonic pricing and travel cost methods) are most successful in estimating the values of direct use benefits associated with forestry while other methods (e.g. replacement cost, opportunity cost, and human capital approaches, etc.) can usefully measure some of the more indirect benefits associated with forestry.

Non-use values are more problematic and can only be measured using economic approaches based on expressed preferences. Such values arise not from the direct or indirect consumption of forest goods or services but merely from the knowledge that the health of the forest is maintained. In some cases these values may reflect an option value associated with the possibility of a future visit, or the possibility that some as yet undiscovered forest product may provide future utility to society. In other cases the non-use value is based merely on the continued existence of the forest and can arise for a number of reasons. These include: the bequest motive (the desire to maintain the forest for future generations to enjoy; altruism (the desire to maintain the forest for other people to enjoy); and stewardship (the desire to maintain the forest for its own sake).

Figure 1.1: Forest function, uses and values.

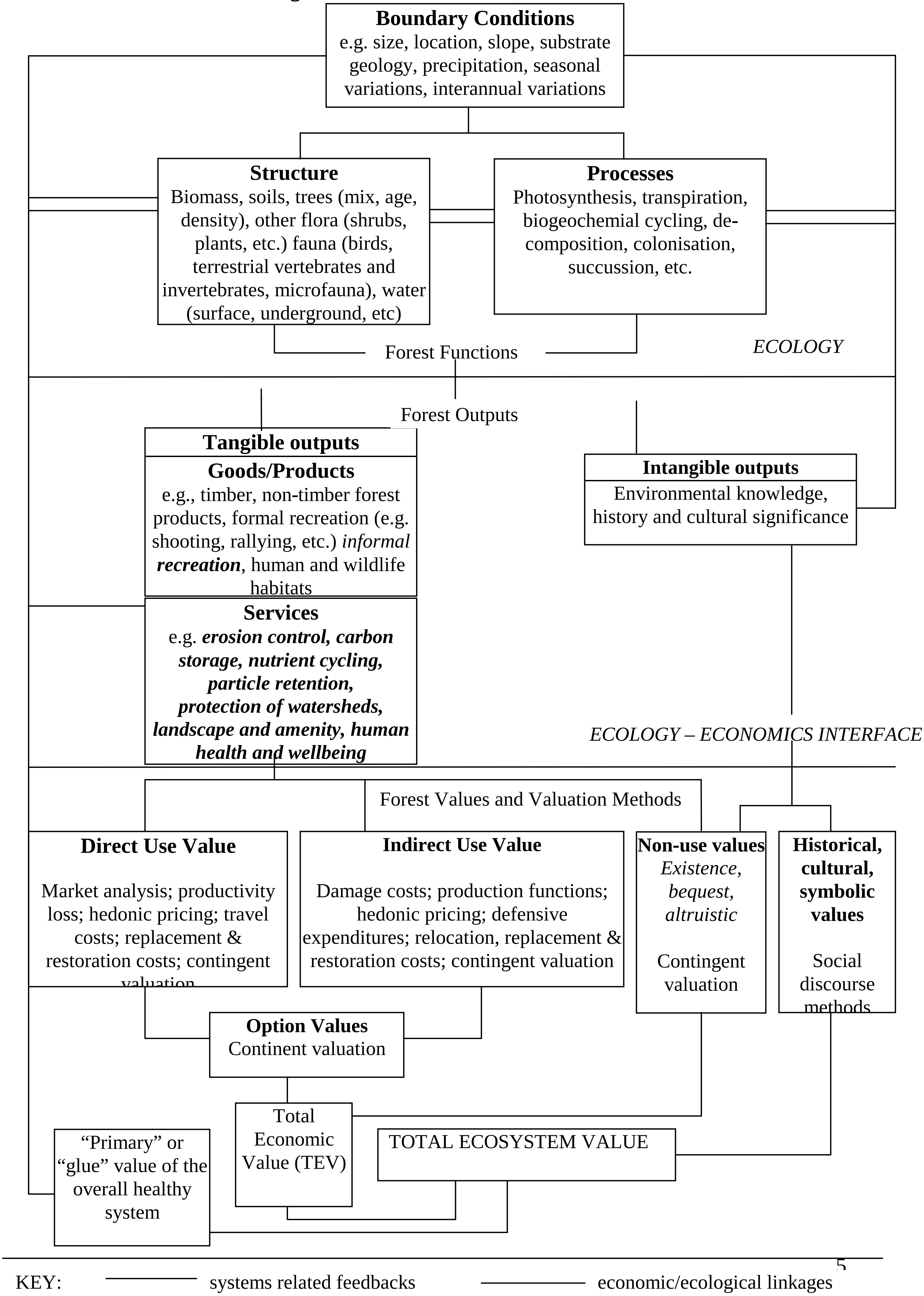


Figure 1.2: Techniques for valuing the non-market benefits of forests

Non-Market Benefits	Estimation Technique	Examples
Informal recreation	*Travel-cost methods*	Hanley & Common, 1987 Benson & Willis, 1990 Willis, 1990 Willis & Garrod, 1991 Hanley, 1989 Bateman *et al.,* 1995
	Contingent valuation	Hanley, 1989
	Choice experiments	
Amenity and Landscape	*Hedonic Pricing*	Anderson & Cordell, 1988 Morales, 1980 Garrod & Willis, 1992 Powe *et al.*, 1997
	Hedonic travel cost	Hanley & Ruffell, 1993
	Contingent valuation	Bergland, 1993
	Choice experiments	
Biodiversity Conservation	*Contingent valuation*	Macmillan & Duff, 1998
	Choice experiments	Garrod & Willis, 1997
	Replacement cost technique	
	Social discourse methods	
Environmental Services *e.g. Erosion, carbon sequestration, nutrient* ***cycling, etc.***	*Market analysis* *Effect on production* *Defensive expenditure* *Contingent valuation* *Choice experiments*	
Human Health and Well-being	*Human capital approach* *Contingent valuation* *Choice experiments*	
Historic and Cultural	*Contingent valuation* *Choice experiments*	
	Social discourse methods	Henwood & Pidgeon 1998

For simplicity a number of broad categories of benefit are considered in this study: informal recreation; landscape and amenity; biodiversity conservation; environmental services; human health and well-being; and historical and cultural benefits. Figure 1.2 lists these categories and attempts to identify the appropriate techniques for valuing these particular forest outputs and provides some examples of their use. This listing does not attempt to be exhaustive but to indicate the scope for the use of economic valuation techniques in valuing the non-market benefits associated with forestry and woodland.

1.5: Theoretical limitations of valuation methodologies

In considering the various goals to which non-market valuation tools can contribute, consideration must be given to some of the inherent limitations in these environmental economics methodologies. In other words, it is useful to address the issue of what can and what cannot be reasonably achieved by using the various methods. It is also useful to address the extent to which more sophisticated techniques can help improve current achievements and what are the implicit limits of each methodology. For ease of treatment, a distinction is made between different categories of revealed and expressed (or stated) preference methods and between use and non-use values.

The main limitation to the quality of information in social science investigations is the cost of conducting surveys and the expertise of the investigators. The following describes the relevant limitations of economic approaches to the estimation of the non-market values of forests.

The nature and reporting of benefit estimates.

Regardless of the method employed, a meaningful benefit estimate is typically computed by means of a statistical procedure based on sampling and therefore on a set of observations provided by a survey or other data gathering procedure. As such it must be interpreted statistically as a random variable, the behaviour of which will depend on the rules or processes that the analyst followed to derive the value from the raw data. Benefit estimates must therefore be expressed in terms of some range of values and the some notion of the probability that the ‘true’ benefit value lies within that range.

The time framework and the event to which the benefit estimate is associated must be clearly reported and understood. For example, the benefit estimates obtained from different techniques based on estimating willingness to pay for access by examining the cost of travel to a site can be based on individuals, households or on aggregates from a particularly defined geographic zone. Similarly, they can refer to a particular visit, season or even to a recreational choice where a forest visit is one of a number of options. The wide range of specifications available to analysts leads to a plethora of choices in terms of the nature of the benefit estimate that they will produce. Without clear explanations from the analyst it would be easy for misunderstanding and confusion to arise.

Revealed preference methods

Revealed preference methods attempt to estimate the value of a non-market good by investigating observed transactions related to the consumption of that good, e.g. the journey to gain access to a non-priced recreational site, the premium paid for a house with a good view.

Travel cost methods

Take travel cost methods (TCMs) for example. Fuel consumption and personal travel time, along with wear and tear of the means of transport, are the inputs that an individual (or household) pays to reach a forest for a leisure visit. It is reasonable to assume that the economic benefits the individual expects to enjoy be at least as large as the incurred expenses. Hence, these expenses can be used as a benchmark for valuing this type of recreation for which there is no formal market.

However, the correct value to attribute to personal travel time is still controversial, and some argue it should not be included. When it is included it must be ascertained that the individual visitor has a positive value for time. That is, s/he actually has an opportunity to gain an income during the time used for travel and recreation. No matter which avenue the analysts undertakes, the main tenet here is that the markets in which these goods are valued, are in fact reflective of value and that the cost attribution is correct. Under these assumptions the estimated value will be a lower bound on the real one, that is, an under-estimate of the real benefit enjoyed by the single visitor. But, what if the trip was not exclusively undertaken for forest recreation at that site? What if the trip was a multi-purpose one? Then some kind of accounting should be made to share out the travel expenses across the various purposes. If multi-purpose trips are prevalent, suddenly the benefit estimate can be seen as a potentially gross over-estimate, and its attribution to that forest site may incorrectly guide policy-making. This is a simple, yet powerful example of how vulnerable many a benefit estimate study can be to criticism, even amongst those published in the "good" literature.

From estimation of systems of recreation demand equations, or from estimates of probability of visiting sites belonging to systems of substitutes, it is also possible to derive marginal effects for various forest attributes, or their proxies. It is clear that this is not achievable from single site data, or even from sets with few sites. This occurs because of the lack of variation in attribute values in one case, and because of the close relationships that exist between various site attributes in the other.

To conclude, TCM estimates can reasonably be taken to reflect recreational use value, but need close scrutiny for a correct interpretation in policy making. In any case these estimates must always be presented in a fashion that provides no scope for ambiguity and clearly spells out the underlying assumptions maintained throughout the estimation.

Hedonic methods

Hedonic methods employing property values rely on stringent assumptions on the behaviour of property markets, which are often unrealistic.

In the particular case of forest non-market benefits, due to the local nature of these and of their external effects on property, it is often difficult to derive meaningful effects that can be unequivocally associated with the presence and quality of forests. Accounting for various forms of statistical problem also creates difficulties for estimation of benefits. The opacity of property markets is a further problem for the widespread adoption of this extremely data-intensive approach.

<u>Stated preference methods</u>

This category of methods is by far the most flexible, yet it is the most complex to employ due the amount of care and testing required by proper survey development. Contingent valuation (CV) surveys perform well when the task is the valuation of a given programme which changes the status of an available resource from A ➔ B, and when this change can be well understood by respondents on the basis of a typical scenario description.

When this is not the case the application is quite problematic. Respondents may be either unfocussed on or unfamiliar with the quality and quantity of the dimensions involved in the program to evaluate. In this case some systematic errors can be present. If this is expected proper tests should be built in the survey instrument so as to assess the magnitude and relevance of these effects. Whenever possible, basic validity tests should be performed to provide general validation of the observed pattern of responses. When employed for estimation of use values CV estimates have proven to be fairly robust and valid (Carson *et al.* 1996). Its use for estimating non-use values is more controversial. For this reasons applications that aimed at non-use values ought to be implemented alongside with requests of real payments for the purpose of validation (Champ and Bishop, 1997).

Choice experiments and choice rating or ranking exercises are other stated preference methods of more recent introduction in non-market valuation. These methods build on the solid knowledge developed in market research and cognitive psychology where they were developed and have been employed for a much longer time. By their very experimental nature they represent multivariate extensions of the basic CV design. More research is needed into the assessment of this category of methods in non-timber valuation of forests.

Chapter 2

APPRAISAL AND VALUATION CONTEXTS

2.1: Introduction

The Forestry Commission (FC) uses appraisal and valuation in different contexts and at different scales or levels of analysis. These levels range from the policy goals of the FC, to the macro level of FC objectives, to the meso level of evaluating particular programs, down to the micro level of evaluating specific forest projects or managing individual forests.

These different levels at which appraisal and valuation information is required are documented by Johnson (1999) (see Table 2.1), with illustrations or examples of cases to which appraisal and evaluation could be applied at each level.

Table 2.1: Levels of appraisal and valuation in Forestry Commission

Policy goal	Achieve a steady expansion of woodland area to provide benefits for society and environment					
FC Objective	Achieve some increase in every part of country	Achieve substantial expansion in specific localities		Provide greater access to woodlands around cities and towns		Increase the area of semi-natural woodland
Program	WGS Planting Grant	National Forest	Forest of the South West	Community Forests Program	Community Woodland Supplement	Native woodlands in National Parks Challenge
Project	Individual WGS applications	Individual tenders	Individual tenders	Individual WGS applications	Individual WGS applications	Individual tenders

Source: Johnson (1999).

In Table 2.1 it can be seen that individual community forest projects contribute to the wider community forests program. Programs, such as the Community Forest Program, contribute to the FC objective of providing greater access to woodlands around towns and cities. In turn this objective contributes to the FC policy of achieving a steady expansion of woodland area to provide benefits for society and environment.

Thus valuation measures of non-market benefits (NMBs) are required for different levels and scales of analysis. This raises issues about the transferability of particular values for recreation, landscape, and biodiversity, not only within one scale of analysis but across different scales of analysis. Can values derived at one scale (e.g. for one project) can readily be transferred or used to estimate NMBs for other equivalent projects? Can values derived at one scale (e.g. the project scale) be applied at other scales (e.g. at program scale or at the FC objective level) ?

Where woodland is either a complement or a substitute, or where woodland is subject to scope[1] effects or embedding[2] effects, then NMBs derived in one situation cannot readily be employed to derive estimates of the NMBs of other woodland (where similar substitute or complement effects do not occur). Similarly, NMBs cannot be aggregated in a simple way where scope and embedding effects exist; nor can they be applied at different scales of analysis.

Where woods are complements their combined value will exceed their separate values. For example, reversing the fragmentation of semi-natural woodland[3] may permit greater biodiversity than otherwise would occur if woodland remained in isolated pockets. Conversely, substitution effects decrease value. Thus the recreational value of two neighbouring woods will be less than the combined recreational value of two spatially separated woods; and similarly the value of two visitor centres in one forest will be less than the combined recreational value of a visitor centre in each of two otherwise identical forests, *ceteris paribus*.

Strategic Plans such as that by the Forest Enterprise South-East England Forest District (1999) rightly point out:

> "All Forestry Enterprise woodlands play a key role in the biodiversity within the region. Their value is increasing as work under the Forest Design Plans diversify woodland structure and creates additional habitats" (page 8)

However, economic theory argues that as the native woodland program expands, if the program creates the same type of woodland as already exists then the additional benefit provided in terms of biodiversity will decrease with each marginal increase in woodland area, i.e. there is a scope effect. However, if the native woodland program results in larger woods that are richer ecologically than smaller ones then this creates an additional biodiversity supply curve, and additional biodiversity benefits. Nevertheless, as the quantity of these larger, more ecologically diverse woods increase, the marginal benefit of each additional wood of this type will also decline, i.e. scope effects will present themselves here too. Unfortunately, apart from the study by Garrod and Willis (1997) no research has been undertaken to

[1] Embedding arises when the same good is assigned a lower value if WTP for it is inferred from WTP for a more inclusive good, compared with when the particular good is evaluated on its own.

[2] Respondents should ascribe different values to different quantities of a good. That is, their responses should be sensitive to scope. Bias with respect to scope might arise if WTP values for different quantities of the same good are approximately the same. Economics theory predicts declining marginal utility (willingness-to-pay) with increasing quantity of a good, and generally this should be observed in the demand function for a specific NMB.

[3] Reversing the fragmentation of semi-natural woodlands to strengthen and enhance nature conservation is a target in the Severn, Wye and Avon Conservancy business plan (Forestry Commission, Severn, Wye and Avon Conservancy, 1999).

measure the benefits of these changes in the marginal benefits of different woodland habitat supply.

Contingent valuation (CV) studies of the value of biodiversity of individual projects to enhance or create areas of semi-natural woodland may encounter embedding effects. For example, in a CV study, respondents may ascribe a value of £*X* to the value of the Biodiversity Action Plan (BAP) to secure butterfly conservation in the Clay-land Management Strategy of the strategic plan for the FE South-East England Forest District (1999). If the same or an similar set of respondents provided a combined value for the wildlife component for both the Clay area, and the Greensands and Gravels area, in the South-East Forest District, which also turned out to be £*X*, then this would be indicative of an embedding effect.

2.2: National level

The FC corporate plan for England (Forest Commission, 1999) is based around four key areas:

- forestry for rural development: bringing jobs and contributing to the rural economy;
- forestry for economic regeneration: restoring former industrial land with trees and attracting inward investment;
- forestry for recreation, access and tourism: supporting recreation and tourism;
- forestry for the environment and conservation: absorbing carbon, filtering pollution and noise, providing habitats for a variety of wildlife and creating distinctive landscapes.

At the national level it is important to ensure the efficient use of resources. The FC (1999) corporate plan for England had a budget income and expenditure of £32.1 million for 1999-2000. £10 million revenue was derived from the forest enterprise (sale of products), whilst £3.5 million was derived from the EU (mainly to co-fund the Woodland Grant Scheme (WGS)), and the remaining £18.6 million coming from HM Treasury by way of a government subsidy. Expenditure amounted to £7.2 million on operating costs; £0.1 million on new planting, £6.7 million on recreation and conservation schemes; and £18.1 million on the Woodland Grant Scheme (WGS). In assessing efficiency in resource allocation it is clearly important to determine whether the net aggregate NMBs from forest recreation, landscape amenity, and biodiversity, exceed the public subsidy element to the FC. These NMBs should also be included in a cost-benefit analysis of FC activity, to ensure an appropriate internal rate of return on investment is derived, and economic efficiency is properly assessed.

2.3: Strategic (regional) level

Strategic level plans document how the Forest Enterprise (FE) plans to manage its woodlands in the forest district over the next 5 to 10 years. Each forest district strategic plan contains broad aims, following those set in their respective national corporate plan. Strategic level plans prioritise these aims in relation to the characteristics of the local forest district. Some plans set targets for specific NMB aims. However, specific aims and actions regarding NMB in forest district strategic plans are invariable either not quantified or incompletely quantified [see for example, the FC North of Scotland (2000) strategic plan]; whilst trade-offs between aims are also not specified.

The Strategic Plan for South-East England, for example, has a target of surveying ancient woodlands and preparing a strategy for restoring key sites by the end of 2000, with the aim of targeting resources towards sites where the greatest environmental gains can be achieved; and developing and enhancing the 'naturalness' of beech plantations on ancient woodland sites. In devising these strategies it would clearly be desirable to know the values attached to the various NMBs. For example, how much do people value the different environmental gains to be achieved? And how much would they value 'naturalness' in beech plantations landscapes of south-east England, compared with their current appearance? Society's value could then be compared with the cost of enhancing the 'naturalness' of beech plantations as part of the government's commitment to biodiversity.

2.4: Forest Design Plans

Below strategic plans, specific forest design plans (FDPs) include operational site plans, SSSI management plans, and archaeological site plans. Forestry Enterprises' (FE's) obligations under UK biodiversity Habitat Action Plans (HAPs) and Species Action Plans (SAPs), place constraints on courses of action open to the FC with respect to SSSI and BAPs. Nevertheless, an indication of the magnitude of values for different changes in the quantity of wildlife would provide the FE with some measure of the extent that it should forego timber production by maintaining a patchwork of clear fell sites to provide continuity of habitat, for example.

The cost of wildlife conservation in forests can be inferred from the opportunity cost of timber production foregone. Such a *dose-response* (DR) model is clearly applicable in cases where there is an established relationship between productive impact (i.e. timber production) and environmental damage (loss of wildlife). In such cases the costs of foregoing timber production in the interests of wildlife readily quantify the cost of conservation in monetary terms. These market-cost based measures, that essentially express the value of environmental goods in opportunity cost terms (the value of what is being lost by conserving them), may be more applicable to costing environmental goods that the public find difficult to conceptualise, and where the general public has difficulty in expressing a value for the good. Biodiversity[4] is a good that has no direct market; and people have tremendous difficulty in comprehending and estimating the utility of biodiversity *per se*. People may also be uncertain about the utility they would derive from the preservation of a particular species. However, this cost can be estimated through what is being forgone to preserve the species. Such an approach was used to assess the costs of conserving the northern spotted owl in Oregon and Washington States (see Appendix 2.1).

[4] Biodiversity in terms of taxonomic diversity in the evolutionary tree of life, including genetic diversity within and between species. Diversity relates to the number of bifurcation points (genetic dispersion) in this evolutionary tree between one species and the next, as well as the (genetic) distance from a common ancestry. These are not easy concepts to comprehend, yet alone express a value.

FDPs have a number of objectives, including providing an audit mechanism for monitoring implementation. This essentially requires FDPs to specify objectives quantitatively, following the brief for forest development in the area. The brief for the Spadeadam Design Plan within Kielder FD (FC, 1998), for example, specifies most objectives in quantitative terms (see Appendix 2.2). Choices in this particular FDP are constrained by military and wildlife (Border mires, and red squirrel) obligations. But for many FDPs, indication of the utility or values people attach to the landscape design, in terms of coupe size, age class structure, and open space, would be helpful in ensuring the most efficient return on forestry investment.

Indeed, the FE's design planning process (Figure 2.1) specifically requires alternatives to be assessed, e.g. in terms of coupe timings and shapes, and also alternative species proportions and layouts, as a process in moving toward a final design plan (FC, 1998). Clearly recreation, landscape, biodiversity and carbon sequestration values for changes in coupe shapes, species proportions, and layouts, could inform an optimal forest design.

2.5: Woodland Grant Scheme

The FC employs a points scoring system to filter and identify those Woodland Grant Scheme (WGS) applications in England that offer most towards achieving the aims of the England Forestry Strategy; and conversely identifying planting proposals that would be inappropriate in the English countryside. A points scoring system is also employed for Challenge Fund applications in England, Wales, and Scotland, including the Woodland Improvement Grant (WIG). The WGS scoring form covers seven categories: rural development; economic regeneration; recreation, access and tourism; environment and conservation; size; landscape enhancement; and additional factors. The maximum points achievable under each category are 6; with the exception of size of woodland, which is 5, and landscape, which is 3. A points system is a simple workable practical tool to prioritise projects within a program, and has been adopted by the Environmental Agency to prioritise investments to improve river water quality (Palmer, 1998). However, with WGS there is no *a priori* reason to suggest that each of these items is of equal importance; nor that the utility of landscape is half that of other factors; nor that the utility of the changing size of woodland is that of the implicit function specified by the points system.[5] An estimate of the utility that changes in these particular attributes create, might aid the derivation of a more consistent and rational decision-criterion for determining WGS and WIG applications.

[5] The points system awards points from 1 to 5 as size increases over the range, 2+ ha, 4 +ha, 8+ ha, 12+ ha, 20+ha.

Box1: Summary diagram of the FE Design Planning Process (all stages must be followed)

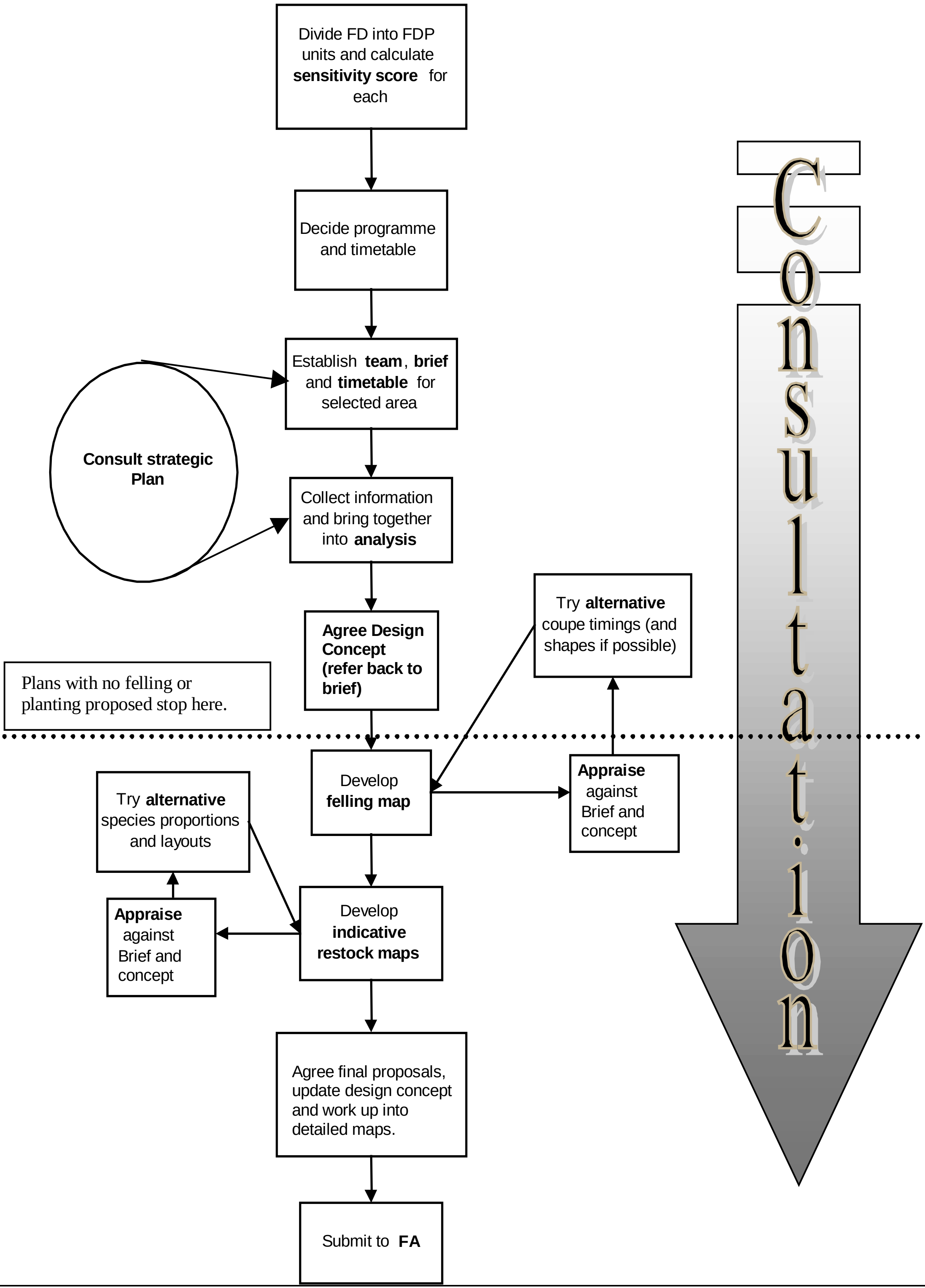


Figure 2.1: Forestry Enterprise Design Planning Process

2.6: Usefulness of previous research studies

The FC, along with many other agencies and government departments, have commissioned studies valuing externalities arising from a variety of public goods. Some of these studies have been perceived to be more successful than others to the commissioning organisation. Hence, an attempt was made to determine the criteria by which studies were judged to be 'successful'. This was undertaken by eliciting written comments from representatives of the FC, DETR (Department of the Environment, Transport and the Regions), SERAD (Scottish Executive Rural Affairs Department), and CCW (Countryside Council for Wales). The comments are not necessarily statistically representative of the experience on the usefulness of research projects commissioned by these organisations, but they provided range and flavour of the criteria considered to be important in determining the 'usefulness' of commissioned research projects.

Criteria for judging the usefulness of projects encompassed

- specification of the brief
- context and methodological appropriateness
- organisation and management of the study
- format and literary style
- results: production of applicable "value" or price for the public good
- policy relevance and acceptability

Specification of the brief

Usefulness was initially deemed to derive from the precise specification of the issue by the client, and the clear conveyance of this to the consultant, with the consultant strictly adhering to the 'brief'. Any ideas developed by the consultant beyond the scope of the brief must be agreed at an early stage with the client. It was seen as the responsibility of the client to specify a brief that would inform policy advice and be relevant for decision-making.

Context and methodological appropriateness

Client representatives also stressed that studies should be technically competent; and pointed out the occasional instances of "cases where reports have been ignored because of technical failings", with the consequence that such reports never inform policy making. For CV studies it was thought that the technical validity of the methodology was enhanced from

(a) the use of an expert group. peer review, focus groups, and debriefing sessions to shape study design and resolve problems with the questionnaire;

(b) careful consideration of the elicitation method and sample size;

(c) minimisation of 'constructed preferences' during interview, by careful questionnaire design and the identification and rating of all problems of environmental concern by the respondent;

(d) adoption of appropriate payment vehicle;

(e) the use of willingness-to-pay for the creation or maintenance of an environmental benefit, rather than a willingness-to-accept (WTA) compensation for the loss of a non-market environmental benefit, so that more credible, conservative, and robust results are produced.

There was a perceived need for the assumptions underlying the analysis in the study to be clearly spelled out; as well as clearly documenting and justifying the method for aggregating the data.

Organisation and management
Clients perceived the need for consultants to develop a good rapport with the Steering Group overseeing the research; and to listen to and acknowledge the constructive comments of the Steering Group on the research. The timely delivery of reports of research contracts was also considered important where they formed an input into policy, and where decisions were driven by a political timetable.

Format and literary style
Many comments stressed the need for consultants reports to be presented in an authoritative, clear, and concise style, written in the simplest appropriate language, avoiding jargon. Reports ought to be well presented, include an executive summary; and avoid the impression of being compiled "in haste". Quality control by the consultant was therefore seen as important in making a report usable to the client. There was also a general consensus that technical annexes were desirable: to present detail, complex methodology, and statistical models, which would otherwise clutter the main text.

Results
As well as addressing the aims and objectives of the brief, the studies should exhibit 'objectivity' with the findings supported by a proper assessment of the evidence, rather than by assertions and prejudices of consultants which occasionally permeate and dominate some reports. Results should present original or innovative views and identify any new angles and linkages. Users must be confident that the report findings are valid.

Policy relevance
Those commissioning studies needed studies to employ the most up-to-date sources of information. There was a requirement for the results to draw out categories of conclusions, present key findings, policy lessons and applicability, and to identify key areas for further work.

For the FC, two studies that are regarded as having great policy and practice relevance and use, are:
(1) the study by Benson and Willis (1992) on *Valuing Informal Recreation on the Forestry Commission Estate*
(2) the study by Garrod and Willis (1997) in conjunction with ERM (1996) on *Valuing Biodiversity and Biodiversity Management Regimes in British forests*.
Both of these studies provided a valuation figure or price that can be directly used in policy evaluation and in local forest management decisions in a straight-forward manner. Furthermore, the relevance and use of these two studies in FC management decisions and policy evaluation is endorsed by the acceptability of the valuation estimates by other government departments. Moreover, the value of informal recreation estimated by Benson and Willis (1992) has the further advantage that it

can easily be indexed over time by a GDP deflator, obviating the cost of commissioning new studies every few years to up-date the estimate.

Studies that do not have policy or practical relevance, such as that by Entec (1997) on Valuing Landscape Improvements in British Forests, occur where the research derives the value for some ‘ideal’, in this instance a forest landscape. The value for an ‘ideal’ forest landscape is of little practical relevance. Forest landscapes change over time due to forest restructuring, whilst an ‘ideal’ forest landscape can take decades to create. What is of more practical relevance would be values for specific changes in forest landscapes, so that forest managers could chart a series of sequential changes that would maximise landscape improvements over time. The household’s WTP value for a forest landscape derived in the Entec study was therefore deemed to be of little practical use in determining the value of changes in forest landscape characteristics.

2.7: Policy appraisal and the environment

KPMG (1997) undertook a review of the extent to which environmental impacts are systematically taken into account in the policy making process; and the scope for further improvement in the way environmental impacts are incorporated into the policy appraisal process. Although forestry was not one of the 19 case studies selected for analysis, the main findings of the KPMG report were that

- there was still room for more comprehensive and systematic consideration of the environmental impacts of policy;
- only 4 of the 19 appraisals made use of techniques advocated in DoE (1991) *Policy Appraisal and the Environment* guidelines for government departments;
- multi-attribute techniques, such as simple decision matrices or scoring and weighting systems, involve a degree of subjectivity and do not allow comparisons across policies;
- the case studies suggested that the more formal the approach to appraisal, the more effectively environmental considerations have been taken into account.

The KPMG report recommended that the ways in which the environmental impacts of policy are appraised should be improved; and stressed the importance of fully assessing the environmental impacts of government and agencies’ policies. This Report commissioned by the FC reflects these sentiments, and aims to contribute to improving the valuation of environmental impacts with respect to forestry.

Chapter 3

VALUATION OF FOREST RECREATION

3.1: Introduction

British woodlands significantly contribute to the welfare of British society by supplying, amongst other benefits, a large variety of sites for low-cost outdoor recreation. In modern society the portion of personal time destined to leisure activities has been on the increase and so has individual mobility. This trend will presumably continue. So, in future, the scope for woodlands to increase the supply of high quality outdoor recreation – and hence contribute to society's welfare – is likely to be high. An important aspect of this supply is that it is available to beneficiaries at a low private cost, hence favouring those segments of society that have low disposable income. In fact, a number of applied studies show that forest recreation is demanded more by low income Households (HHs) (Reiling and Anderson 1985; Hutchinson et al. 2000; Scarpa et al. 2000e). However, high income HHs may reveal higher benefits values, often associated with forest recreation motivated by specific purposes and in more remote woodlands.

While quite a considerable body of research work has been produced in the last decade in this field, it would appear that a number of potentially relevant policy issues have been neglected. In revising the existing body of knowledge, with respect to the criteria laid out in the kick-off meeting, a particular attention will be paid to these neglected areas, and their potential interest for policy maker will be fleshed out.

The importance that the FC places on the recreational function of forests is reflected by the fact that it figures quite predominantly in all the National Strategy documents for forest management. The recreational use of a forest or woodland is affected by its <u>accessibility to visitors</u>. So, woodlands location with respect to main avenues of transport (roads and railways) and their distance from potential users, are paramount in determining access time and – as a consequence – the potential social benefits from recreation. Identical forests may have very different recreational values simply because of differences in their location with respect to avenues of access for visitors.

For a forest or woodland to be visited, its use as a recreational destination must <u>be known to the public</u>. So, users' knowledge of the potential use of a woodland for recreation is a second important determinant of forest recreation. These are two main issues in any strategy aimed at increasing the benefits from recreation of existing forests.

Estimates of these benefits have been derived by studies that employ different – and sometime quite sophisticated – versions of well known non-market valuation methods: Contingent Valuation (CV), Choice Experiments (CE) and Travel Cost (TC). From existing analyses comes confirmation of many intuitive facts. To set the context we cite and comment on some of these here.

Visitors' taste for the degree of wilderness or naturalness of a forest varies. It is true, however, that the presence of recreation facilities is found to be appealing by the majority of visitors. Hence it represents a way to increase a given woodland's appeal and to deliver highe benefits to the representative visitor. When present, site congestion is found to be a disbenefit, and access charges can be seen as a regulatory option to mitigate congestion and produce revenue whenever the associated administration costs are sufficiently low.

Tree variation – in terms species and age (size) – is generally welcome by visitors, who tend to favour woodlands with high percentage of trees of broadleaf species and numerous trees of old age, possibly because of both their prominence in the landscape due to their larger sizes and the wider walkable openings under their canopies. In woodlands with mixed-aged and mixed-species coverage, older trees tend to increase the complexity of the canopy cover increasing attractiveness. This stratification may also produce variations in habitat which can then host a larger variety of animal species (especially birds). This increases a forest's biodiversity, which is typically larger in mixed coverage forests.

The presence of other attractive items within the woodland (waters, archaeological sites, scenic points, nature reserves etc.) generally adds to the benefits produced by the trees alone.

Recreational benefits in systems of forests are inter-related. That is, the size and magnitude of recreation benefits of a single woodland placed in a given system is dependent on the accessibility status and on the conditions of use of the other woodlands in the system. For the purpose of economic benefit estimation, the word "system" here is synonymous of "market". As we shall make more explicit in what follows, market definition, conditional probability of recreation use and seasonal patterns of use are three of the main uncharted issues of much potential value to forest managers and planners.

3.2: Benefits and Beneficiaries of Forest recreation

There are three main groups of beneficiaries from forest recreation. People may value forest recreation because at present they are active users, and this generates a <u>use value</u>. They may also value forest for their potential future use for outdoor recreation, even though, they do not use them at present, and this generates <u>option value</u>. Finally, they may benefit from knowing of the <u>existence</u> and conservation of woodlands because of their ethical and moral persuasions over the availability of forests for recreation for the U.K. population at large, even though they personally do not practice any form of forest recreation.
Benefits are therefore generated by direct use, by enjoying the option to future use and by knowing that the public action is directed towards the achievement of some personal convictions. Most recreation studies centre on benefits from present and past use. This is normally justified by the fact that benefits from option and existence values of woodland recreation are more controversial and they potentially represent only a fraction of total benefits. However, these recreation values may be significant and worth investigating in specific instances, especially for forest sites with high historical values (i.e. Nottingham Forest).

It is conceptually useful to separate various categories of benefits associated with forest recreation:

Leisure benefits: these are benefits derived by people who visit forests to carry out specific leisure activities. Woodlands provide pleasant environments for running, cycling and strolling as well as playing ball or hide-and-seek with friends and/or children, berry-picking and mushroom etc..

Health benefits: in a country where heart disease continue to be one of the major killers, the gentle physical activity that is typically associated with a visit to the woods plays an important role. It both prevents and cures cardiovascular problems and generally contributes to good health.

Educational benefits: woodlands host a variety of plants and animals and supply the ideal setting to develop flora and fauna identification skills. Group visits to woodlands for educational purposes have few substitutes and are actively pursued by schools, scout groups, bird-watchers and other educational organisations.

Lifestyle benefits: for many people attending activities of any sort in woods is a way of maintaining an important contact with nature. For these people nature plays an important role in their lifestyles: visiting forest constitutes an essential component of their identity and spiritual well-being. These values will be higher for certain types of woodlands with historic and cultural values (i.e. Forest of Dean, the New Forest, Caledonian Pine Forest etc.).

Few studies have attempted a distinct valuation of these four categories of benefits connected with forest recreation. The unit of economic analysis most often employed in recreation studies is based on individual Willingness To Pay (WTP) for one forest visit, regardless of the typology of use. Presumably other paradigms could and should be followed to frame distinct valuation studies for each of these additional categories of less explored dimension of benefits.

Different forest types also show different attractiveness for different kind of users. More research needs to be carried out in the context of forest characterisation by various types of forest users.

3.3: Review of forest valuation studies

3.1: A foreword on forest recreation studies.

Given the purpose of this scoping study it must be made clear that most of the recent studies on forest recreation in the U.K. did not specifically aim at contributing towards an overall estimation of NMBs of U.K. forestry. Most studies were conducted by academics and were aimed at resolving important methodological issues. As a consequence, although the amount of work done in this field is vast, the results may appear to contribute quite little to the overall objective of producing a reliable estimate of NMBs in the U.K.. The methodological progress, however, has been quite considerable.

In particular, the sampling frame used in the recreational value studies was not designed to be representative of all U.K. forests, but only of some types of them. As a consequence we have a set of quite accurate estimates for the recreational value of some categories of forests (such as recreational forest parks), while we are quite at a loss for other categories (more remote forests and small woodlots), which might have lower frequency of visitors, but may well be associated with higher levels of individual economic surplus. Further, in a number of otherwise methodologically interesting studies, estimates of confidence intervals for WTP are not reported, making it difficult to assess their statistical significance (Hanley and Ruffel 1991, 1993).

A useful distinction to make in assessing the literature on the value of recreational functions of forests is between studies that use stated preference methods, such as CV, choice experiments, ranking experiments etc. and studies that are based on revealed preference, such as real recreational expenditures, i.e. travel cost data.

3.1: Revealed preference forest recreation studies.

Revealed preference methods have been used in a number of studies. The earliest studies – mostly North American – estimated the effects of forest quality on demand for recreational activities such as camping, hiking, hunting, visiting resorts etc. (Michaelson 1975, Leuschner and Young 1978, Wilman 1984, Crocker 1985, Brookshire and Coursey 1987); Sorg and Loomis (1984) review the early literature. McCollum *et. al*. (1990) investigated the recreational values of national forests, and Englin and Mendelsohn (1991) applied a travel cost hedonic pricing approach to value the recreational benefits of forest landscapes in the Pacific Northwest. Willis and Benson (1989), Willis (1991), Willis and Garrod (1991) and Dobbs (1993) all used travel cost functions to derive recreation benefit estimates from U.K. woodlands. These studies made use of the best methods of the time, however, since then the methodological progress has been quite remarkable. The existing gaps are particularly large especially with respect to the modelling of competing recreation choices and the role of forest attributes in determining recreational value. To address this issue in the 90's a new class of multi-attribute analytical tools was developed and applied to value the benefits of outdoor recreation.

In the 90’s the international literature on travel cost took a particular direction. The zonal travel cost method was mostly supplanted in favour of sophisticated refinements of the individual travel cost method. While the latter attempts to predict the demand of a given area around a forest site, the former attempts to predict the number of visits for a representative individual. In this context, much emphasis was placed on models of destination choice, in the effort to better account for substitution effects amongst alternative destinations. This because, in models where substitution is not adequately accounted for, the estimates of benefits are known to be biased (Caulkins et al. 1985). In these contexts, the adequate definition of the “choice set” becomes important. That is, the set of alternative forest sites that the visitor considers before setting out to visit a given destination in which to recreate. More importantly, multi-stage decision models became well accepted.

These models explicitly recognise the complexity of the household decision to visit a single forest site. To make the analysis tractable the typical approach is to break down the basic recreation decision in at least three components: the participation decision, the quantity demanded decision (intensity) and the site selection decision. Each decision level is driven by the expected utility from the subsequent stage.

The participation decision is a market decision. It answers the question: what is the probability that a person (or HH) with given characteristics be in the market for forest recreation? In other words, given certain socio-economic characteristics (distance from residence or from site of trip origin to the nearer forest, age, education, family composition etc.), what is the probability of the person or HH being a forest visitor in the period under examination?

The quantity demanded decision relates to the number of visits in the period of time. How many times would a person or HH with these characteristics visit a woodland in the season? This part of the model is essential in determining the seasonal consumer surplus (a rough measure of the economic benefit experienced in the period) enjoyed by each unit of analysis.

Finally, the probability of site selection answers the question: given that this person or HH *is* in the market for recreation in forests, what is the probability that a forest site with these attributes be chosen as the destination in each choice occasion? Clearly this is an interesting question because it involves implicit answers for forest managers with respect to the effect of forest attributes on the appeal to visitors. Indeed, this is the decision stage in which one can typically account for substitute effects, role of measurable forest attributes, interactions between individual characteristics and forest traits.

Starting from general population surveys, integrated recreation demand models can be estimated by combining various models and by dealing simultaneously with the issue of participation, demand intensity and site selection (Morey et al. 1993, Romano *et al.* 2000). This kind of studies is very informative because it can be used with ease to infer the welfare estimate of the population at large as a consequence of variation in the attributes of forests or even in the availability of the various elements of the choice set. For example, one may estimate the local (at the trip origin district) and aggregate benefit loss due to a permanent or temporary closure of one or more forests in the set of substitutes. Alternatively, one can simulate the change in economic benefits from the variation in probability of visit to a forest associated with variations in management style that affect the recreationally significant forest attributes (Hutchinson et al. 2000).

Because they require extensive datasets sequential travel cost studies are rare. In the British Isles forest recreation literature, only two sequential decision travel cost studies exist: one for Northern Ireland (Hutchinson et al. 2000) and the second for the Republic of Ireland (Hutchinson 1999). They are twin-studies as they have been developed on the basis of the same survey design and model definition: the EU-CAMAR (Dhubhain et al. 1994). Further large scale travel cost analyses are reported in Ph.D. theses by Hutchinson (1999) and Scarpa (1999). These studies, however, have the implicit limit of being based on on-site sampling and therefore do not compute conditional probabilities of households for being in the market for forest recreation. Nevertheless, in terms of potential applications to forest management, the travel cost data collected in the EU-CAMAR (Dhubhain et al. 1994) study provide a very large scope, and the Scottish section of the data – originally set-up with advice from Adrian Whiteman – has not yet been analysed.

Starting from on-site surveys, and with some knowledge of the number of visits recorded at each site in the unit interval under analysis, it is possible to estimate the last two elements of the decision sequence: demand intensity and site selection. However, participation probabilities, which are quite important in the aggregation phase, cannot be determined on site. Since participation is the final link to overall aggregation, estimates of this probability are necessarily important, and need be accurate.

Other recent work in revealed preference methods for forest recreation was recently carried out in the U.K.. In the last five years a group of travel-cost practitioners has had as the main focus of their attention the issue of how to identify and improve on measurement bias and benefit transfer by using geographical information systems (Bateman *et al.* 1996, Lovett *et al.* 1997, Bateman *et al.* 1999a and 1999b). Results from these studies indicate that the conventional practice of measuring travel distance and travel time from centroids can be improved upon by using GIS, and that the number of visits predicted at each forest can also be more effectively achieved by using GIS. Whereas the practice of centroid-based costing is clearly a rough approximation, it is unclear as to whether similar accuracy about the measures of travel distance and travel time can be achieved by asking visitors to self-report this information in surveys, or indeed by using readily available road planning software such as Milemaster® by the Automobile Association.

Because of the wealth of spatial details that can be elaborated, GIS have potentially a greater scope to improve the zonal than the individual version of travel cost method models. For example they can be used to define the extent of the market supplied by forests and help towards the definitions of the real versus the individually perceived set of forest substitutes for recreation. Yet, these aspects are still to be thoroughly investigated.

Altogether, in the last ten years, our understanding and empirical modelling of forest recreation in the British Isles has much improved. This growth of knowledge has resulted from two concomitant factors. In the first place, sizeable resources have been made available by the European Union Research programmes and by ESRC. The EU mandated a particularly large valuation study in which both CV and TC data were collected – the EU CAMAR – which was carried out in 1992, and the TC results of which have only recently started to become available in the literature (Hutchinson et al. 2000).

Secondly, much technical progress has been made in the econometric modelling of outdoor recreation. In particular, the properties of demand functions based on count data and those based on choice probabilities from a selected set of alternatives are better understood. The former are used to predict the number of expected visits in the unit interval and are conceptually linked to models of repeated choices each with low choice probabilities (Parsons et al. 1999). The latter predict the probability of visiting a single destination conditional on various visitors' characteristics and destination's attributes.

Amongst the significant results recently obtained from large-scale revealed preference analyses, we can list the following:

- linked choice-count models can be used to accurately predict changes in the geographical distribution of recreation benefits resulting from management actions that change forest quality, access charges or access status of a forest (Hutchinson et al 2000);
- individual demand for forest visits in Northern Ireland for visitors who set out from the site of trip origin for the main purpose of conducting a recreation visit to a forest enjoy substantially higher economic benefits than previosuly estimated, (over £4) and with quite a variation of across forest sites (£1.15-£7) (Scarpa 1999);
- once forest attributes are accounted for in the demand system of the Northern Ireland portion of the EU-CAMAR data the model fits better and the expected benefit of each forest visit goes up from £2.25 to £3.70.

What gaps remain to be filled for the purpose of valuing the recreational component of NMBs produced by UK forestry with revealed preference methods? As said in the foreword, this was never the principal goal of any of the recent R.P. recreation studies. However, because of its scope (42 major recreation forest sites in Scotland, Northern Ireland and the Republic of Ireland) and sample numerosity (over 14 thousand surveys), the various analyses supported by the EU-CAMAR dataset are quite informative for this category of forests. Validation studies need be carried out to assess the reliability of these estimates for forests in this category which are outside that sample of investigated forests (i.e. England and Wales). If these were to be found reliable, then multi-attribute benefit function transfers can be used to obtain accurate estimates of recreational benefits. Another large gap that needs to be filled is that concerning forests not belonging to the set of recreation parks, or – more generally – forests with low frequency of visitors because of their remoteness. The recreational value of these can be higher than expected because of the high benefits enjoyed by each visitor, even though the share of total visits captured by these sites is low. Finally, for the purpose of aggregation, market definition must be investigated at the local to national level and the role of on-site recreation surveys carried out by the Forest Enterprise should be re-evaluated in this larger valuation context.

3.2: Stated preference forest recreation studies.

Stated (or "expressed") preference methods are often used in forest valuation studies. We describe here only CV and CE applications, which seem to be the predominant methodologies in this context.

Because of its wide acceptance amongst nonmarket valuation practitioners and its inherent flexibility, CV has been used extensively in recreation studies in general, and with some applications to forest recreation. However, most of the CV studies relating to forests and woodlands where aimed at non-recreational values, such as conservation values (Lockwood et al. 1992), landscape values (Mattson and Li 1995) etc. A second tool for investigating economic preference for woodland recreation are "choice experiments" (CE). This is a multi-attribute variant of CV that was adapted from conjoint analysis and market research to valuation of environmental and other public and quasi-public goods. Although possibly more powerful and sample efficient, choice experiments are implicitly less robust as their specifications inevitably suffer from omitted variables, which might be correlated with included variables and produce bias in parameter estimates and, therefore, in benefit estimates as well.

Nevertheless, recent advances in econometrics of discrete choices show potential to overcome most of the typical shortcomings of CE. In particular, mixed parameter and multivariate models seem to produce significant improvement in models' fit when respondents are asked repeated choice questions (Train 1998a, 1998b, Garrod et al. 2000).

Although no CE study appears to have been conducted to specifically investigate economic preference for recreation in woodlands, interesting large scale and multi-attribute WTP functions were estimated from the CV analysis of the EU CAMAR data of Northern Ireland, Republic of Ireland and Scotland (Scarpa 1999). Because of the advanced methods employed in this analyses and the variety of forest environments at which surveys were conducted, this dataset is possibly the most extensive forest recreation survey with stated preference ever conducted in the world. Some results from the analyses of the CV data are reported in two doctoral research theses (Hutchinson 1999, and Scarpa 1999). Some are reported in manuscripts under review (Hutchinson et al. 2000; Scarpa et al. 2000e) and some in published papers (Scarpa et al. 2000a, 2000b, 2000c). However, more work can be done on these data to answer specific policy questions, including NMBs estimates. The survey data would also appear to have good scope for being supplemented with GIS information to address issues such as market definition and other spatial problems.

Amongst the significant results obtained from the stated preference analyses conducted so far, we can list the following:

- discrete choice responses to CV questions appear to be consistent with plausible distributions of benefits across the population of visitors. Per visit willingness to pay at the forest gate ranges between 70 pence and two pounds (Scarpa et al. 2000a, Hutchinson et al. 2000). Scarpa et al. (2000d) provide a number of estimates for mean and median WTP *at the gate* and show that 25 percent of the estimates for mean WTP have values of less than 160 pence, and 25 percent have a value higher than 245 pence, with a maximum of 4 pounds in some high quality forests (all in 1992 values).
- The means of the distribution of benefits are affected significantly and in the expected direction by important forest attributes. These include a quantitative index for forest quality which is meant to capture non measurable aspects of the aesthetics of each forest site and was developed by experts (Scarpa et al. 2000c);
- The estimates of the marginal effects of these forest attributes on the benefit function appear to be stable (robust) to the sequence of responses and to the type of assumptions employed in the analysis (Scarpa et al. 2000c);
- Of particular interest is the strong positive effect produced by the presence of Nature Reserves that has allowed the estimation of the potential benefits to recreation associated with a switch to the forest management regime towards the creation of nature reserves in those forest sites currently without one (Scarpa et al. 2000b). A present value conservative estimate for this was found to be in excess of 16 million pounds at 1992 currency values. Everything else equal, average WTP at the gate was 30 pence higher at forest sites with Nature Reserves;
- A systematic analysis of the reliability of benefit value transfers based on forest attributes and on the EU-CAMAR data for Ireland has shown good reliability (Scarpa et al. 2000d): more than 60 percent of the transfers of mean WTP were not statistically different (at conventional significance levels) from the estimates obtained on site. For those estimates that were not transferable, overprediction occurred more

frequently than underprediction. This seems to indicate that when good quality information is available to describe those forest attributes which are recreationally valuable, then the estimated multi-attribute benefit functions can reliably be used to transfer benefit values. In this context reliability means that, once accounted for sampling variation, the estimates obtained with on-site surveys were often not significantly different from those predicted for the site on the basis of its attributes by using the benefit function;

- Recent work on transferability and reliability of multi-attribute benefit functions (not value) over the entire set of 42 forests seem to indicate that the estimated benefit function is reliable in 60-70% of the sites (Scarpa et al. 2000f).

What gaps remain to be filled for the purpose of valuing the recreational component of NMBs produced by UK forestry with stated preference methods? Much of what discussed in the case of R.P. methods above applies also here. However, since S.P. methods are always about hypothetical choices, the effect of hypothetical bias should be investigated more in depth, possibly by validity studies involving experimental introduction of access charges, to assess whether the shift in recreation demand due the charge is correctly predicted on the basis of S.P. responses. Another potential use of S.P. studies in this context is that of investigating the dimension of various categories of benefits that might be double counted. Forest visitors enjoy the recreational experience as a whole, potentially enjoying the benefits of all of the various components of NMBs. Experimental interviews can be designed and conducted with S.P. methods so as to separate and rank these various dimensions and value their part-whole effects, hence deriving a relative preference weighting for each of them.

3.4: Valuation issues

In this section we identify and describe some of the main research issues that have arisen from recent research in benefit valuation from forest recreation. We focus on the most relevant issues for forest policy and decision-making, with a particular eye to NMBs valuation, rather than on issues of more academic or theoretical interest.

3.4.1: Valuation issues in TC

Travel cost analysis is the preferred tool of revealed preference approaches in forest recreation. In general, the applications to forest recreation are no different from those developed from other kinds of natural resources with recreational use (fishing waters, hunting sites etc.). An extensive contribution to the refinement of travel cost methods has been provided by studies centred on water recreation (canoe, rafting, fishing etc.) and hunting (deer, geese, etc.). The main difference between these activities and forest recreation is that the latter has a more occasional nature, whereas the former often require licensing and/or joining some particular list of recreationists from which it is possible to accurately derive the size and sampling frame of the relevant population (i.e. the consumers in the market) of beneficiaries. Forest recreation studies therefore suffer from a more inaccurate knowledge of the extension and size of the market supplied by each particular forest. The implication is that particular care must be given to the adequate definition of market boundaries and extent. This issue can be approached in different ways, but it is vital that it be adequately dealt with to allow meaningful aggregation of benefit values. In adding-up the total impact of aggregation errors may easily become larger than that from estimation errors. It is pointless to employ very sophisticated estimation techniques and then to proceed aggregating over inadequate population sizes.

Travel cost models are of various kinds. There exist two main variants of the basic model: the zonal and the individual. The individual models define the quantity demanded by the individual or by the household, typically conditional on individual characteristics and forest site attributes. Total recreation benefits estimates are derived by adding-up estimates of consumer surplus per visit, which – in turn – is derived by integrating under the individual demand function. The typical zonal model, instead, defines the quantity of visits demanded of one single site by the surrounding population of residents.

To improve market definition, it seems particularly useful to employ GIS, with which population densities and distances from recreational sites can be easily handled. This can provide the researcher with more accurate estimates of target populations than those available with other means and may help to ultimately resolve the aggregation problems that often affect the computation of aggregate benefits.

- **Research Needs:** GIS-supported TC applications have been successful in proving the existence and measuring the size of potential bias that GIS may help reduce (Bateman et al. 1996). However, GIS alone cannot resolve the problem of characterising the probability of being in the market for recreation. So, specific studies should be carried out in each potential woodland recreation market by *ad hoc* surveys.

An area that deserves further enquiry concerns the potential improvement that the zonal version of the travel cost method can benefit from a wise application of GIS. Another field concerns the mapping of important forest attributes across woodlands and their weight in attracting visits from distant origins, as well as their role in substitution effects across sites in the same market.
Predictive performance of forest benefit values with travel cost models ought to be tested, possibly with existing large-scale data, such as the EU-CAMAR one.

- **Policy Gain:** Improved understanding of how to integrate GIS systems with forest recreation analysis. Precise definition of size and extent of recreation markets at local, regional and national levels. Tests of reliability of benefit function and value transfer and simulation of changes in recreational market systems.

3.4.2: Valuation issues in CV and CE

In stated preference analyses the main valuation issue is that of validation of the welfare estimates, especially in terms of their robustness to underlying assumptions in estimation and their sensitivity to embedding. These issues are too often altogether ignored in many studies. The U.S. National Oceanic and Atmospheric Administration appointed a panel of experts to produce guidelines for CV studies. They recommend policy agencies using valuation results from CV surveys to require that these studies include a validation of these estimates wherever possible and basic tests of economic rationality of agents. The issue of validation is complex and well discussed in various contributions (Bishop et al 1995, Mitchell and Carson 1989). CV studies should clearly describe how truth-telling is promoted by employing adequate mechanism designs in surveys, possibly incorporating recommendations from game theorists (Green et al. 1998, Carson et al. 1999).

Because the travel cost method is the privileged tool of revealed preference analysis in outdoor recreation, it is advisable that stated preference estimates be compared with those from travel cost, whenever possible and theoretically adequate. Revealed and stated preference information can also be jointly analysed to provide more integrated information and analyses, and more efficient parameter and value estimates. Validation and a robustness analysis should be an integral part of every stated preference study, but currently they are not.

- **Research Needs:** Investigate conceptual and practical ways to conduct exercises for validation, robustness and sensitivity analysis in stated-preference forest recreation studies.

- **Policy Gain:** More persuasive value estimates and increased acceptance of stated preference method estimates.

3.5: Double Counting

A well thought out recreation study ought not to be affected by double counting. However, some forest attributes that are valued by recreationists may also be an integral part of other types of values not associated with recreation use.

The case of landscape values is one instance of this kind. Estimates of hedonic functions for WTP for access to forest for recreation (Scarpa et al. 2000c) provide evidence that broad-leaved trees have strong positive value to recreationists, and that mixed woodlands contributes more to private non-timber values than single species plantations, especially when old tall trees are present and add layers to the canopy complexity. Mixed woodland is also more appealing from the scenic viewpoint, because it adds to the variety of the landscape. It is a self-evident truth that forest recreationists will enjoy outdoor activities more in woodlands with high internal landscape values. Since landscape appeal is difficult to quantify and it varies in its internal and external components, one can resort to proxy this factor by means of site quality indices. Some strong evidence exists that numerical indices reflecting internal landscape quality have significant and strong effects on estimated WTP for recreation in both TC (Hutchinson 1999, Hutchinson et al. 2000) and CV (Scarpa et al. 2000d) models.

At the same time forest traits will add to the appeal of the landscape and will be enjoyed actively or passively by other categories of people, who may or may not be forest recreationists. In case they are also forest recreationists, then some potential for double-counting mistakes arises, in that they will benefit from landscape values during forest visits, as well as in other moments, such as travelling by a forested landscape, or simply admiring the landscape from a photograph.

Similarly, biodiversity may produce multiple types of benefits from direct and indirect use.

Short of a specifically designed S.P. approach, it is virtually impossible to separate these consumption moments by using standard revealed preference approaches. This issue might be ignored in NMBs estimation, if addressed it requires the conduction of specific studies. We find ourselves in front of a typical joint production – joint consumption problem. Forest landscape or forest biodiversity are jointly produced and supplied with woodland management to conceptually different categories of users, which may or may not coincide in the same individual. In case they do coincide, they may be separate in time. For example, the contemplative and evocative value of landscapes may be predominant in older age groups of the population, while the scenic landscape values associated with recreation can be more appreciated in young age groups. However, one can reasonably expect that there be limits to the introspective efforts that an individual can make to separate these consumption moments, and even specific studies will soon meet the practical limits due to this problem.

- **Research Needs:** It is difficult to definitely address the issue of double counting in forest recreation. Before embarking on large scale studies specifically addressing this issue it would be worthwhile to reach ball-park estimates of the bias that this type of double counting produces in the final aggregated estimates of recreation benefits. Double counting may well result in a relatively small bias if compared to that due to inadequate aggregation methods.

- **Policy Gain:** More precise welfare estimates and good understanding of the decomposition of total values into specific ones.

3.6: Benefit Transfer

For a general definition of benefit transfer see the Landscape section in chapter 4. Benefit transfers for forest recreation have not been sufficiently investigated yet. This technique, although potentially very useful, is still subject of some controversy.

3.6.1: Benefit Transfer from CV models

Existing studies on benefit function transfer from CV models for water recreation show that unconditional (mono-attribute) transfer are found not reliable (Downing and Ozuna 1996). Recent results specific for forest recreation show that benefit value (Scarpa et al. 2000d) and function (Scarpa et al. 2000f) transfers conditional on forest attributes (multi-attribute) perform quite well from benefit functions calibrated on a large number of forest sites each sampled with an usual sample size. The issue of how to measure reliability is also controversial. In general expected benefit values will strongly depend on the specification used in the econometric analysis. In other words, the same observed data are compatible with different magnitudes of benefit estimates, depending on the type of econometric analysis performed. Testing for the correct econometric analysis is often impractical because at normal sample sizes the power of the test statistics tend to be low. This means that benefit transfers have little robustness to mis-specification errors. When benefit functions, rather than benefit values, are transferred – such as in Downing and Ozuna study – reliability is defined in terms of statistical tests aimed at assessing the significance of the null hypothesis that the data share the same functional form *and* parameter values. In such a context it is clearly important to use a persuasive specification for the benefit function. That is, a specification with high plausibility and therefore high likelihood to be shared across recreation sites. For example, as shown in meta-analysis studies (Santos 1998, Rosenberger and Loomis 2000), in this context it is conceptually important to recognise the potential effect of site-specific recreationally relevant attributes. Downing and Ozuna (1996) use a simple slope-constant specification, which clearly ignores the effect of any site attribute, as well as socio-economic characteristics of visitors, and this may well be the cause of their negative result about the transferability of the benefit function. Scarpa et al. 2000d report positive results for the transferability of recreation benefit *estimates* from more persuasive benefit functions that include site-specific attributes. The issue of *parametric robustness* of the benefit value *function* is investigated elsewhere (Scarpa et al. 2000f) and with a different methodology.

<u>3.6.2: Benefit Transfer from TC models</u>

Benefit functions can be derived also from revealed preference studies such as TC observations. Three studies deal with benefit transfers of forest recreation in the UK (Lovett 1997, Brainard et al 1999, Bateman et al. 1999), but they do *not appear* to investigate reliability of transfer with any statistical test apart from point prediction of expected number of visits. Existing data-set could be used to conduct reliability studies, although they might be supplemented with more data.

- **Research Needs:** Benefit transfers are potentially very useful in forest recreation evaluation. Existing datasets have not been completely exploited in terms of testing for benefit value or benefit function transfers. An exhaustive analysis of the existing datasets on recreation is recommended before proceeding to any new collection of the necessarily large datasets required to make sizeable progress in this field. For example, no benefit transfer study based on travel cost data has been conducted, in the data collected in the EU-CAMAR research project. The Scottish section of both CV and TCM data is also mostly unexplored in many respects. Since forest attributes appear to play an important role in value transfer, some specific studies ought to be carried out to define those woodland attributes that determine recreational values. Once identified the common determinants of value across recreation sites, objective measures of these attributes ought to be developed and applied to the inventory of recreational sites. This dataset could then be used to make econometric specifications of value functions more realistic.

- **Policy Gain**: Improving our understanding and performance of benefit transfers in recreation is quite crucial as benefit can be transferred not only across sites but also across time. The time factor is often not well investigated, but one ought to bear in mind that both the beneficiaries of recreation and the woodland supplying it are dynamic entities. Representing benefits from snapshots in the space-time dimension may be misleading in the forestry contexts in which long time intervals elapse between policy decision and the full realisation of their outcomes.

3.7: Sampling and Aggregation

Different sampling strategies must be adopted in different recreation surveys. It is important to identify the population of relevance for the goal(s) of the study. To improve efficiency (allow the use of low sample sizes) and reduce costs, especially in studies with a large number of goals, it is advisable to break-down the sampling process into different moments, each feeding additional information into subsequent stages.

As expanded upon elsewhere in this report, it is noteworthy that aggregation must be guided by good knowledge about the relevant population. Poor information about this will lead to inadequate aggregate values and therefore will amplify any bias present in the initial individual value estimates and probably cause bias in aggregate values of a magnitude which goes well beyond the gains achieved by employing the most sophisticated estimation methods.

- **Research Needs:** The catchment areas (markets) of different forest recreation sites are important elements in benefit aggregation and need to be assessed at the local, regional and national level. On-site samples need to be weighted by frequencies of visit to avoid sample self-selection bias which arise from the fact that frequent users have higher chances of being sampled on-site than less frequent users (Manski and Lerman 1977). The additional potential provided by general population surveys – relying on samples drawn from the general population, rather than on site – ought to be explored as means to correct the inevitable deficiencies of on-site sampling.

- **Policy Gain**: An improved understanding of geographical market conditions and determinants of positive demand for forest recreation.

3.8: Embedding

Embedding may be a relatively big problem in stated preference studies for non-use values. For example, stated preference studies aiming at estimating option values of recreational sites, or conservation value of forested areas may well suffer from embedding. However, recent tendencies show that adequate survey design may significantly reduce embedding problems. To this end focus groups, pilot studies and debriefing questions are crucial moments in survey development and administration to detect and address this problem. Even the most experience researcher can never be sufficiently confident of having completely eliminated the scope for embedding problems. Therefore embedding tests should always be incorporated in these studies.

However, in forest recreation CV studies, which aim at defining use values, embedding effects should not be a problem unless the scenario specification is poor constructed.

A form of bias, which is conceptually related to embedding, may also arise in TC models when there are joint travel costs to forest recreation visits. For example, in multiple destination trips.

Suppose a visitor who is intercepted at a forest site is asked where his journey originated, and the respondent indicates the origin of his/her journey, but fails to record that the visit to the forest was only one of the sites s/he set off to visit. Then, during the analysis that data point will be attributed a cost for the visit that is higher than what s/he really had, since s/he actually split the cost between multiple destinations. If this condition is widespread in the data, then the resulting welfare estimates will be biased upward. This is similar to what happens when the cost of reaching substitutes forest sites is omitted in the demand specification.

Problems are also detected in the correct definition of substitutes. To a given visitor who has decided to visit the forest to play ball games with his family in an open area, another open area suitable to play ball games can be perceived as a reasonable substitute. Clearly this need not be placed in a woodland. Presumably the set of substitutes sites is different for people seeking to perform different activities during the visit. This consideration raises the issue of choice-set endogeneity, i.e. the problem of adequately specifying substitute effects in recreational demand systems. Alternative journey destinations should be defined on the basis of what was perceived as a substitute by the visitors, and not arbitrarily chosen by the researcher.

- **Research Needs:** The bias produced by embedding-like effects and by the incorrect definition of substitution effects are both worth investigating further. The investigation can be carried out both at the conceptual and the empirical level. Conceptual investigations are cheaper to conduct as they do not require data collection and can rely on simulation techniques. Inexpensive empirical investigations can also be conducted on data already available. For example, supply and demand characterisation may be usefully conducted by cluster analysis of forest-sites and visitors.

- **Policy Gain:** Addressing the potential bias of the conventional TCM modelling techniques is crucial in developing an understanding of the robustness of the various methods to common mis-specifications. The gains in terms of policy-making are represented by more instructive and realistic models of recreation demand and recreationists' preferences.

3.9: WTA and WTP

Bateman et al. (1996) illustrate the results from a small scale, but quite interesting study on the estimation of farmers' WTA and HHs WTP for establishing a recreational woodland. Although, the results are difficult to generalise, they illustrate how nonmarket valuation can be used in this context.

More frequently policy maker are concerned by observed differences in stated WTA and WTP that the same agents express for identical changes in state of supply. Recent theoretical examinations on the rational causes of these discrepancies have developed a number of persuasive reasons as to the causes of this disparity (Coursey et al. 1987, Hanemann 1991). This asymmetry is no longer puzzling to economists and neither should it be to policy makers. Individuals in society are averse to loss and show strong preference rankings over alternative distributional states. Although these concepts have a difficult rationalisation in conventional neo-classical wisdom, advances in game theory and in explanatory theories of value show that this asymmetry can be rationalised. In the case of forest recreation most investigations are centred on the WTP for access to the site.

Aggregate WTP for creation of new woodland recreation sites can be inferred by the potential market they can serve and by means of previously estimated benefit functions. For example, conditional choice models of travel cost for a system of substitute sites have been used to obtain these types of forecast (Hutchinson et al. 2000) following, for example, increases in site quality. Symmetrically, similar estimates can be obtained for WTA values to prevent loss of recreation benefit from site closure and/or worsening of site quality. These category of models are extremely flexible and can be used to estimate variation of flows resulting from variation in site quality and in cost of access for the entire system of substitute sites. Changes in welfare (gains and losses) can also be broken down spatially so as to identify and quantify gains and losses at the district level, along with other distributional issues.

- **Research Needs:** The potential of integrating conventional approaches of travel cost with powerful GIS is, at least in principle, very large. Specific pilot studies could be conducted to explore the additional knowledge that can be produced by integrating these tools in a sound econometric framework, providing both, estimates of WTP and WTA from the same set of behavioural assumptions.

- **Policy Gain:** A more detailed understanding of the spatial relation and substitution effects for residents in the same system of recreational forest sites. An understanding of how forest attributes can affect probability of site visit, and thereby total benefit supplied by a given forest to the community.

3.10: Research Needs: Summary

1. Investigate individual determinants of probability of being forest-users for recreation.

2. Identify spatial boundaries of markets for forest recreation, for each forest system, and for the recreation catchment area for each forest.

3. Identify determinants of choice set formation and patterns of substitutability.

4. Use stated preference to explore individuals values of NMBs likely to be double counted or embedded in aggregate estimates.

5. Study the pattern of forest recreation dynamics, across seasons and across family life-cycle.

6. Exploit further existing good quality data set to gain inexpensive, but important methodological knowledge on valuation modelling and to lead future research.

Chapter 4

FOREST LANDSCAPE VALUATION

4.1: Introduction and aims

Woodlands make an important contribution to the landscape of the British countryside. Carefully designed and located new woodlands have the potential to enhance the diversity and aesthetic appeal of landscapes around towns, in areas of intensively cultivated farmland, or in the hills and mountains. On the other hand, inappropriately designed forests can impact negatively on treasured views in more sensitive locations. As woodlands approach maturity, management and in particular the timing and nature of harvesting, can also have a major landscape impact.

The important contribution of forestry to the landscape is recognised in public policy. Landscape enhancement is a key objective in both the state and private sector. The conservation and enhancement of the landscape is an objective of Forest Enterprise's activities, and applications to plant trees under for the Woodland Grant Scheme or for major harvesting and restructuring operations are carefully scrutinised to determine landscape impact. In England landscape is one of seven criteria under a new competitive system for scoring applications to plant trees, and was an important consideration in the development of regional Indicative Forestry Strategies.

Evaluation of the landscape impacts of forestry has been guided to a great extent by the expert opinion of landscape architects. Early work by Dame Sylvia Crowe in the 1960's has been refined and developed into a comprehensive package of design guidelines for foresters (Forestry Commission, 1998). However, economic approaches which reflect public preferences about landscape impacts of forestry are now beginning to play a more important role in the evaluation of forestry policy and practice. Over the last decade there have been a number of studies which have attempted to evaluate landscape in monetary terms using a variety of methods including contingent valuation, choice experiments, and hedonic price models.

Economic valuation of non-market outputs can help guide forest decision-making at a range of levels. In national and international terms, economic values are useful for national reporting and accounting purposes, and in assessing compliance with international obligations on sustainable forestry practice. Valuation can help guide regional forest strategies and assist in a range of local decisions regarding the design and location of new woodlands, forest management and harvesting. The key advantage of monetary valuation is that it allows market and non-market goods and services to be directly compared on an equivalent basis with financial returns from timber, rather than in an ad hoc or otherwise subjective way.

Valuing the landscape impact of forests has proven to be more difficult than for other forestry outputs such as recreation. In part this reflects the absence of any technical or biological relationship between the forest's appearance and individual preference -

beauty is very much in the eye of the beholder! Contrast this with ecological benefits where links between the habitat requirements of rare species and woodland type, or between cultivation practice and water quality are well understood. But there are also other features of landscape which make it less tractable than other non-market benefits.

First, landscape is a very complex good that can be valued from aesthetic, ecological, social, and subconscious perspectives, and in different ways by different people (Hutchison, *et al.*, 1995). Second, preferences for forestry in rural landscapes are conditioned by the landscape setting itself. Values for landscape reflect the specific composition of features and objects with that landscape vista, and will vary depending on how this complex array of substitute and complementary elements are arranged. Hence, physically similar woodlands in different landscape settings and in different parts of the country can generate vastly different benefit values.

Finally, there can be difficulties identifying relevant user groups and hence aggregating policy benefits. Some user groups such as forest recreationalists or local residents are relatively easy to locate and sample, whereas other groups are not. Take hill-walkers for example. In hilly or mountainous landscapes forests can often be seen from great distances, yet it is difficult to identify and interview hill-walkers and other outdoor enthusiasts who appreciate forests from some distance away. Commuters and scenic drivers are also likely to appreciate forests in the landscape, but from where and how is difficult to assess.

Although previous forest landscape valuation research has helped gain an understanding of and insight to these and other issues, considerable difficulties remain. The aim of this chapter is to assess the extent to which landscape valuation studies have contributed to decision-making at local and national levels, and to identify key issues that require further research. The remainder of this chapter is divided into 3 sections. In the next section, the potential benefits and beneficiaries of forest landscape are described. In Section 3 the main findings of existing forest landscape valuation studies are reviewed and in Section 4 the main valuations issues arising are described, together with suggested future research that could assist forestry decision-making at all levels. Section 5 provides a summary of a possible research agenda for landscape valuation research.

4.2: Benefits and Beneficiaries of Forest landscapes

Forest landscape impacts are a classic example of an economic externality whereby the owner of the resource provides uncompensated goods and services to other individuals. These individuals can be categorised into four types.

Forest Users: People who frequent forest areas for informal recreation such as dog-walking and cycling and formal recreational activities such as orienteering. Changes in the internal appearance of the forest, for example through the creation of open spaces or broad-leaved areas within the forest, can directly affect enjoyment of these activities. The extent to which enjoyment is affected may depend on the nature of the activity - dog-walkers and other general visitors tend to be less sensitive to changes in the landscape than some specialist users such as hunters.

External Users: This group refers to non-visitors and includes people who appreciate forests from outside the forest boundary. Some examples include local residents who enjoy the views of a nearby forest from their living room, hill-walkers who stop to appreciate the view from a nearby mountain top, and the train-bound commuter glancing out of the window at the passing landscape.

Indirect users: People may also benefit indirectly from viewing attractive forest images in books and magazines, or on television programmes. The Queens View in Perthshire is well known to may subscribers to the Scots Magazine, many of whom have never actually been there.

Non-users: It is possible that some forested landscapes generate non-use values. For example, some people may value knowing that a special forest view exists even if they have never actually seen it for themselves. It is not clear from existing research the extent to which non-use values for woodland landscapes actually exists, or of their importance relative to use values. However, it is possible that in general non-use values for landscape may be less important in the UK than in other countries and cultures where forest cover is ore intimately associated with life, work, and culture. In Germany, for example, forests are highly valued for sport and timber, but also as places deep in symbolic meaning closely associated with national identity.

Why people should value forest landscapes is not fully understood. Clearly the benefits are psychological rather than physical, but the rewards from viewing an attractive landscape may not only be linked to aesthetic considerations. Landscapes can be perceived and interpreted in more complex and subtle ways, often linked to knowledge of the place and personal experience. For example, farmers and other country people tend to recognise the practical and cultural significance of objects in the view. For some people landscapes can be cognitively linked to wildlife habitat or to a way of life (O'Neill and Walsh, 2000).

This report is concerned primarily with how landscape benefits can be valued - motivation is perhaps best left to the psychologist. In the next section the main valuation research relevant to forest landscape appreciation is reviewed.

4.3: Review of forest valuation studies

For many years the valuation of landscape benefits of forestry was considered to be too intractable. The 1972 Treasury cost-benefit analysis of forestry for example, made no attempt to evaluate the impact of forestry on the landscape and the NAO study published in 1986 stated that '*landscape and amenity values are essentially subjective and difficult to quantify and it is not therefore possible meaningfully to estimate any economic benefits or disadvantages arising*'.

It was not until the 1990s, following the recommendation of the House of Commons Committee of Public Accounts, that the non-market benefits of forestry should be quantified in monetary terms, that the Forestry Commission become actively engaged in valuation research. Funding to this end became available for the application and testing of valuation approaches that had been developed for a number of years in other fields.

The purpose of this chapter is to review the main valuation studies that are relevant to forest landscape valuation in the UK. Given the objectives of the project and the resources available, the review was guided by the following criteria:

1. Relevance: Due to the importance of the socio-economic, cultural and landscape context of landscape appreciation the review concentrates on UK applications, except where important methodological issues are identified from the international literature.
2. Methodology: Studies that applied preference based monetary valuation methods such as contingent valuation that could be used to measure consumer surplus were reviewed. Expert based methods and hybrid techniques as developed by Helliwell (1990) and Price (1993) were therefore excluded.
3. Scientific Quality: Only those studies that had been published in reputable academic journals or for which full details regarding implementation and statistical analysis were available for scrutiny were included.

Forest valuation studies relating to landscape traits fall broadly into one of three categories: woodland creation (Macmillan and Duff, 1998; Bateman et al., 1996, Bishop, 1992); woodland in the wider (agricultural) landscape (Hanley et al., 1999; Garrod and Willis, 1992), and characteristics of existing forests (Entec, 1997; Hanley and Ruffell, 1993; Scarpa 2000 a and b). Typically three different valuation methods have been used: Contingent Valuation (CV), Choice Experiments (CE), and Hedonic Price Models (HPM).

The general research findings of these studies are summarised below:

- Importance of woodland type. Hanley and Craig (1991) found that the general public were willing to pay over £300 per hectare to prevent commercial afforestation of the 'flow country' in northern Scotland with non-native species. Macmillan and Duff (1998), on the other hand, report that on average the general public was WTP £24 per household per year for a project to restore native woodland on heather moorland in Strathspey[1]. Willis and Garrod (1992), using an HPM covering over 100 000 properties found that broad-leaved trees had a positive effect on house prices, while mature Sitka spruce reduced their value. Scarpa *et al*. (2000b and 2000c) in a study of 28 Irish forests, found that the same percent increase in broadleaf cover is worth 10 pence per visit, around 12 pence for larch and 5 pence per visit for evergreen conifers. (These are marginal values and they may well relate to the specific mixture of species present in the 28 forest parks investigated in Ireland in the EU-CAMAR study).
- Importance of the existing landscape. The valuation of afforestation projects is influenced by the nature of the existing landscape. Willis and Garrod (1993) found a preference for the existing landscape of the Yorkshire Dales over any form of land use change, whereas the restoration of scrub and trees was strongly

[1] Neither of these studies focused on landscape, but estimated use and non-use values for forest creation inclusive of wildlife and environmental impacts as well as landscape impacts.

preferred in the more monotonous landscape of the southern uplands (Bullock and Kay, 1997).

- Importance of location both in terms of the total number and type of beneficiaries: landscape impacts of community forests are more significant than those of a remote plantation because many more people see it. Location also influences visual impact and aesthetic preferences because landscapes are compositions: the same woodland in one location can have an entirely different visual impact when placed in another location.
- Landscape preferences are diverse. Unlike environmental policies such as pollution control, afforestation and other forest landscape projects can have a positive or negative impact on the landscape. Hence it may be necessary to estimate both WTP and WTA compensation from landscape users. Macmillan and Duff (1998) for example, found that native woodland restoration in Strathspey was favoured by 67% of respondents surveyed, and opposed by 24%. When WTA compensation was included in the calculation of overall project benefits mean WTP fell from £53 to £24 per household.
- Insensitivity to change in the landscape attributes of existing forests. Hanley and Ruffel (1993), found that visitors on average were WTP less than £1 for each of three different attribute changes (uniform v diverse tree height, mixed species v conifer only, and presence of water feature). Entec (1997) studied a wider range of variables using CE and CV approaches but found that WTP varied within a fairly narrow range for different attributes. For example, WTP per household for selective felling and 'organic shapes' was £12.89 and £13.90 respectively using CE, compared to £10.97 and £12.75 with CV.
- Residential values: Using HPM, researchers estimate that forest cover can increase property values by between 2-6% depending on location, species and age of trees, but problems with multi-collinearity and the lack of appropriate data hinder interpretation of HPM results (Willis and Garrod, 1992; Anderson and Cordell, 1988; Morales, 1980; Tyrvainein, 1999).

4.4: Valuation Issues

In this section some of the main research issues that have arisen from the valuation work carried out to date are identified and described. The assessment focuses on issues which are considered to be most relevant to forest policy and decision-making, rather than issues of more academic or theoretical interest.

<u>Description of landscape change</u>

Stated preference methods such as contingent valuation and choice experiments require the landscape change to be clearly and accurately described. Many early landscape studies relied on textual description or simple photographic images contrasting a wooded with a non-wooded landscape (Hanley and Craig, 1991). The development of computer software such as 'Photoshop' have greatly increased realism because existing landscape images can be manipulated to show the desired landscape impact (Macmillan and Duff, 1998; Hanley et al., 1998). Computer images can also be modified to examine the impact of altering contextual details such as brightness and overhead conditions, and even season.

Although single computer generated images of landscape change are currently best practice (Entec, 1997) with regard to presenting future policy options to participants in a valuation exercise they have several drawbacks. First, single pictures inevitably can only show the impact of afforestation or forest restructuring from one locational perspective. However, forest landscape are typically enjoyed from a number of locations in the landscape and each position will offer a different and possibly contrasting view of the proposed change.

Second, landscape pictures rarely show how the landscape might change through time: the dynamic evolutionary nature of landscape is rarely captured. This could be critical where respondents exhibit a strong preference for the status quo (Willis and Garrod, 1993). Under this circumstance before and after pictures (of afforestation for example) may exaggerate the degree of landscape change that would be perceived by an actual user and could mean that project benefit are underestimated. Also, as Willis and Garrod (1992), showed, assumptions about when the flow of amenity benefits from woodland begin can have a substantial impact on the internal rate of return from tree planting.

Third, landscapes may often be appreciated 'on the move', usually as a series of views following one after the other. This is certainly the most likely form of viewing experience that a walker, car driver, or cyclist would have. Finally, pictorial representation does not communicate the richness of the landscape experience. Landscapes are perceived by multiple sensors, not just with our eyes: our appreciation of the landscape is influenced and modified by sounds and smells, the weather and the time of day. Kroh and Gimbell (1992) found that the multi-sensory variables had a profound impact on preferences for certain landscapes that could not be replaced in controlled conditions by photographic images.

- **Research Needs:** Improve realism of landscape change by utilising emerging computing software and video technology that allow landscapes to be appreciated from different locations and through time. Multi-sensory virtual reality technology could be developed which allowed visitors to walk through a proposed community forest or clear fell area or for local residents to see the landscape impact from their living room window.
- **Policy Gain:** Greater confidence in the use of stated preference techniques in supporting forest level decision-making. Improved accuracy in estimating internal rates of return and optimal rotation length for individual compartments. In addition to providing relevant benefit estimates, such a tool could also be used to stimulate and improve community involvement with the forest design process.

<u>Selection and measurement of landscape attributes in HPM</u>

Hedonic Price Models have been used to value the landscape/amenity value of woodland in close proximity to residential areas (Garrod and Willis, 1993, Anderson and Cordell, 1988, Morales, 1980). Variation in house prices can be statistically related to variation in woodland types or characteristics through multiple regression techniques. As HPM utilise market data there are considered by some decision-makers to be more reliable than stated preference methods which rely on hypothetical choices.

However, many of the variables used in HPM are correlated with each other. Multi-collinearity can lead to irrelevant variables being selected in the model and can generate counter-intuitive results. For example, Garrod and Willis (1993) found that woodland views reduced house prices but the presence of 20% woodland cover increased house prices: the implication being that forests should be present, perhaps for access purposes, but not seen. A second and related problem, is that many of the variables used may not be good measures of landscape quality but are the only data available. HPM are data intensive and it is very difficult to obtain relevant data on landscape quality. Garrod and Willis (1993) had to use FC forest compartment data such as age and species as proxies for landscape quality.

- **Research Needs:** Collect data that accurately and reliably reflects landscape quality of woodlands close to residential areas. One possible option would be ask experts or the residents to 'quantify' landscape quality using Likert scales[2]. Hanley and Ruffel (1993) for example, found that Likert scores for alternative forest landscapes given by visitors were a far better predictor of WTP than forest compartment data such as tree height or species diversity. Surveys of local residents would also allow further information of a quantitative and qualitative nature to inform model development and interpretation.
- **Policy Gain**: Improved economic appraisal of management decisions affecting the woodland landscape around residential areas. Greater confidence in HPM will benefit policy dialogue with Treasury and other government departments.

Double Counting

In attempting to provide a total value for the forest estate policy-makers can run the risk of over-estimating the value of forests if outputs are valued separately, and then added up. Apart from the problem of ignoring income and substitution effects, dividing forests by function (wildlife, landscape recreation, etc.) can lead to double-counting.

Although CV studies tend to value forests benefits as a whole, rather than as a collection of separate goods, some researchers have tried various methods to identify and isolate values for individual forestry benefits. One approach is to emphasise one particular attribute in the information set given to respondents, but this can be unsuccessful because some respondents may focus on other attributes regardless, or may link the described change to inferred changes in other goods from the information given. For example, Edwards-Jones et al. (1997) when comparing a number of conservation sites found that WTP was determined more by aesthetic preferences rather than by conservation considerations. Also, Hanley and Ruffell (1993) observed that many respondents preferred certain forest landscapes because of the perceived impact on wildlife in the forest.

Another approach would be to ask respondents to allocate their WTP to different attributes (Bishop, 1992; Gourlay and Slee 1998). However, this is an arbitrary and demanding task for some respondents. Individual valuations for forest attributes can also be attempted be identifying different user groups and assuming that they have

[2] Likert scales allow respondents to score, typically on a scale of 1 to 5, how much they like or value a particular attribute (e.g different forest structures).

certain 'bounded' values. For example, visitors will only value the forest for recreation, residents will only value woodland for the scenic view it provides and so on. Clearly this is difficult to sustain as people can interact and value forests for many reasons.

The problem is not restricted to SP approaches as it is difficult to identify if house values in HPMs are affected by proximity to forest views or to access points for recreation. This is often left to the investigators to decide. For example, contrast Powe *et al*. (1997) with Willis and Garrod, (1993).

- **Research Needs:** Forests generate a combination of economic goods and services and it can be difficult to sort this bundle out, particularly in the case of recreation and landscape, and to a lesser extent landscape and biodiversity. Qualitative research involving focus groups and de-briefing/feed-back sessions following the survey will help develop a better understanding of WTP for different forest benefits. However, this remains a difficult area for valuation research and for policy. Due to unresolved problems with double-counting, substitution and general equilibrium effects it is not advisable to generate national estimates for the value of the UK forest stock from adding up values from individual studies, or from estimates for individual forestry benefits.
- **Policy Gain**: None envisaged in the short term.

Benefit Transfer

Benefit transfer provides policy-makers with an alternative to conducting new and project-specific valuation studies. Benefit transfer involves taking values derived from one project (the study site) and applying them, usually with some adjustment for different project conditions, to another project site (policy site). There are three main approaches to benefit transfer:

1. Transferring mean unit WTP values without adjustment: Very unreliable to transfer benefit values from one project to another unless projects are very similar and affect the same or a comparable population. For example, mean WTP among the general public for native woodland restoration on moorland in Strathspey was £53 per household per year, but for a similar project in Glen Affric mean WTP per household (using a different sample) was £35 per year (Macmillan and Duff, 1998). As both areas are already heavily afforested it is not clear why such a difference should have arisen. One explanation may be that the existing moorland landscape in Strathspey, a popular tourist destination, is preferred by more people than is the case for Affric. (A sample of respondents who were asked to pay for both forests plans, had a mean WTP of £67 per household per annum).
2. Transferring adjusted mean unit WTP values: In this case, unit values are adjusted to reflect different conditions at the policy site and the relevant socio-economic characteristics of households in the local area. Generally done on an *ad hoc* basis with quality data rarely available to guide adjustment of mean WTP.
3. Transferring demand functions: A more elegant approach to adjusting unit WTP values that predicts WTP for a new policy site using a statistical model. Regression techniques can be used to model the influence of differences in environmental quality between the study site and the policy site, alternative policy

delivery mechanisms (e.g. payment method), the availability of substitute and complimentary goods and services, and socio-economic characteristics of the target and study site populations.

Although the demand function method offers a potentially tractable solution to the issue of benefit transfer it has limitations. First, there is usually a lack of reliable data from other studies that would allow a predictive model to accurately predict benefits for a range of policy sites. This would require would include information on the reference and future level of the environmental good, and the socio-economic characteristics of the population such as income and age.

A particular problem for landscape valuation via benefit transfer models is the need to take account of an almost infinite array of substitute and complimentary landscape elements and the diverse and often conflicting preferences of the populations of interest. Unlike concern for an endangered species for example, WTP for a landscape project is likely to be influenced by the particular landscape that the project is set. Each landscape represents a spatially defined assemblage of landscape elements that must to a greater or lesser degree be considered unique. In economic jargon, there are almost unlimited opportunities for substitutes and complements to influence WTP. For example, a benefit transfer function for broad-leaved woodland would have to include variables that reflect the position of the woodland in the landscape relative to other woodlands, fields, and landforms.

The Entec study (1997) tried to avoid this effect by using images of forests set within a bland landscape, but this is not a solution, it simply avoids the real issue that forest landscape values depend on landscape setting. There is also the problem of multi-collinearity discussed earlier that can lead to problems in terms of selecting the most relevant variables to model WTP with. These subtle interactions and correlations between landscape features may simply be too numerous and too complex to be represented in statistical models.

WTP for the same forest landscape is also likely to be influenced by the knowledge, experience and cultural perspective of the viewer. To a day-tripper, a recently coppiced hazel wood may aesthetically be unappealing, but to the local people it is emblematic of a working countryside. As a farmer in the Yorkshire Dales said '*visitors look at the landscape like a pretty postcard, we're looking at it in a different way ..... (it) represents a way of life'* (quoted in O'Neill and Walsh, 2000). The implication is that WTP will vary considerably across groups (local residents, rural and urban people etc.) and hence complicates any attempt at benefit transfer still further. For example, some people could value (positively or negatively) the presence of small broadleaf copses in the landscape because they are synonymous with pheasant shooting and the enjoyment of country sports. Would it then be valid to transfer WTP for this broadleaf landscape to another landscape where there is no sport shooting?

It has been suggested that CEs offer considerably greater potential for successful benefit transfer than CV (Adamowicz, 1997) but problems with landscape setting and of multi-collinearity also apply to this method. As many landscape variables are correlated with each other it is possible that the experimental design, which assumes orthogonality between attributes, will generate a high proportion of unrealistic choice sets. For example, if age and tree height are selected as attributes, a choice set could be generated that provides a landscape with trees that are over 30 metres tall but are less than 10 years of age. Setting is also a problem in that the landscape within which attributes are presented represents part of the contextual information for the choice, hence their choices are entirely dependant on the landscape depicted. Furthermore, as attribute levels are varied in each choice set, it is likely that there will be some interaction with the contextual landscape. For example, increasing levels of afforestation may change important contextual variables such as 'openness' or 'colour balance'. In CE the contextual information is assumed is be independent of attribute levels and should not therefore influence the respondent's choice.

- **Research Needs:** Investigate variability in WTP for forest landscapes by location and by beneficiary. Nested benefit transfer models could be developed which would allow benefit transfer within relatively homogeneous landscape regions or allow the introduction of locational or landscape 'setting' variables to improve predictions from Benefit Transfer Models. Landscape Character Areas of England developed by the Countryside Commission or Scottish Natural Heritage's Landscape Character Assessment programme could provide a useful basis for this approach. WTP for specific landscape changes among specific groups should be investigated as study and policy site populations may be quite different in both socio-economic characteristics and their preferences for landscape change.

- **Policy Gain**: Improved reliability of benefit transfer as a means of assigning values to individual forests and better guidance in developing regional priorities for grant-aid and Forest Enterprise activities.

<u>Sampling and Aggregation</u>

As discussed above, landscape valuation presents particular difficulties for sampling strategy and aggregation. Given the potential for WTP to vary across a range of different groups of people it is necessary to identify these relevant populations of interest. This may not be straightforward because the landscape can be appreciated by different people in a variety of circumstances: for example, commuters travelling to and from work, walkers within and outwith forests, local residents, and perhaps even magazine and book readers.

One of the shortcoming of existing valuation studies is that they have tend not to recognise this spread in user groups. HPM for example, can only estimate the benefits of landscape to residential users. Typically, CV forest landscape studies have also tended to focus on the general recreational visitor or the general public (Hanley and Ruffel, 1993; Entec, 1997) and have not sampled from more specialist user groups such as canoeists, hunters and horse-riders, or from different sections of the general public (rural, urban). The main reason for this relying on this restricted sampling framework is cost and ease of survey management.

However, evidence from North America suggests that participants in more specialised forms of recreational pursuit are more sensitive to landscape than general visitors. For example, Englin and Mendelson (1991) found that forest characteristics significantly affected consumer surplus estimated from a hedonic travel cost model for overnight trail users, as did Coyne and Adamowicz (1992) for bighorn sheep hunters, and Boxall *et al*, (1999) for canoeists in Alberta. Also, for some landscape projects the largest group of beneficiaries may not be local residents or forest visitors, but commuters. For example, a newly established forest may be remote from any settlement but may be passed daily by thousands of commuters travelling by train or road.

The diversity in user groups creates problems with sampling strategy and aggregation. Valuation studies tend to restrict sampling to one or two sites within a forest, typically a forest car park where a regular stream of forest visitors can be interviewed. Bias can easily emerge with this strategy: many entry and exit points are ignored and car visitors tend to be favoured over other types of visitor. In order to interview specialist forest users, hill-walkers, or commuters a more sophisticated and expensive sampling strategy may be required that must consider the type of user but also a range of locations (e.g. hill-tops, lay-byes, train stations) at different times of the year.

Investigators also rarely know how many people constitute the relevant populations of interest. Residential viewers can be established fairly accurately, but visitor numbers are not regularly kept at many forests. The number of hill walkers who can see the forest site is usually not easy to predict, nor are the number of commuters or scenic drivers.

A further sampling and aggregation issue concerns the extent to which forest landscapes have non-use values and, as in the case of other goods, non-use values are likely to depend on distance from the location and degree of familiarity with it. Although, many woodlands may not have been present in the landscape long enough to generate non-use values, it would be surprising that some forest locations were not valued simply for being there (e.g. native woodlands). None of the studies reviewed in this section shed any insight or empirical evidence on this issue.

- **Research Needs:** More comprehensive sampling of all beneficiary groups. However, sampling at a wider range of sites and occasions will be considerably more expensive than current practice. One alternative would be to use advanced computer technology to simulate landscape changes from a variety of locations in the landscape. For example, by mapping photo-realistic images of forest landscape changes onto digital 3-D models that can be rotated and viewed from any direction and angle. Software also exists that can predict from which locations particular forest landscape changes are visible from, and hence could be used to help identify the type and size of relevant target populations.

  Explore the extent and nature of non-use values for different forest landscapes using qualitative and quantitative survey methods

- **Policy Gain**: Improved reliability of user and non-user benefit estimates for particular landscape changes. Help improve accuracy of benefit transfer models.

Embedding

Embedding manifests itself in three ways: lack of sensitivity to the scope of environmental change, sequencing bias, and sub-additivity bias. Scope tests are an important way of assessing the validity of CV because economic theory predicts that consumers will prefer more of a good than less. There have been no direct tests for scope in the landscape studies reviewed although it is clear that people have higher values for new woodlands within the landscape, as opposed to changes to the characteristics of existing forests. The existing empirical work on forestry characteristics also suggests that respondents are insensitive to the nature of the landscape change. For example, Entec (1997) estimated WTP for a range of forest landscape changes to be within a relatively narrow range of £11 and £13 per household.

Part of the problem with testing for scope in relation to landscape is that the variables used to depict landscape change may not be directly linked to preferences. For example, Hanley and Ruffel (1993) and Entex (1997) used variables derived from the FC compartment database rather than attributes that might be more related to demand. Another problem is that landscape variables are usually considered to be quality rather than quantity variables. Hence demand curves based on quantity could exhibit non-convexities – that is utility could increase and then decrease as quantity of woodland in a landscape increases.

Sequencing and sub-additivity effects are hard to test in landscape valuation studies there is no clear expectation regarding effects. With a range of other goods and services we would expect both sequencing and additivity effects emerge due to income constraints and various substitution possibilities. However, in landscape valuation this simple theoretical relationship is more complex because some landscape elements may be compliments rather than substitutes. For example, a woodland may be valued higher when introduced fourth in a sequence of landscape changes than when valued first because the overall impact of the woodland on the landscape is enhanced by the three other landscape elements (a wall, a flower meadow, and a small pond) introduced earlier in the sequence.

- **Research Needs**
  Investigate relationship between different landscape elements to establish compliments or substitute relationships.

- **Policy Gain**: Clear understanding of the role of woodlands in different settings and landscapes. Identify marginal benefit curves for marginal increases in forest cover.

WTA and WTP

As observed earlier it is possible, and possibly expected that people will differ considerably with respect to their preferences for landscape change. In some cases a proportion of respondents may in fact prefer the existing landscape. Macmillan and Duff (1998) for example, found that native woodland restoration in Strathspey was opposed by 24% of respondents and when their WTA compensation values was included net non-market project benefits from £53 to £24 per household. WTA compensation may also be significant if other plausible counter-factual scenarios are introduced (e.g. woodland planting versus habitat creation plan on farmland). CV practitioners have in the past been reluctant to ask WTA due to problems with protesting and strategic bidding, but this could lead to project benefits being over-estimated (Knetsch 1992).

- **Research Needs**
  Valuation studies should establish if the proposed landscape change will affect negatively a significant group of people, and if this is the case then should estimate WTA compensation for this group
- **Policy Gain**: More accurate estimates of project benefits.

<u>Property rights</u>
A number of landscape valuation studies have reported a relatively high degree of protest bidding. For example, 38% of all respondents in the Entec study (1997) of forest characteristics were classed as protest bidders. Although some protesters objected to aspects of the questionnaire such as payment method, others may have had concern over the implied property rights over landscape. Evidence from other research suggest that people perceive to have rights in landscape - and indeed they do through the planning system and grant system (O'Neill and Walsh, 2000). Currently protest bidders are ignored in benefit estimation, yet they may have very strong underlying preferences and values for forest landscape characteristics.

- **Research Needs** More qualitative research required to examine perceived property rights over landscapes and what factors influence this perception. For example, do visitors who use forests on a regular basis establish property rights over the forest?

- **Policy Gain**: Better understanding at policy level of the role of property rights issues in conflicts over landscape change. Reduced protesting in SP surveys will improve reliability and accuracy of benefit estimates.

4.5: Research Needs: Summary

1. Develop computing and video technology to help describe and communicate landscape change to participants in SP surveys

2. More qualitative work to supplement and support valuation work and to help understand the wider issues.

3. Investigate possibility of using Landscape Character Assessment Zones to help develop regional benefit transfer models

4. Broaden and intensify sampling of all landscape user and non-user groups. More attention to be paid to specialist recreational users, commuters and non-forest outdoor enthusiasts.

Chapter 5

BIODIVERSITY VALUES OF FORESTS

5.1: Introduction and aims

The UK government is committed under the Rio Principles and Helsinki Guidelines to conserve and enhance biodiversity in British forests and woodlands, a commitment initially outlined in the policy document 'Sustainable Forestry: The UK Programme' (HM Government, 1994). However, whilst the area of woodland and forest in the UK doubled between 1920 and 1990, the majority of new forests were planted with non-native coniferous which do not support as extensive a range of species as native woodlands. In addition, some existing ancient woodlands (which constitute 13% of the total forest area) and many semi-natural areas were replanted with coniferous species reducing their extent and therefore reducing biodiversity. Some of the most important ancient and semi-natural woodlands have been given a measure of protection by being designated as Sites of Special Scientific Interest (SSSI); however, the amount of semi-natural woodland protected in this way is relatively small. Such forests may also be protected under various other national or international designations.

Most forests in the UK are planted with mainly coniferous species, and often consist of Sitka spruce plantations that offer lower value in terms of biodiversity when compared with native species such as the oak. Thus, many forests created in the UK in the 20th century lack the structure and diversity of native woodland, though this structure should develop over time. The balance between open space and planted habitats is also an important issue in some areas (particularly in Scotland), threatening species such as the Golden Eagle.

In addition to the priorities for biodiversity management set out in Biodiversity Action Plans and FC Structure Plans, the 1995 Rural White Papers envisaged a doubling in woodland in England over the next half century, and anticipated a significant long-term expansion of tree cover in Wales. The English target would require one million hectares of new woodland, i.e. 20,000 ha of new planting per annum, compared to the current average of about 5,000 ha. This expansion would not be wholly broadleaf and biodiversity is only one of a number of objectives underlying these proposals. The Rural White Papers provided little guidance as to how government's specific environmental commitments on biodiversity and landscape enhancement might be delivered in this context. Even so the FC are committed to the long-term policy goals of achieving sustainable forest management within the context of a steady expansion of woodland area which will provide additional benefits for society and the environment.

This commitment is expressed in the UK Forestry Standard, published in 1998 and regarded as a key instrument in helping FC meet its international commitments for sustainable forestry. The UK Woodland Assurance Scheme, launched in June 1999, provides a voluntary means for the independent assessment of whether forests are being managed in a sustainable way.

The FC are currently examining policies that generate biodiversity and other benefits on their estate, and their deliberations will have impacts on Biodiversity Action Plans focusing on Caledonian Pine forests and other woodland and forest habitats. Current important changes arising from the England Rural Development Plan include an increase in spending from £24m in 2000/01 to £36m in 2006/07 on improving the landscape, habitats, and wildlife of amenity farmland through planting new woodlands and improving existing ones. In addition a total of £77m over the next seven years will be spent under the Farm Woodland Premium Scheme and £139m on the Woodland Grant Scheme (WGS). Other initiatives aimed at expanding woodland and linked to the WGS include the Community Forests Programme and the Community Woodland Initiative. Areas of semi-natural woodland rich in biodiversity will be provided through the Native Woodlands in National Parks Challenge

At a local level forest business plans stress the need to safeguard semi-natural remnants of native woodlands and the creation of new areas of native woodland both for their intrinsic and biodiversity habitat values. Challenge funding is available within the Commission to support scheme likely to enhance biodiversity, e.g. in 1999-200 £0.3 million of challenge funds was set aside to enhance native woodlands in the Cairngorms and Argyll and Bute.

5.2: Benefits and beneficiaries of forest biodiversity

Multi-purpose forestry has been a Government objective since 1990, and forest management decisions now aim to prioritise commercial and environmental objectives within an agreed multi-purpose framework. The Forestry Commission (FC) has made progress in identifying methods for improving biodiversity in forests, and in determining the biodiversity standards that need to be achieved in forests (Ratcliffe, 1993). Levels of biodiversity in uniform coniferous forests can be increased by investment in diversification and restructuring. The former would entail planting appropriate additional tree species and at the same time creating more open areas within the plantation. The latter would be more complicated, and entail staggering the rotation period between areas of the forest to permit species which inhabit the forest at different stages of its development to move to new locations as the forest evolves over its rotation period and as it is felled and replanted.

Increasing biodiversity levels in forests has benefits for a range for direct and indirect users and from a broader perspective the maintenance of biodiversity in wooded areas offers benefits to the broader ecosystem. Informal use of forests for amenity and recreation may be enhanced by the diversity of species encountered. The pleasure of woodland walks or picnics may be increased by encountering a variety of wild flowers or by seeing an unfamiliar species of bird such as the Crossbill. Similarly, forest design attributes such as tree mix, use of open spaces, and treatment of dead wood will all impact on biodiversity levels and may also influence the recreational experience. Many strategies aimed at improving biodiversity in FC plantations may have the externality benefit of providing more attractive conditions for certain types of informal recreation.

Increasing interest in wildlife over the last hundred years has led to a growth in the number of individuals interested in studying nature in the field. Most common among these naturalists are the birdwatchers, but there are also dedicated bands of recreationalists with interests in wildflowers, invertebrates, bryophytes and lichens. One increasingly fashionable manifestation of this phenomenon is the growth in numbers of people scouring forests for fungi: often these are intended for consumption- a factor that may run counter to biodiversity objectives. Increasing the number and diversity of species found within British forests offers clear benefits to these formal recreationalists.

Users may never directly experience increases in biodiversity brought about by changes in management. This reflects the fact that some of the forests in question are remote and attract very few visitors but also the observation that many visitors fail to observe much of the diversity in the forest that surrounds them. The fact that individuals may never directly experience the changes in biodiversity brought about by shifting management priorities does not prevent those individuals from benefiting from the knowledge that these enhanced levels of biodiversity exist. Some individuals will benefit simply from the knowledge that the range and diversity of species found in British forests has been maintained or enhanced. Indeed, Randall (1991) states that:

> "an action has a prima facie economic benefit if an action increases the availability of something that is scarce at the margin and if that "something" is desired by someone; that is, if it is at least potentially a source of human utility" (page 303)

From this definition a range of non-use values can be determined. Although the non-use benefits associated with a site may be related to previous recreational visits or to living close to the site, it is also possible for individuals to receive considerable benefits without coming into contact with the site. These benefits can be associated with knowledge of the continued health of the forest, or purely from satisfaction that the biodiversity it maintains is preserved regardless of human use (Krutilla, 1967). This form of benefit is referred to as existence or passive use value. The future stream of such benefits may be of particular importance in circumstances where an ecosystem may be irreversibly damaged. This brings into question the use of cost-benefit analysis for project appraisal because of its limited ability to deal with the impacts of such irreversible damage.

Although individuals may receive non-use benefits without visiting the site in question, Larson (1993) suggests that it is unlikely that such benefits will be large in the absence of some related behaviour on the part of the respondent. For example, the benefits may be related to the vicarious use of forest biodiversity through reading about or looking at pictures of unusual or rare species such as the Pine Martin or Red Squirrel. Bequest value is another example of a non-use benefit and derives from the knowledge that forest biodiversity resource will be maintained for one's children, grandchildren or just future generations.

Using the conventional valuation framework no new components of value emerge under the introduction of uncertainty. Nevertheless, in the presence of uncertainty, there may be a special case of 'quasi-option value'. This reflects the potential benefits that may arise from a good at some time in the future following the discovery of some unforeseen use, e.g. a plant derivative may be found to offer a cure for some chronic ailment. Arrow and Fisher (1974), who originally introduced the term, asked whether the introduction of uncertainty in the costs and benefits of a proposed project would have any effects beyond the replacement of certain values with expected values. Due to the irreversibilities and uniqueness associated with some fragments of ancient woodland, quasi-option value may be important at a local level.

Chapter 1 reported these categories of benefit, and also introduced the notion that forests may have benefits for non-human systems. These primary values are associated with the continued well-being of forest areas which, in the long term, is dependent upon the robustness and resilience of the forest ecosystem. Scientists argue that particular levels of genetic diversity, both within and between species, is a necessary condition for ecosystem health. Therefore increases in forest biodiversity resulting from changing management priorities may therefore have the direct benefit of increasing the probability that the forest ecosystem will persist over time.

While the benefits of managing forests for biodiversity can be argued at an ecological systems level, it is not possible for human beings to estimate any values for this management apart from those that reflect the benefits that we receive, either directly or indirectly, from this management. Scientists do not fully understand the impacts of biodiversity conservation in a particular forest ecosystem, though many can be described. The benefits of biodiversity conservation can be contemplated in terms of the contributions made to increasing system resilience and reducing risk of irreversible damage and clearly extend to the role that genetic diversity plays in the day-to-day function and maintenance of the biosphere. The work of Turner, de Groot and other so-called ecological economists may shed some light on the issue of ecological value. This work is, however, somewhat controversial and outside the scope of this study which, instead, seeks to examine the scope for neo-classical economic techniques to estimate the more well-understood non-market benefits of forestry (though these values and the techniques used to estimate them are almost as controversial as those of the ecological economics fraternity).

To attempt to enumerate such values would be futile, but this does not mean that they can be forgotten and decision-makers must consider the deeper systems impact of actions that alter levels of biodiversity. In the meantime, economists have attempted to value the use and non-use benefits that biodiversity conservation offers to humanity. This chapter investigates these attempts and will report on the progress that has been made in this direction in forests and other natural areas. In particular, we concentrate on an important study of the non-use benefits of forest biodiversity carried out on behalf of the FC in 1995.

5.3: Review of biodiversity valuation studies

Before curtailing timber production in the interests of biodiversity, and accepting lower commercial rates of return on forest investment, some indication is required of the benefits yielded to society from biodiversity in forests. Such analysis forms part of the appraisal process used by the FC to inform its decision-making procedures. Thus, as well as estimating the financial costs resulting from a specific change in management, the appraisal process requires some estimate of the public's WTP for the changes in biodiversity that could occur.

<u>5.3.1: The non-use value of biodiversity in British forests</u>

Up to the mid 1990s, the FC had limited knowledge of the general public's preferences for forest management with respect to biodiversity, and on the overall level of resources it should be devoting to biodiversity conservation. This lack of information was redressed in a study conducted for the FC in 1996 by the University of Newcastle upon Tyne and ERM (UNERM, 1996) which investigated public preferences for enhancing biodiversity in British forests through management. The study concentrated on estimating WTP for forest management standards that will improve the quantity and diversity of plants and animals in large areas of remote forests that are currently managed on a commercial basis by the FC. WTP estimates were generated using both contingent valuation (CV) and contingent ranking (CR) techniques based on stratified random sample surveys in nearly 1700 households across Great Britain.

The FC was particularly interested in the public's mean WTP for a number of forest management standards that could be adopted to improve levels of biodiversity in 300,000 ha of remote coniferous forest. that very few people ever visit. Thus, any value that individuals might hold for improving biodiversity in these forests should comprise mainly non-use values.

The Forestry Commission identified four different forest management standards for achieving different levels of biodiversity in this remote forest including a 'basic' biodiversity management standard (Standard A) which the FC is already moving towards in some areas. The 'desired' management standard (Standard B) would meet UK biodiversity obligations for managed forests, whilst still permitting some timber production. Conversion to native woodland (Standard C) would be the most far-reaching option for biodiversity conservation and timber production.

Median willingness to pay (WTP) estimates suggested that 50% of households would pay between £2 and £5 per year for a Management Option offering improved biodiversity. Mean estimates suggested that the magnitude of sample mean WTP for forest biodiversity was somewhere between £19 and £29 per household.

In the CR survey respondents were given the choice between four Options, three of which offered an improvement in biodiversity at the expense of additional taxes and one which didn't, 90% of respondents chose one of the former. The ranking exercise found that the most popular Options were those offering a combination of improved biodiversity and commercial forestry. Over a quarter of respondents chose as their first choice the combination of standards that offered the biggest increase in biodiversity. Estimated income adjusted annual WTP trade-offs for a 1% increase in the proportion of the 300,000 ha of FC woodland managed to a given Standard were: Standard A, £0.30-£0.34; Standard B, £0.52-£0.56; and Standard C: £0.19-£0.21.

In terms of the magnitude of WTP estimates the results of the two studies were similar; however, comparison of the estimates between the two studies suggests conflicting evidence regarding preferences for different Management Standards.

While Management Options rich in Standard B were the most popular in the ranking study, the option in the CV study offering the most Standard B generated the lowest mean WTP estimate. It was suggested that because respondents may have problems regarding the feasibility of Options that move too far away from the current management regime, it is only within the ranking exercise that preferences for Options rich in Standards B or C can be measured reliably. Here choices are made between different hypothetical combinations and questions of the plausibility of these combinations are irrelevant.

The results of the CR study suggest that substantial non-use values would be generated if the UK Forestry Commission were to continue in its current efforts to develop management practices that promote an increase in biodiversity across a large area of its commercial holdings.

5.3.2: Other relevant studies

No other study has investigated the benefits of biodiversity conservation in UK forests to the same depth as the one reported above. Indeed, the study reported above valued management for biodiversity rather than biodiversity per se. Rather than demonstrating a serious omission on the part of practitioners and those commissioning valuation studies, this observation reflects the acknowledged difficulties in asking the general public to value changes in biodiversity.

A number of other studies have, however, investigated specific issues of interest. For example, several market-based studies have adopted approaches that use government failure as a vehicle to value biodiversity. For example, direct use values have been used to compare sustainable timber and non-timber products (marketed and non-marketed) with the social value of alternative agricultural benefits forgone (see Pearce and Warford, 1993).

Benefits not enumerated due to market failure, can be estimated using surrogate markets for complementary private goods. For example, travel-cost methods have been used to value ecotourism benefits of tropical rain forests (Maille and Mendelsohn, 1993; Tobias and Mendelsohn, 1991). Probabilistic theoretical models have been used to explore the benefits of biodiversity for pharmaceutical products. Upper-bound estimates of the value for pharmaceutical research of both the marginal species and marginal hectare of habitat turn out to be modest, even under very optimistic assumptions (Simpson *et al.*, 1996). Studies more relevant to this investigation have adopted approaches based on expressed preference methods. These techniques are the only approaches capable of enumerating the possibly substantial non-use benefits that can arise from biodiversity conservation. Many applications of these methods could be argued to have some relevance to the valuation of biodiversity conservation, though few studies are directly focused on forestry. Often, studies focus on the impacts of particular programmes or policies some of which may be relevant to biodiversity conservation.

In many cases the benefits associated with these programmes cannot be apportioned between their various impacts. For example, the UK Environmentally Sensitive Areas (ESA) scheme has impacts for recreation, landscape, amenity and conservation but these impacts are often inter-related and hard to separate (Garrod and Willis, 1995).

Problems of additivity mean that it is difficult to interpret results when respondents are asked to value different attributes of a programme using CV methods. Similarly, the non-separability of these attributes means that choice experiments cannot be used to investigate how respondents would trade-off various attributes of these programmes. This phenomenon tends to lead practitioners to adopt techniques that focus either on the holistic impacts of a programme or policy or on a particular discrete outcome.

One prominent study that follows this tradition is Macmillan and Duff (1998), who used a discrete choice CV question to estimate the value of restoring two native pinewood forests in Affric and Strathspey in Scotland. Mean household WTP for those supporting a particular restoration plan ranged between £35 for Affric and £53 for Strathspey. The latter figure was reduced when compensation for those who preferred the existing moorland landscape was included. The issue of the opportunity costs of biodiversity conservation is further addressed in Macmillan *et al.* (2000) who noted that the net benefits of a number of schemes aimed at improving biodiversity conservation were reduced when the opportunity costs of these activities was considered. In an earlier study, Garrod and Willis (1994) looked at the willingness of members of a wildlife trust to pay increased membership fees to support a programme to increase red squirrel numbers in Kielder Forest in Northumberland.

A number of studies in North America and Europe have used contingent valuation techniques to value wildlife protection programmes. For example, Willis *et al.* (1996) investigated public WTP for the Wildlife Enhancement Scheme on the Pevensey Levels in the south of England, while Benson and Willis (1989) estimated WTP for Sites of Special Scientific Interest in northern England. Many of the issues covered in international studies are located in non-temperate regions or involve species or habitats with very different characteristics to those found in the UK (e.g. larger carnivores) and these can only provide us with general insights into the valuation of biodiversity conservation.

For example, Samples, Gowan and Dixon (1986) used CV techniques to estimate existence values for a range of species including the blue whale, grizzly bear and whooping crane (see also Bowker and Stoll, 1988). Duffield (1992) estimated WTP to estimate welfare losses associated with the reintroduction of the wolf in Yellowstone National Park. Boman and Bostedt (1994) and Dahle et al,. (1987) looked at similar issues in Sweden and Norway respectively. Many other studies have investigated how the public values wildlife conservation, but only a few have attempted to systematically test the magnitude of expressed WTP.

Navrud (1992) and Seip and Strand (1992) conducted studies in Norway to test stated WTP for membership of environmental organisations, such as the World Wide Fund for Nature, which engage in biodiversity conservation among other activities. While relatively high WTP figures were observed among respondents, investigation of these bids by subsequently revealed that relatively few respondents in each study (between 10% and 31%) actually took out some form of membership. While these results can be explained in a number of ways they do provoke some concern over the reliability of estimates of WTP for biodiversity generated by CV studies. The next section addresses a selection of important issues relevant to estimating the non-market benefits of biodiversity conservation in forests.

5.4: Valuation issues

What is being valued?

One of the major challenges facing practitioners attempting to value biodiversity conservation is to provide respondents with an appropriate description of what is being valued. In the forestry case, the valuation instrument may have to describe the conservation of various species, sites or habitats. Where particular well known sites or species (e.g. the red squirrel) are being studied then it is relatively straightforward to describe a scenario leading to a particular outcome. Problems arise when the study concerns less well known species or more complex scenarios such as habitat conservation. In these situations it is likely that the information needs of the respondents are likely to be considerable if consistent and robust valuations are to be obtained across the sample. This is particularly important if problems of embedding are to be avoided (see the following sub-section). In some cases it may be decided that the information requirements of respondents are too great, leading the valuation to be abandoned.

In many cases though, it should be possible to provide respondents with enough information to answer a valuation question. Strategies to achieve this should focus on providing respondents with a sufficient quantity of appropriate information from which they can make a reasoned judgement about preferences. The question of what constitutes adequate information in any given study may be addressed though focus group work and careful pre-testing.

For example, particular management plans for sites or habitats may impact upon a range of species that interact in complex ways. Rather than attempt to address the full complexity of the problem it should be sufficient to identify the level and type of information that respondents require before they can accurately assess the utility that they associate with the change in management. This may constitute a non-technical description of the change in management; an indication of the impacts that this would have on familiar species (e.g. various birds, mammals, wild flowers or butterflies); and perhaps more general information about changes in numbers and diversity in other less charismatic groups (e.g. other invertebrates, mosses, liverworts, bryophytes, etc.). A similar approach to this was adopted in the University of Newcastle and ERM study in 1996. Here respondents were asked to make trade-offs between forestry management standards across a range of remote FC plantations. These management standards were described in pictorial form to respondents in terms of the physical changes that they entailed (e.g. in terms of planting, felling, clearing, etc.) and the impacts that they would have on the variety of various types of wildlife. These groups were shown in pictures rather than words (e.g. large mammals; small mammals; game birds and raptors; other birds; invertebrates; trees; flowering plants and grasses; fungi; mosses, liverworts and bryophytes). The various pictures used to describe the four management standards used in this study were tested using focus groups and refined as a result of comments.

- **Research Needs**: For any given valuation exercise, FC need first to identify the appropriate questions to ask about the non-market benefits of forest biodiversity. Then they must determine the necessary and sufficient information that respondents require if they are to give reliable and robust responses to these questions. This can be achieved by investigating information needs, and by testing various alternative formats through focus groups and pre-surveys. Information must also be presented in a way that will help to prevent problems of respondent perception that may lead to embedding or scope effects as discussed in the next section and also provide opportunities to better incorporate risk and uncertainty into valuation scenarios.

- **Policy Gain**: The main potential gain to the FC of conducting additional studies to value the benefits of biodiversity, would be to help them demonstrate the benefits of managing different types of woodland. Thus, the benefits of non-commercial woodland can be compared with coniferous plantations, providing information that can help the FC to make decisions about, for example, restoring or replanting native woodland.

To ensure that this information is useful, valuation studies must ensure that the benefit estimates being generated accurately reflect the management changes being considered by the FC. By obtaining a better understanding of the information requirements of the general public, economic valuation studies will elicit values that will map more directly onto the change in biodiversity being valued.

It will also lead to an improved understanding of the perceptions of the general public regarding biodiversity conservation and perhaps provide some ideas to those areas of the organisation whose task is to ensure that the general public are better informed about the work and management objectives of the Commission.

Scope and Embedding Effects

Critics of CV, such as Diamond and Hausman (1994), suggest that the results of CV surveys often fail to reveal in variation in WTP with the scale or scope of the thing being valued. A study of WTP to maintain fish stocks in lakes in Ontario reported in Kahneman and Knetsch (1992) is often cited as a prime example of this phenomenon. That particular example is dismissed by other authors (e.g. Hanemann, 1996) and by reviews such as Carson (1996) which show that the vast majority of CV studies testing for scope discover some statistically significant difference.

Advocates of CV (e.g. Hanemann, 1996) argue that an absence of scope effects is likely to be an artefact of poor survey design rather than respondents' inability to value different levels of biodiversity conservation in a manner consistent with economic theory. Hanemann focuses on a study on the relative WTP of a sample of individuals to prevent the deaths of 2,000; 20,000; and 200,000 migratory wildfowl respectively. He questions the validity of the study's sampling strategy and the presentation of the valuation scenario which instead of numbers used the phrases 'much less than 1 percent', 'less than 1 percent' and 'about 2 percent' of the relevant bird population (which consisted of about 8.5 million birds). Hanemann argues that respondents may not have considered these phrases as significantly different, though other authors (e.g. Fisher, 1996) disagree. Clearly, respondents' perceptions of scope can influence benefit estimates. Even so, careful study design and information provision backed up by careful pre-survey investigations should help to limit this problem. Choice experiments can be used to investigate scope sensitivity by allowing respondents to trade off different levels of biodiversity protection in a structured way. Garrod *et al.* (2000) used choice experiments to investigate public WTP to prevent reductions in bird numbers and plant diversity at two internationally important wetland sites in the south of England. Their work demonstrated clear scope effects as respondents had clear preferences for preventing a 10% decrease in biodiversity levels compared with a 5% decrease.

Embedding relates to the observation that some people's WTP for a change in the level of one environmental good is sensitive to the level of other environmental goods or to the position of that good within a sequence of changes involving a set of environmental goods (Hanemann, 1996). Hanemann (1996) suggests that this phenomenon is consistent with economic theory can be explained by substitution effects and diminishing marginal utility. Other authors (e.g. Fisher, 1996) contend that other factors apart from substitution effects may be responsible for at least part of the embedding effect. Whatever the explanation for this phenomenon it is clear that a certain degree of embedding is to be expected when estimating the benefits of any environmental good for which there are close substitutes.

When dealing with biodiversity it may be the case that many individuals would consider that there are high degrees of substitutability between many of species, sites and habitats with which they have little familiarity. Protection for any of these goods may be placed under the broad umbrella of the term 'nature conservation' and individuals may be indifferent between how their taxes are apportioned between a range of different types of conservation management. This could lead to significant levels of embedding being observed when estimating benefits for particular conservation programmes or sets of conservation programmes. This may be emphasised when studies deal with species or sites that mean little to respondents or which they might regard as broadly similar (e.g. one section of rainforest is very much like another to the lay person). The solution to this problem lies in whether or not the information provided to respondents can address the issue of substitutability. If the good in question is unfamiliar then the practitioner must attempt to provide sufficient information to explain the importance of the good within the context of other environmental goods. Respondents must be able to see the biodiversity protection being offered as important in its own right rather than as just one of a number of inter-changeable conservation projects. Only then can respondents be expected to value the biodiversity protection in a rational way.

In the University of Newcastle/ERM (1996) study number of techniques were used to minimise embedding in responses to both CV and CR responses. In order to make respondents concentrate on the non-use values of the changed management (values mostly associated with changes in biodiversity) it was stressed that the forests being studied were remote and unlikely to be visited by respondents. Similarly, respondents were reminded that there were many other nature conservation schemes to which they might like to contribute; and that paying for biodiversity in remote forest might mean that they could not support other schemes some of which might be in areas that they would visit. These attempts appeared to have been partially successful, though follow-up questions did detect that some responses were still predicated on the possibility of visiting the sites in question at some time in the future. Such responses were eliminated from the analysis, further reducing the effects of embedding.

- **Research Needs**: Future studies using expressed preference approaches to estimate the benefits of biodiversity conservation must continue to take account of potential problems with scope and embedding effects in their design. Embedding cannot be entirely avoided but can be minimised by appropriate study design that takes full account of possible substitution effects and aims to ensure that respondents have the proper incentives to concentrate on the good in questions. Researchers should also endeavour to identify cases where embedding and scope effects are hardest to eliminate and identify alternative strategies for estimation of biodiversity benefits, e.g. by identifying discrete, non-overlapping classes of biodiversity goods regarded by respondents as close substitutes (and therefore normally subject to embedding effects when valued individually) that could be used as the basis for more robust valuation exercises.

- **Policy Gain**: Minimisation of embedding, scale and scope effects in estimates of the benefits of biodiversity conservation will allow policy makers to be more confident that the figures presented to them are an accurate reflection of public preferences for the biodiversity conservation being considered. Knowledge of sets of biodiversity goods that the public treat as equivalents will be useful to practitioners investigating WTP for biodiversity conservation and portraying the results of that work to policy makers in a more meaningful way.

Benefit Transfer

While context-specific estimates of the non-market benefits associated with biodiversity conservation remain the gold standard, many policy makers would value the ability to utilise results from a specific study more widely. These results could be presented on a per hectare or per individual basis, or in some other form relating to benefits associated with percentage increases in areas of habitat or in numbers of individuals. The interest in transferable benefit estimates has led a number of studies to generate context-free benefit estimates for biodiversity

For example, the University of Newcastle/ERM (1996) study gave no indication to respondents of the type or location of the forests involved apart from the facts that they were remote and unlikely ever to be visited by the respondent. Therefore the estimates generated relate to changes to the management of generic forests and as such could be readily used to investigate the benefits of management for biodiversity in any forests matching the description provided to respondents. The use of such generic, context-free valuation scenarios is a particular advantage if it is required that estimates are used as widely as possible. Indeed it has been possible for the FC to transfer these benefit estimates to management changes associated with any plantation consisting predominantly of exotic species. One disadvantage of this particular approach is that it can only value changes in management at a particular forest as the benefits of a marginal change in the overall management of the FC estate. This does not take account of any special conditions that may exist in the forest that could otherwise raise or lower WTP estimates.

- **Research Needs**: As in other applications of benefit transfer, insufficient research has been done to ensure that the value transferred from one site to another is a robust estimate of the benefits generated by the second site. In order to test this, it would be necessary to conduct a systematic study across a number of sites that would compare site-specific benefits with transfer estimates estimated at a transfer site. Furthermore, it may be possible to derive transfer models that can be adjusted to account for differences between otherwise similar sites. In addition to this type of empirical analysis it may be necessary to investigate which sites respondents perceive as equivalents and where benefit transfer is most likely to be justified.
- **Policy Gain**: Reliable transferable estimates of the benefits of biodiversity conservation on a site or unit (e.g. hectare of forest or individual) basis would provide managers and policy makers with a useful input to their decision-support systems. Such estimates would, once derived, be cheap and quick to use and would ensure that the benefits of biodiversity conservation are more realistically accounted for in management decisions.

Choice of Methodology

The UNERM (1996) study was the first in the UK to adopt a choice experiment approach to the study of the non-market benefits of forestry. As such it represented a timely use of cutting-edge methodology to an important policy question. Large sample sizes, face-to-face interviews and the use of a highly respected professional survey company (MORI) all reflect the overall quality of the study and the substantial investment of the FC.

The comparison of CV and CR results provides a useful means of investigating the robustness of the estimates and generated the health warnings about the usefulness of specific estimates that were detailed earlier. In retrospect, it could be argued that more should have been done in the 1996 study to test the sensitivity of estimates to changes in study design and specification. Overall, however, the comparison of benefits across the two techniques suggested that the magnitude of biodiversity benefits estimated by the study was reasonable.

- **Research Needs**: Some further clarification of the circumstances where it is more appropriate to use CV or CE techniques to value biodiversity conservation would be a useful research gain. The specification of these particular problem to be investigated will usually determine the appropriate approach to adopt, as would an understanding of the attitude of respondents (e.g. different approaches may need to be adopted to deal with sampling from groups of lay people or experts). CE is likely to be more useful for determining the marginal value of marginal increases in biodiversity and can account for either linear or non-linear relationships. CV has potential in assessing the value of increments, or sequential provision, to existing biodiversity conservation. CV might also be applied to assess the WTP of individuals to buy into a particular package of conservation measures, with CE to determine the influence of various biodiversity attributes in determining that choice.

- **Policy Relevance**: While both techniques have a role to play in the appraisal of biodiversity management, they can only reflect public preferences and interests up to the limit of the information that people can assimilate and understand. Responses may not always reflect what ecologists would regard as the actions necessary to maintain viable ecosystem diversity. Therefore it is important not to regard the level of benefits estimated expressed preference techniques as the crucial element upon which decisions are made, but rather to treat it as a useful parameter in the decision making process.

Incorporating Risk

One important aspect of management for biodiversity is that the outcome of such work is uncertain. When asking the public to value biodiversity conservation some strategy must be taken to accommodate risk and uncertainty with regard to outcome and to describe the risks associated with not conserving biodiversity. Different individuals have different attitudes towards risk and these attitudes colour how much they are willing to pay for a particular conservation initiative with a given or perceived probability of achieving its objectives. However, the difficulties faced by individuals in making decisions about WTP for biodiversity under uncertainty have led some to suggest that a cost based approach might be more appropriate.

Montgomery *et al.* (1994) used a cost-based approach to determine targets for species preservation. The study estimated the marginal cost of preserving the northern spotted owl, an endangered species resident in old growth forested areas in the west of the United States and Canada. In 1992, as part of a programme to remove the threatened status of the species, the American Fish and Wildlife Service designated an area of 6.9 million acres as critical habitat for the northern spotted owl. Where this designation is coupled with active conservation measures, the result is a reduction in timber felling to preserve the owl's habitat. This reduction in productivity had considerable economic implications for local communities whose economies rely on timber production. Under US Forest Service and US Department of the Interior conservation proposals for the northern spotted owl, it was estimated that over 40,000 workers could lose their jobs.

Montgomery *et al.* (1994) estimated a marginal cost function for the probability of the survival of the species in its natural habitat. This approach was novel, in as much as it examined marginal increases in the chance of survival rather than preferences for a scenario which offered only certain survival or certain extinction. This change in perspective may be important, as by examining changes in marginal costs and benefits some conclusions can be made as to the appropriate scale of conservation.

Their analysis relied on deriving a supply function for the probability of owl survival, and subsequently an estimate of the welfare loss in the wood products market for a given probability of owl survival. To achieve this, the authors needed to extend an existing population simulation model for the owl, relating probability of species survival to protected habitat capacity, and also to derive a marginal physical cost curve relating increased protected habitat capacity to its costs in terms of reduction in timber harvested. The estimated total welfare loss associated with a reduction in timber supply was then related back to habitat capacity and probability of owl survival to generate the marginal cost curve for the probability of owl survival, i.e. the additional cost required to increase the probability of survival by one percent.

Derivation of this marginal cost curve allowed an analysis of various management proposals, each designed to aid the preservation of the northern spotted owl: illustrating the marginal costs involved in increasing survival probabilities. Each proposal examined fell into the range of the steepest increase in marginal costs, that is the area where the increases in the probability of survival derived from an increase in habitat capacity are smallest. Thus, for the choice between competing conservation programmes, the analysis posed questions such as: is it worth an additional $13 billion to increase the chances of owl survival from 91 to 95%?

- **Research needs**: The provision of information of this kind may be important for policy makers in assessing key conservation decisions and for individuals participating in valuation exercises. Most conservation initiatives will only make marginal improvements to the probability of species survival and benefits should be judged on this basis. Respondents in expressed preference exercise should be better able to make judgements about the benefits of a particular biodiversity gain if they have information about how this gain impacts on broader policy objectives, e.g. reducing the risk of extinction. Information on the absolute or relative extent of the biodiversity change is by no means as relevant in determining value (particularly non-use value) as a clearer understanding of the overall consequences of that change for a species or ecosystem. Therefore it would be desirable to test how this different approach to portraying the impacts of biodiversity conservation impacts on the benefit estimates generated through CV or CE approaches.

- **Policy Gain**: At a broader policy level it is desirable to derive functions of the costs and benefits of marginal gains in biodiversity conservation and to investigate, where possible, how these marginal gains contribute towards overall conservation objectives. Only by incorporating better information about the consequences of particular improvements in biodiversity conservation will policy makers be better able to set targets for biodiversity conservation and make judgements about the value for money associated with programmes that deliver marginal improvements in biodiversity.

5.5: Recommendations

Biodiversity conservation is characterised by risk and uncertainty. There are no guarantees that a particular management solution will have the desired impact on a given species, and limited information about the impacts that changes on the number or distribution of that species might have on society or on the ecosystem. In the face of this uncertainty it is difficult for individuals to articulate their preferences and values for a given conservation scenario.

The lack of any comprehensive study of the value of biodiversity in British forests is a problem for policy makers. From their perspective it would be highly desirable to undertake a thorough study to value the biodiversity benefits of native woodland compared with conifer plantations and the benefits of replanting or restoring such native woodland. Indeed there are a number of questions about the benefits of biodiversity management that need to be answered to improve the efficiency of future forest design and management strategies. For example, it may be important to provide a comprehensive measurement of the value of non-commercial woodland (including biodiversity benefits) precisely because their most important outputs are non-market goods. Once these questions are asked, however, it is important to ensure that valuation methodologies can provide robust and reliable answers.

If economic valuation techniques are to provide decision-makers with coherent estimates of the benefits associated with management options that benefit biodiversity then particular care needs to be taken with the design of the study and with the application of any estimates that it generates. It is particularly important that studies provide respondents with clear information about the good being valued and the consequences associated with changes to that good. This will help to minimise problems associated with embedding and scope effects and to provide better opportunities for benefit transfer.

There seems to be little value in asking the general public to value the more esoteric species found in forests. In these cases the amount of information that would be required by respondents would be high and it is unlikely that this could be provided in a questionnaire situation. It would seem sensible to concentrate on understanding what is required if the public is to place reliable and robust values on particular ‘headline’ species or on generic indicators of biodiversity. It has been suggested that the work of UK BAPs in popularising biodiversity values to the general public could be a useful resource here. More complex scenarios may be better dealt with by approaches that allow respondents more time to assimilate information and, as with citizens’ juries, allow scope for discussion and consensus across groups of individuals.

Similarly, the use of conventional economic techniques to value irreversible damage may provide flawed results. The stream of future benefits lost is hard to quantify and conventional techniques are only effective in estimating the loss of welfare to current generations rather than to future ones (though it can reflect the preferences of individuals to retain biodiversity for future generations). As a general principle, irreversible environmental damage should be avoided and where such damage is unavoidable, the loss to society should be compensated through ‘shadow projects’ which attempt to redress the losses made at one site by achieving equivalent gains at other sites. While the cost of such projects could be argued to reflect society’s value for the biodiversity losses, such reasoning neglects issues of context and supply that negate the possibility of such like-for-like exchanges. The developing discipline of ecological economics may provide some valuable insights into the issue of valuing irreversible damage, though whether its arguments prove persuasive to policy makers is another matter.

In the current political climate, quantitative estimates of value tend to be required for decision-making, with cost-benefit and cost-effectiveness analysis the preferred tools for economic appraisal. In the University of Newcastle/ERM study conventional estimates of costs and benefits were obtained. Here respondents were asked to value different standards for forest management rather than particular species or biodiversity levels. Concentrating on management standards and providing information about their impact on biodiversity conservation provided a relatively straightforward valuation scenario for respondents. Valuation of generic biodiversity goods, headline species or management standards provides the solution to problems of unfamiliarity and helps to resolve the information question.

The complex inter-relationships between ecosystem components means that it is difficult to value different aspects of a habitat or site separately. While it may be possible to reliably estimate public WTP for changes in the numbers or diversity of particular species (e.g. the red squirrel) or groups of species (e.g. birds), it is much harder to succeed in estimating the benefits by various ecosystem components. The first exercise may lead to problems with embedding as respondents treat the species in question as a proxy for a larger more inclusive group of substitutable species, while the second exercise is likely to suffer from problems of additivity. Moreover, in the second case the ecosystem components being valued may be related so that levels cannot be varied independently. It is this problem that makes approaches based on choice experiments largely unsuitable for investigating preferences for sets of ecological goods.

Simple CVM approaches using open-ended or dichotomous choice questions are most effective for valuing a single well specified and defined conservation good that can either be accepted or rejected compared to an alternative good. However, where there are a number of alternative biodiversity standards that have to be compared and valued, each with different combinations and quantities of flora and fauna, then an approach based on some form of choice experiment is more appropriate. Choice experiment approaches provide a particularly useful format for investigating the preferences of members of the general public by encouraging them to make decisions about the provision of biodiversity that require them to make trade-offs between different aspects of biological diversity or other public goods. This approach was successfully used by Garrod *et al.* (2000) in a study for Southern Water, investigating whether or not consumers were willing to sacrifice biodiversity (portrayed as numbers of bird and bird species, and the variety of plants found on two important Sussex wetland sites).

Cost-based approaches can be utilised to value biodiversity in a number of cases, and where policy dictates a given outcome, cost-effectiveness analysis is an appropriate technique for determining the most appropriate route to the outcome. In many circumstances, cost-based approaches would provide insufficient information to decision-makers who may require estimates of both the costs and benefits of biodiversity conservation. This information would be used to decide whether or not to pursue a project or to evaluate the benefits of projects that have already been undertaken. Similarly, where biodiversity is only one of the benefits of a particular change in management (or one of a number of costs, in, say, the case of a new road development through woodland) both costs and benefits would be required if cost-benefit analysis were to be used.

Chapter 6

VALUE OF CARBON SEQUESTRATION IN FORESTS

6.1: Introduction

Current evidence suggests that global warming is underway, and that part of this is at least attributable to the anthropogenic emission of greenhouse gases (GHGs). Governments have agreed to slow and reduce GHG emissions. Under the 1997 International Kyoto Protocol and EU agreements the UK is required to reduce its 1990 baseline emission of six greenhouse gasses by 12.5% by 2008-2012. Policies to slow or reduce GHG emissions, including CO_2 emissions, include:

- taxes: e.g. fuel taxes; emission taxes; road congestion pricing;, variable car excise taxes, to encourage use of smaller more efficient cars;
- subsidies: e.g. public transport subsidies to encourage a switch from private to public transport, home insulation;
- regulatory controls: e.g. emissions regulations, land-use planning policies to reduce the need to travel especially by car by steering development towards locations accessible by public transport (DoE, 1994).

A non-market benefit (NMB) of forests is the extent to which forests result in carbon sequestration; and hence slow global warming, by locking up carbon. The UK climate change programme (DETR, 2000) shows a carbon sink from forestry of between 2.6 to 3.3 MtC/year through to 2020; although of this amount only 0.3 MtC/year in 2000 rising to 1.2 to 1.4 MtC/year in 2020 can be counted towards meeting the UK's commitment under the Kyoto Protocol. An NMB or external benefit of a maturing forest and of new planting is therefore carbon sequestration.

The strategy for forestry in Scotland (National Office for Scotland, 2000) suggests that on an annual basis Scotland’s forests might absorb approximately 10% of CO_2 emissions attributable to Scotland, and that “the greatest sequestrations gains are likely to come from forests growing high quality timber (which will be put to long-lived end uses) on long rotations, in complex forest ecosystems with soils of low organic content” (NOS, 2000, page 26). However, the strategy implies uncertainty about the *net* amount carbon sequestration attributable to Forest Enterprise estates, and does not include any quantification of the total and marginal benefits of additional planting, or of changes in species proportions. Cannell and Dewar (1995) provide global estimates of the rate of carbon accumulation in forest plantations in Britain, using a model that calculates the flow of carbon from the atmosphere to trees, litter, soil, wood products, and back to the atmosphere. However, this model assumes that all trees planted to date have the carbon accumulation characteristics of *P. sitchensis* Yield Class 14 m^3 ha^{-1} a^{-1}. Since FC policy has been to include broadleaved species in new plantings, the model assumes that 20% of all new forests are planted with trees having the storage characteristics of *Fagus sylvatica* (yield class 6); and another scenario was developed in which all future plantings on lowland agricultural land consisted of *Populus* (yield class 12). Clearly, whilst helpful in providing a global aggregate estimate of carbon sequestration across woodland as a whole, this model does not estimate carbon accumulation on a detailed spatial basis that would be of use in developing detailed forest strategies for different areas of Britain, and which might inform forest design plans.

Carbon sequestration of course is a pure national public good. One tonne of carbon locked up in Scotland has the same value as one tonne locked up in Wales, as a contribution to reducing global warming. Hence the value of carbon sequestration is not subject to many of the problems that affect the estimation of other externalities from forestry such as recreation, landscape and amenity, and biodiversity. For example, within carbon sequestration there are no problems concerned with embedding effects, or with scope effects, or with sequencing effects, and aggregation is relatively straightforward.

Valuing carbon sequestration concerns two principal issues: the *net* carbon sequestration under forestry; and the value per tonne of carbon sequestration.

6.2: Physical effects of forestry on carbon sequestration

Research suggests that the *net* amount of carbon sequestration attributable to forestry depends on a number of factors.

First, different tree species have different amounts of carbon per kg/m^3. The Forestry Commission have undertaken some work on the amount of carbon sequestration by species of tree (Matthews, 1993). Early work in Canada (see Table 6.1) indicates that carbon sequestration per kg/m^3 of wood differs significantly between tree species; although the proportion of dry-weight which is carbon is roughly constant at about 49% (Matthews, G. 1993).

Table 6.1: Weight of carbon in green wood by species.

Species	*Specific gravity*	*Carbon in green timber (kg/m^3)*
Douglas fir	0.450	225.0
Western Hemlock	0.409	204.5
Sitka spruce	0.347	173.5
Lodgepole pine	0.403	201.5
Alpine fir	0.331	165.5
Sugar maple	0.597	298.5
Red oak	0.581	290.5
White Birch	0.506	253.0
Tamarack	0.485	242.5

Source: Jessome (1977).

Second, the amount of carbon sequestration depends upon the rotation period, thinning, and productivity and volume of timber growth or yield class of the timber by species. Yield class is itself a function of climate and soils. Clearly the FC has detailed information on these variables through their sub-compartment data base.

Third, *net* carbon sequestration depends on the previous use of the soil. Again considerable research has been conducted on this issue. This has encompassed carbon storage in uncultivated soils [where carbon content is influenced by soil texture, moisture, temperature, and the lingin content of the natural plant cover] and cultivated soils [where crop selection, tillage regime, addition of fertiliser and organic matter, irrigation, and residue treatment (e.g. stubble burning, etc.) affect soil organic matter] (Parton et al, 1987). Generally switching from uncultivated to intensive arable land is commonly associated with significant losses in soil organic matter, and substantial increases in CO_2 emissions (Post et al, 1990). Soils which are poorly drained and frequently water-logged, typically in upland areas, have organic accumulation rates that exceed their slow decomposition rates, leading to peat formation and consequently the accumulation of carbon. Such soils have very high carbon contents, so that afforestation on this type of land results in significant *net* carbon losses in these areas (Adger et al, 1992; Cannell *et al*, 1993).

Methodological uncertainties associated with the forest sink (+15%) are recognised to be much less than the uncertainties associated with changes in the carbon content of soils (+50%) (DETR,2000).

- **Research Needs:** Refinements in the equilibrium soil carbon storage measures on a spatial basis using GIS for forested and alternative agricultural land-use scenarios, or actual agricultural uses where applicable, would improve confidence in the estimates of carbon sequestration as a NMB.
- **Policy Gain**: Greater confidence in estimate of the amount of carbon sequestration under forestry compared with alternative land-uses. Future research on carbon sequestration may become increasing important with large policy implications if other measures to slow or reduce carbon emissions become politically less acceptable (e.g. rising fuel escalator).

6.3: Benefits of Greenhouse Gas Abatement

Research on the benefits of greenhouse gas (GHG) abatement has concentrated on the opportunity costs of slowing down atmospheric concentrations of GHGs. Estimates of the costs of greenhouse gas (GHG) abatement have been derived from:
(1) aggregate economic models that balance supply and demand;
(2) partial equilibrium models, such as

- the use alternative energy sources or transport modes;
- damage impacts of GHG emissions particularly with respect to agriculture (see Kane et al, 1992; Parry, 1990); and the cost of a sea level rise (see Titus et al, 1991), both of which underlie the work of Nordhaus (1991a, 1991b);

(c) the costs of various strategies adopted for slowing down GHG and CO_2 emissions, and meeting respective country emission targets set under International Conventions.

Nordhaus (1991a & 1991b) estimated the social costs of CO_2 emissions at $7.3 per tonne of carbon sequestrated. This implies that abatement and carbon sequestration should be undertaken as long as costs were less than $7.3 per tonne of carbon abated. Nordhaus estimated the overall damage of global warming at 0.25% of GNP. But to allow for the many non-market impacts neglected in the study this value was raised to 1% of GNP, with a range of error of 0.25% to 2%.

Cline (1992) and Fankhauser (1993) suggested improvements to the analysis of Nordhaus. But both agree that a ball-park figure of the damage resulting from a doubling of CO_2 ($2*CO_2$) is in the order of 1% to 2% of world GNP. However, imposing different assumptions on the discount rate and $2*CO_2$ damage in the Norhaus model, leads to a damage estimate range of $0.3/tC to $65.9/tC.

Concerns about the this estimate stem from the

- $2*CO_2$ estimate, which many regard as being too low;
- model, which assumes a resource steady state, implying a constant level of CO_2 emissions over time. IPCC (1992) predicted an increase in annual CO_2 emissions from about 7 tC in 1990 to about 9-14 tC by 2025.

If the climate and damage sectors are non-linear, then future costs of CO_2 damage may rise over time. A tonne of CO_2 added to an already large stock of atmospheric CO_2 may cause more damage than a tonne emitted at current levels.

A more sophisticated non-linear stochastic model was developed by Fankhauser (1993, 1995), which examines future emissions, atmospheric concentration, radiative reinforcing, temperature rise, annual damage, costs of sea level protection, and discounting. Lower and upper bound and intermediate best guess estimates, of growths in GNP, population, carbon, N_2O, CFCs, concentration parameters (in atmosphere), energy efficiency improvements, temperature change parameters, damage estimates, and discount rates (e.g. to include risk aversion), lead to a range of values for carbon sequestration. Fankhauser’s best estimate (expected) valuation rises from $20.3 /tC in 1991, to $22.8, $25.3, and $27.8 /tC in the three subsequent decades to 2021, reflecting the predicted increase in greenhouse gas damages during that period. Thus a forest project that resulted in 1 million tonnes of carbon[1] sequestration per year would result in $22.8 million/yr between 2001 and 2010, and $25.3 million/yr and $27.8 million/yr in the two subsequent decades, resulting in total undiscounted benefits of $759 million, or approx £506 million.

The Intergovernmental Panel on Climate Change (IPCC, 1996) published a range of best guess damage estimates for the period 2001-2010 of $8.7 to $197.1 /tC (2000 prices). The most sophisticated of the studies since 1995, that undertaken for the European Commission, produced a marginal damage estimate of $80 /tC (2000

[1] One million tonnes carbon is equivalent to a little over 0.5% of the UK’s annual carbon dioxide emissions.

prices) for CO_2 emitted between 1995 and 2004. This estimate appears to be derived from parameter estimates that enjoy the greatest support in the literature (Clarkson, 2000). However, this value is subject to significant levels of uncertainty, and excludes any consideration of possible climate catastrophes, such as the melting of the West Antarctic ice sheet, that could potentially increase the size of damages considerably. Hence Clarkson (2000) recommends employing $80 /tC (=£55 tC in 2000 prices), but also employing an upper value of $160 /tC (£110 /tC) and a lower value of $40 /tC (£27.60 /tC) for sensitivity analysis. Whichever of these values is adopted, the NMB carbon sequestration value of forestry is clearly very large.

- **Research Needs:** The value of carbon sequestration is of more concern to DETR in estimating the impact of transport, industrial, and other sources of carbon and GHG emissions. To achieve consistency in governmental decision-making we recommend that a value for carbon sequestration acceptable to DETR should be adopted by the FC, without the need for further research on this topic.
- **Policy Gain:** Adopting an agreed DETR tC value will provide greater confidence in FC estimates of the aggregate value of carbon sequestration through forestry; and greater acceptability in other government departments of any estimates of the NMBs of carbon sequestration in the FE's forests.

6.4: Modelling the value of carbon storage in forests

Modelling the value of carbon storage in trees requires information on a number of parameters:

- the timber yield of live wood
- information on forest management
- estimates of carbon liberation from wood products
- assessment of carbon flux in soils
- discount rate

The FC have detailed models of timber yields, by different tree species, and yield classes, and according to different management regimes (thinned or unthinned). Timber yields over time to felling, typically exhibiting an S-shaped curve, to which carbon storage can be related, and this has been successfully modelled as a cubic equation (Bateman and Lovett, 2000):

$$\text{u or tTWCS}_{iYC} = \beta_{1iYC} + \beta_{2iYC}t + \beta_{3iYC}t^2 + \beta_{4iYC}t^3$$

where u= unthinned; t = thinned; i = species; YC = yield class; t = years from planting.

Carbon liberation occurs from from felling waste, and from destruction of timber products. Cannell and Cape (1991) and Thompson and Matthews (1989a,b) estimate carbon liberation rates for softwood and for hardwood by a variety of product uses. These estimates can be used following the methodology of Bateman and Lovett (2000), to derive carbon liberation schedules for specific species of tree.

Bateman and Lovett (2000) provide some estimates for post-afforestation changes in equilibrium soil carbon storage levels for various soils previously under grass. Table 6.2 indicates a large carbon loss under afforestation on peat-land; and a long term net increase of around 50 tC/ha on non-peat soils. However, there are considerable margins of error in estimates for non-peat soils that will affect the magnitude of the NMB of estimates of carbon sequestration.

Table 6.2: Post-afforestation changes in equilibrium soil carbon storage levels for various soils previously under grass (tC/ha) at upland and lowland sites

Soil type	upland sites			lowland sites		
	under grass	under trees	change	under grass	under trees	change
Peat	1200	450	-750	n/a	n/a	n/a
Humic gley	180-400	250-400	50-70	180-350	180-450	0-100
Podzol	200-400	250-400	50	100-200	100-450	0-250
Brown earths	n/a	n/a	n/a	100-120	100-250	0-130
Humic stagno podzol	180-400	250-400	50-70	120-350	120-450	0-100
Stagnogley	180-400	170-450	0-50	100-120	100-450	0-330

n/a = not applicable soil type at this altitude
Source: Bateman and Lovett (2000).

Resolving the net effect of afforestation on equilibrium soil carbon storage levels is important in estimating the total net NMB from new planting, and for replanting where a comparison is being made with an alternative (agricultural) land-use. New planning is relatively small compared with replanting, so any error here is unlikely to affect any estimate of the stock value of sequestrated carbon in forests. But the net impact of soil carbon storage is important in estimating the carbon sequestration value of margin increases in forest area (one of the objectives of forestry policy – as outlined in Chapter 2 of this report).
Bateman and Lovett (2000) present some estimates for net carbon storage values for Sitka spruce and Beech, for a range of yield classes and discount rates, over an initial optimal rotation, and a perpetual series of rotations. Both yield class and discount rate are highly influential in determining net carbon sequestration values (see Table 6.3).

Table 6.3: NPV of net carbon flux (sequestration in live wood and liberation from products and waste) for an optimal rotation of Sitka spruce (£, 1990 prices).

Discount rate	*YC4*	*YC8*	*YC12*	*YC18*	*YC24*
1.5%	811	1491	2122	3002	3902
2%	699	1290	1837	2634	3404
3%	536	1005	1415	2015	2567
5%	342	643	916	1278	1626
6%	284	535	761	1060	1367

Note: YC=yield class. YC is (mean) cubic metres of wood added per hectare per annum. Thus YC12 has a mean addition of 12 m^3 per annum per ha. over the rotation period.

Of course, net carbon flux strongly reflects the pattern of timber yield: higher for Sitka spruce than for Beech; and higher in lowland compared to upland sites.

The methodology presented by Bateman *et al* (2000) is capable of being applied in 'back-of-the-envelope' type calculations to assess the NMBs of afforestation and planting at new sites. It can thus estimate the marginal benefits of new planting in terms of carbon sequestration.

However, the value of carbon sequestration of the total FC's stock should be estimated, as an element of the total NMB of forests. This is both a stock and a flow problem. It is important to assess the amount of carbon in the total stock; and also to assess how this is changing with rotation, and forest restructuring i.e. to estimate marginal changes as the forest ages and is replanted or diversified in the interests of biodiversity.

- **Research Needs:** Develop and apply a model to estimate carbon sequestration on a spatial basis across Great Britain. GIS can be used to relate these to grid squares or the FC's sub-compartment data base. Application of the model will permit the calculation of the total value of carbon sequestration of the FC stock, and marginal changes in that value across Great Britain.
- **Policy Gain:** A clearer understanding of the trade-off between carbon sequestration and biodiversity and recreational NMBs at local planning design and forest management stages. Also a more accurate and robust national measure of carbon sequestration as a NMB, that can be used to judge investment decisions in forestry and priorities in the FC's objective of multi-purpose forestry.

Finally, a relevant policy question is "what is the least cost, or the minimum alternative cost at the margin, to slow or reduce carbon emissions into the atmosphere? If this was researched then the forest carbon sequestration policy to extract carbon from the atmosphere could be judged in the context of the cost of alternative policies adopted by society to reduce carbon emissions.

Chapter 7

OTHER NON-MARKET BENEFITS OF FORESTRY

7.1: Background

The main NMB to be gained from forestry appear to be recreation, landscape amenity, biodiversity, and carbon sequestration. There are a number of other NMB, namely water quality, pollution absorption, health effects, and archaeological preservation benefits. This latter group is distinguished from the former in that the scientific evidence can be ambiguous about both the direction and the magnitude of the physical scale of these NMB. Although economic methods of analysis exist to measure the value of these NMBs, because their physical impacts are uncertain, virtually no reliable estimates exist of the value of pollution absorption, water quality, heath and archaeological preservation benefits. .

7.2: Water quality

Depending on its location, forestry can have both positive and negative impacts on water quality. In lowland areas forests may have a less detrimental effect on water quality than intensive agriculture, while more intensive forestry operations in upland areas may have more adverse effects on water quality and yield. While negative impacts on water quality from upland forests may be observed during much of the rotation, the most detrimental effects are observed after felling.

Neal *et al.* (1992) in a study of the effects of felling on water quality in Plynlimon, Wales found that sediment flows into nearby streams from forests is much greater than from grassland. This may be a consequence of work conducted in preparation for felling or result from sediment washing along tracks or paths into watercourses. The same study suggested that sediment flows these increase by an order of magnitude after felling. Swift *et al.* (1990) came to similar conclusions and observed that felling may increase the nutrient and sediment load of adjacent watercourses for up to two years after felling. Hornung and Anderson (1991) also conclude that intensive forestry in upland areas are likely to pose water quality problems through increasing sediment load and in sensitive areas increasing acidity and aluminium levels. Neal *et al.* (1992) found significant increases in the levels of nitrates, potassium, bromides and iodine in local watercourses following tree removal.

The consequences of increased sediment flow into watercourses reflect the role of mature forest soils in storing nutrients and in chemical cycling and the increased risk of soil erosion following clearfelling. The impacts of forestry on water quality can generally be considered to be negative if they are more damaging than the next most likely land use. Any negative effects on water quality through sediment run-off may be exacerbated by the use of chemicals, e.g. pesticides, during the rotation.

A 1998 report produced by consultants ERM for the then Countryside Commission, listed a variety of hydrological impacts of forestry, identifying both positive and negative benefits. These included impacts on water quality and river flows, and highlighted forestry's influence on dampening flood peaks and reducing catchment water yields. While the latter may have some disbenefits in areas of low rainfall and low river flow, the former could be regarded as a potentially important contribution to reducing the risk of flooding.

Significantly, forest planting in some areas may reduce the incidence of low flows in rivers by reducing evaporation compared with the existing vegetation cover (e.g. on wet moorland, see Neal *et al.,* 1992). Harding *et al.* (1992) investigated the hydrological impacts of broadleaved woodlands and concluded that on average they were small but possibly significant during dry summers. Water use by broadleaved woodland was found to be lower than for grassland but higher than for some crops such as winter wheat. Swift *et al.* (1990) report initial increases in water yield associated with upland afforestation, though subsequently, following the closure of the canopy, this situation is reversed due to transpiration and other processes. Clear-felling of woodlands is likely to change the hydrological balance and lead to an increase in low flows (e.g. see Black *et al.*, 1995) though harvesting will reduce evaporation rates (see Neal *et al.,* 1992).

A number of papers (e.g. Willis and Garrod, 1996) have reported on the benefits associated with increasing flow levels in rivers, though the associated studies have tended to concentrate on amenity and recreational benefits rather than related issues of water quality. Issues of water quality have been addressed in a number of other studies, mainly in the US, but these have tended to look at impacts on the quality of drinking water or pastimes such as angling

ERM (1998) echo this observation and their report noted that little work had been done to monetise the hydrological impacts of woodlands. They go on to suggest that adverse impacts on water quality and catchment are likely to be greatest in upland areas, with some benefits possible in lowland areas. They contend that it could be feasible to monetise the hydrological impacts of woodland for both negative and positive impacts.

There are certainly a number of approaches that could be adopted for this exercise. Simple cost-based approaches could be used to look at the equivalent expenditure required to replicate the beneficial impacts of woodland planting on water quality, or to estimate the cost of mitigating the negative impacts on river flows and water quality. Such approaches are likely to be considerably more cost effective than the use of specially designed studies aimed at measuring public preferences and WTP for changes in water quality and river flows. Such studies would necessarily have to be generic as they would be applied in a wide variety of circumstances both with respect to planting and to the underlying hydrological conditions.

7.3: Pollution absorption

The role of forests in trapping air pollutants is relatively well understood: in upland areas much of the particle deposition results from the passage of mists and clouds through the forest canopy, while in lowland areas dry deposition of particles is more important, though lowland ash and beech, especially at the edge of the canopy, have been found to be effective in capturing small rain droplets rich in pollutants.

Despite our understanding of the mechanisms by which forests remove particulate matter from the air the benefits of this aspect of forestry have yet to be systematically monetised (ERM, 1998). These benefits are relatively clear: some of the pollutants trapped by woodlands (e.g. nitrogen dioxide, sulphur dioxide) play a role in acidification of water; others, such as ozone, are greenhouse gases; while PM-10s and other airborne particles that are filtered during their passage through the canopy may increase the incidence of various chronic and acute conditions of the respiratory tract.

Broadmeadow and Freer-Smith (1996) conducted an extensive literature review investigating the role of woodland in reducing air pollution, concluding that forestry can play a significant role in reducing various forms of pollution. Trees facilitate the uptake, assimilation and decomposition of pollutants such as ozone, sulphur dioxide and nitrogen oxides and can thus reduce the concentrations of these gases in the atmosphere. A simple model of pollution uptake was derived by the authors and tested in Greenwood Community Forest, with the conclusion that the existing 20% woodland cover should reduce these pollutants by 4-5%, with a similar additional uptake if the area of forest were to be doubled.

The filtering of particulate matter from the atmosphere may be particularly important in urban areas, where tracts of woodland could act as air filters between population centres and busy arterial roads running around the periphery of settlements. Freer-Smith *et al.* (1997) measured the uptake of particulates at a broad-leaf urban woodland site located adjacent to the M6 at Walsall. They found significant amounts of inorganic particulate matter, though these were less numerous than organic particles, suggesting that woodland can make a significant impact on reducing air-borne particles near urban locations. Goodman (1996) estimated that over a typical growing season such urban broad-leaf woodland could capture up to 50kg of dust and PM-10 in the upper and lower canopies.

While useful in suggesting the scale of the contribution made by urban woodland in reducing air pollution, these papers contain little information about the net impact of woodland planting on reducing particulate matter compared with other land uses, or on the optimal planting for air filtration. Broadmeadow and Freer-Smith (1996) suggest that any planting configuration that maximises leaf area per hectare of planting will increase the uptake of pollutants and suggest that coniferous species such as Norway Spruce may be the most effective air filters. Other observations from their study include the notion that the edge of the canopy is most effective at taking up pollutants, implying that linear planting in areas of pollution (e.g. along roads or adjacent to industrial areas) may be a cost-effective solution to reducing emissions. The observation that uptake of pollutants increases during periods of high emissions suggests that woodland planting can not only act as permanent air filtration mechanism but could be designed to mitigate against possible pollution incidents in areas adjacent to high risk industrial facilities.

Additional research on these issues may be necessary before conducting any benefit estimation. Even so, given further information on this issue it would certainly be feasible to set up contingent valuation scenarios investigating public willingness to pay for cleaner air arising from woodland planting. Indeed, in the past, a number of CV studies have investigated WTP for cleaner air, while several hedonic price studies have estimated the marginal benefits of improving air quality. Experience from these studies suggests that it may prove difficult to separate out amenity and landscape benefits in these situations, as the public would naturally consider the wider role of woodland planting acting as pollution corridors or shelter belts when considering their values.

Alternative estimates of benefit could use cost-based approaches. Impacts of acidification could be estimated through the effect-on-production approach, or in cases where damage could be offset by liming, through the estimation of restoration costs. The human health impacts of a number of chronic respiratory ailments could be measured through the human capital approach by estimating the costs to society of medical treatment and of time off work through illness.

Trees also provide a means of reducing noise pollution in urban areas, again acting as shelter belts between residential centres and roads or industrial areas. Again, a number of studies have used CV, hedonic pricing and choice experiment approaches to estimate public WTP for noise abatement. It is conceivable that some of these values could be used to estimate the noise reduction benefits provided by shelter belts of trees adjacent to busy roads.

With a growth in public concern over the impacts of air pollution, in particular when related to the growing incidence of respiratory ailments such as asthma in adults and children, there is certainly scope for investigating the scale of monetary benefits associated with woodland's role in air filtration.

7.4: Health effects

A limited amount of research exists on the heath impact of trees. This research has largely concentrated on the psychological benefits of trees on well-being. The impact of woodland on health has often tended to be an adjunct to models relating aesthetic responses to specific visual properties of environments. Thus Ulrich (1986) argues that when aesthetic preferences are compared for urban and unspectacular natural views, American and European adult groups evidence a strong tendency to prefer nature. Views of nature, compared with most urban scenes lacking natural elements such as trees, appear to have more positive influences on emotional and physiological states. Ulrich (1986) argues that the benefits of visual encounters with vegetation may be greatest for individuals experiencing stress or anxiety. In a subsequent study Ulrich *et al* (1991) found, from physiological measures (heart period, muscle tension, skin conductance, and pulse transit time) that recovery was faster and more complete when subjects were exposed to natural rather than urban environments. However, the natural environment to which subjects were exposed in an audio-visual experimental situation, comprised tree, openness among trees, light breeze, a stream, and no people; compared to the urban situation of heavy traffic, more noise, and crowds of pedestrians. Thus, trees are only one component in stress and anxiety relief.

In another study Ulrich (1984) studied the therapeutic effect on post-operative patients assigned a rooms with a view of a small stand of deciduous trees or a brown brick wall. In all other respects, such as size, furniture arrangement, size and placement of the window, double room occupancy, proximity to nurses' stations, etc., the rooms were identical. The rooms differed only by what could be seen through the window.

Records of patients in these rooms between 1972 and 1981 were obtained, and matched for illness (all patients in the sample had undergone a cholecystectomy), age, sex, weight, smoker or non-smoker, previous hospitalisation, year of surgery, and room colour (blue or green). Patient under 20 and over 69 years, and those with serious complications were excluded. Only patients receiving treatment when the trees were in leaf (1st May to 20th October) were included in the sample. The final data base of 46 patients were grouped into 23 pairs, and compared for (a) days of hospitalisation (b) number and strength of analgesics taken each day (c) number and strength of doses for anxiety (tranquillisers and barbiturates) taken each day and (d) minor complications such as reported head aches and nausea requiring medication.

Results showed that patients with window views spent less time in hospital (7.96 days) than those with views of the brick wall (8.70 days). This result was significant on a Wilcoxon match pairs signed-ranks test, with $P = 0.025$. In days 2 through 5, patients with a tree view took fewer doses of moderate and strong analgesics than did the brick wall view group, and more doses of weaker analgesics.

However, there was no significant variation between groups with respect to doses of anti-anxiety drugs. This may have resulted from wall view patients taking more doses of narcotic analgesics, which have sedation effects, thus reducing their need for sleeping pills and tranquillisers. However, not all variables were standardised, between the tree and brick wall view groups. The principal omission was the physician treating the patients!

The problem with many of the studies on the health effect of trees is that little or no hard statistical evidence is presented to justify the reliability of the conclusions drawn. Therapeutic effects are also observed when other natural features such as water, gardens, and other vegetation features are present. Hence, the net contribution of tress to health impacts is small.

Moreover, research in this area has not related the scale of woodland to health effects. The general conclusion is that a few trees planted at a relative low cost will have just as much health benefit effects as a forest. In addition, whilst research might demonstrate the health benefits of trees to those who are ill or hospitalised, this is not a large element of the population. Even if WTP of the cost savings of visual views of trees were significant, aggregate benefits are unlikely to be large because the population of relevance is so low.

Large areas of mono-culture forest could conceivable cause adverse health effects, by creating a more drab, monotonous and depressing environment. Anxiety could also increase with forests that appear to be forbidding.

Some recent research in Norway suggest that small forests or woodlands have a positive influence on children's (5 to 7 years) motor development. Fjørtoft and Sageie (2000) found that the natural landscape had qualities to meet children's needs for a stimulating and varied play environment, with a positive relationship between landscapes structures (shrubs, trees, slope and roughness of terrain) and play activities. The play functions afforded by a small woodland landscape had a positive impact on motor development in children as well as positive health effects.

The health benefits of forests, apart from reducing air pollution, are derived from specific and localised woodland areas. The health benefits of forests for recreational visitors are captured in recreational use values. Other health benefits appear to be small, and attributable only to limited small woodland areas rather than the large hectares of commercial plantations.

7.5: Archaeological sites

The Forestry Commission has thousands of archaeological sites on its land, and hundreds of scheduled ancient monuments. No research has been conducted on the value of these archaeological sites, nor on the value that forestry itself adds to these sites.

In some cases forestry has contributed to the preservation of historic monuments and ancient field systems, by preserving the land from mechanised agriculture. As the owner, the FC has a duty to care for scheduled monuments. Buildings and foundations can be damaged by trees and tree root growth. Thus the preservation of scheduled ancient monuments can incur costs as well as benefits. The amenity value provided by ancient monuments might be enhanced by the presence of surrounding woodland. However, care must be taken not to double count this is a forest landscape benefit.

The economic tools exist to value the archaeological sites and scheduled monuments on FC land. CV could be used to estimate the option and existence values of those sites that have not been excavated. Since the number of ancient monuments, and especially archaeological sites, is so large, the value of the marginal site will be close to zero. However, intra-marginal sites will have some value, especially those that have national historical significance. But the value of intra-marginal archaeological sites needs to be assessed in relation people's WTP to conserve all the other archaeological and scheduled monuments that currently exist outside woodland areas.

CV or TCM could also be used to estimate the number and value to visitors and archaeological experts of opening a site such as Breidden Hill near Welshpool, once occupied by the British chieftain Caractacus in resisting the Roman occupation of Britain. The 30 hectare Breidden Hill site has just been cleared of trees planted in the 1930s. Once opened for excavation and for general public visitors, forestry may have little value to sites such as Breidden Hill, other than forming a pleasant surrounding landscape feature.

A major problem in valuing archaeological sites is assessing the contribution that trees, as an attribute, make to the value of the site. Where they are wholly responsible for preserving the site, then the entire option value can be ascribed to the woodland. Where woodland damages sites, or adds the cost of their excavation, then this could result in forestry creating negative benefits for some archaeological sites and scheduled monuments. Where the excavated archaeological site is independent of woodland for its existence, then the value of the site cannot be attributed to forestry.

Chapter 8

AGGREGATION OF NON-MARKET BENEFITS

8.1: Economic value: some basic concepts

Forests generate a wide diversity of values. Forests are complex goods, composed of a diverse array of attributes, the values of which interact to produce the total value of the good. Some attributes complement each other such that their combined value exceeds that of their separate values (e.g. a woodland area which has attractions for both adults and children may have a recreational value which exceeds the sum of two otherwise identical areas one of which only has attractions for adults the other only having attractions for children). Conversely other attributes are substitutes (e.g. the recreational value of a woodland area with two marked trails is unlikely to either equal or exceed the combined recreational value of two otherwise identical woodlands each with one marked trail).

Value is measured by an individual's willingness to pay (WTP) for a good or attribute. Because of the complementarity and substitution effects, summing the separate values for each attribute is liable to yield an incorrect estimate of total value. A distinction also needs to be drawn between the 'marginal WTP' that an individual holds for a small (one-unit) change in an attribute or good, and the total WTP the individual has for the entirety of that good as the former may be a poor indicator of the latter.

It should be noted that WTP might not relate well to what an individual actually has to pay for a good or attribute. An individual can walk into most Forestry Commission woodland without charge and enjoy its recreational attributes without direct payment (although this may not be the case for those arriving by car). Such attributes are denoted as 'non-market' because their enjoyment does not incur any direct monetary transaction. Non-market attributes may be either benefits (such recreation) or costs (such as the acidification impact of certain conifer species upon surface waters). Of course a number of the benefits and costs of forestry do have market prices (for example, timber benefits and the opportunity cost of not using the land for other purposes such as agriculture).

A key issue concerns the definition of the relevant aggregation population: i.e. the group of people who hold WTP values, and across whom total values should be calculated. For market priced goods this is unproblematic as data on sales provides all the information necessary for aggregation. However, for non-market costs and benefits other sources of information are required to determine who holds values and whether (and how) values vary across that population.

This chapter sets out the various issues entailed in estimating the aggregate value of, and changes to, the Forestry Commission estate. Section 8.2 considers the diversity of attributes that require assessment in order to estimate aggregate values, and the concepts of 'use' and 'non-use' values as a method of decomposing these various attributes. Section 8.3 discusses the influence that different management regimes may have upon aggregate values; while Section 8.4 appraises the spatial distribution of values as method of identifying the relevant aggregation population. Section 8.5 considers the relationship between marginal WTP and the quantity of provision of each attribute. This discussion shows that failure to consider diminishing marginal WTP may result in considerable overestimates of aggregate values and this is extended in Section 8.6 which reviews the problem of 'double counting', whereby the value of a given attribute is reflected in measures of the value of other attributes causing an inflation of total values. Section 8.8 provides a summary and draws conclusion including identification of a research strategy for addressing aggregation issues.

8.2: Benefits, costs and values

Aggregation encompasses all attributes; both benefits and costs, market and non-market. Benefits and costs can be subdivided between those that are market priced and therefore 'internal' to the producer (e.g. the Forestry Commission or some private producer) and those that are 'external' to the producer and fall upon society. Internal market priced items include benefits such as timber values.

The principal concern here is with external costs and benefits for which market values are not readily available. These include items such as open access recreation for which entrance and other charges are not levied; the wildlife habitat and associated biodiversity values; landscape amenity; the value of sequestering carbon (thereby contributing towards reduction of greenhouse gases); hydrological effects, etc. External costs and benefits do not have directly observable market prices. Hence, assessment of these costs and benefits is often complex and frequently necessitates use of the non-market valuation techniques.

Many of the items in this category can appear as both external benefits and external costs. This is because different management regimes can generate quite opposing benefit and cost streams. For example, the decision to replant a recently felled area with oak may result in substantial recreation, biodiversity and landscape benefits. Conversely the decision to plant with Sitka spruce may result in recreational, biodiversity and landscape costs. This issue is addressed in more depth in Section 8.3. Values associated with forest attributes can themselves be classified into various types, as discussed in Chapter 1.

The bulk of economic analyses concentrate upon the instrumental or use values of a commodity. Most prominent amongst these are the direct use values generated by private and quasi-private goods (Bateman and Turner, 1993) which are often partly reflected by market prices, and those indirect use values associated with pure and quasi-public goods that generally have no market price description. A unifying characteristic of these values is that they are all generated by the present use of the commodity by the valuing individual. An extension of the temporal frame allows for the possibility of individuals valuing the option of future use (Weisbrod, 1964; Cicchetti and Freeman, 1971; Krutilla and Fisher, 1975; Kriström, 1990). Related to this is the notion of bequest value wherein the individual gains utility from the provision of use or non-use values for present and/or future others. Pure non-use values are mostly commonly identified with the notion of valuing the continued existence of entities such as certain species of flora and fauna or even whole ecosystems. As before this is generally both an intra- and inter-generational value and because of the lack of an instrumental element has proved problematic to measure. Nevertheless, the theoretical case for the `existence of existence value' is widely supported (e.g. Young, 1992).

8.3: Impact of management regime upon aggregate forest values

FC policy goals, objectives, programs, and management regimes result in changes in the mix of market and non-market attributes produced, and consequently the market and non-market value of the estate and, hence its aggregate value.

Two examples illustrate this point. First, consider the balance of market timber values and non-market carbon sequestration values (with respect to carbon fixed in live wood, but omitting release of carbon in forest soils and post-felling products to simplify the argument[1]). As a plantation ages, and the trees increase in volume, so the amount of carbon fixed in live wood increases. However, the choice of species, the rate of tree growth and, more pertinently, the management regime all strongly affect the amount of carbon fixed and the external benefit value thereby generated. This is illustrated in Figure 8.1 which, for a single species (Sitka spruce), considers live wood carbon sequestration for three growth rates under two management regimes. Under both of these regimes, higher tree growth rates (here shown from yield class (YC) 8 to 22)[2] correspond with higher rates of carbon sequestration. However, a much larger effect is due to management regime. When plantations are allowed to grow in an unmanaged way (shown in the dotted line curves) they sequest far more live wood carbon than when they are managed so as to maximise net timber values. This is because the latter regime involves the removal ('thinning') of smaller, less productive trees at regular periods throughout the rotation. This produces a lower number of high timber volume trees that attract a higher market price than do the lower volume trees produced in unthinned plantations. Therefore a thinning management regime results in a higher (market) timber value but a lower (non-market) carbon sequestration value. The net effect upon total values is, a-priori, indeterminate.

Second, consider the impact of management regime upon aggregate values concerns changes in the species mix. A decision on whether to plant an area with either a hardwood or softwood species will result in a very different set of market and non-market costs and benefits, typically leading to a different total value. Characteristically hardwoods produce higher value felling revenues, but these are much more delayed than those for softwoods, so that after discounting softwoods yield higher net present timber values[3]. Therefore, a switch to softwood may well maximise the market value of a given plantation[4]. However, many softwoods generate substantially lower (or negative) net external benefits than do hardwoods. Recreation, wildlife habitat, landscape amenity and many other non-market values are lower (or negative) for softwoods than hardwoods. This may mean that while the market value of a specific softwood plantation is lower than the same area planted with hardwoods, the total value for the latter exceeds that of the former.

The fact that a management regime affects total value is not unique to forestry. However, the wide diversity of market and non-market values generated by forestry means that total values will be more subject to management regime choice than is typical of other sectors of the economy. This will be particularly true where decisions are principally driven by just a subset of those values, (e.g. those with market prices) with other values just being a by-

[1] For an analysis of all these factors across a two species (hardwood and softwood) model see Bateman and Lovett (2000).

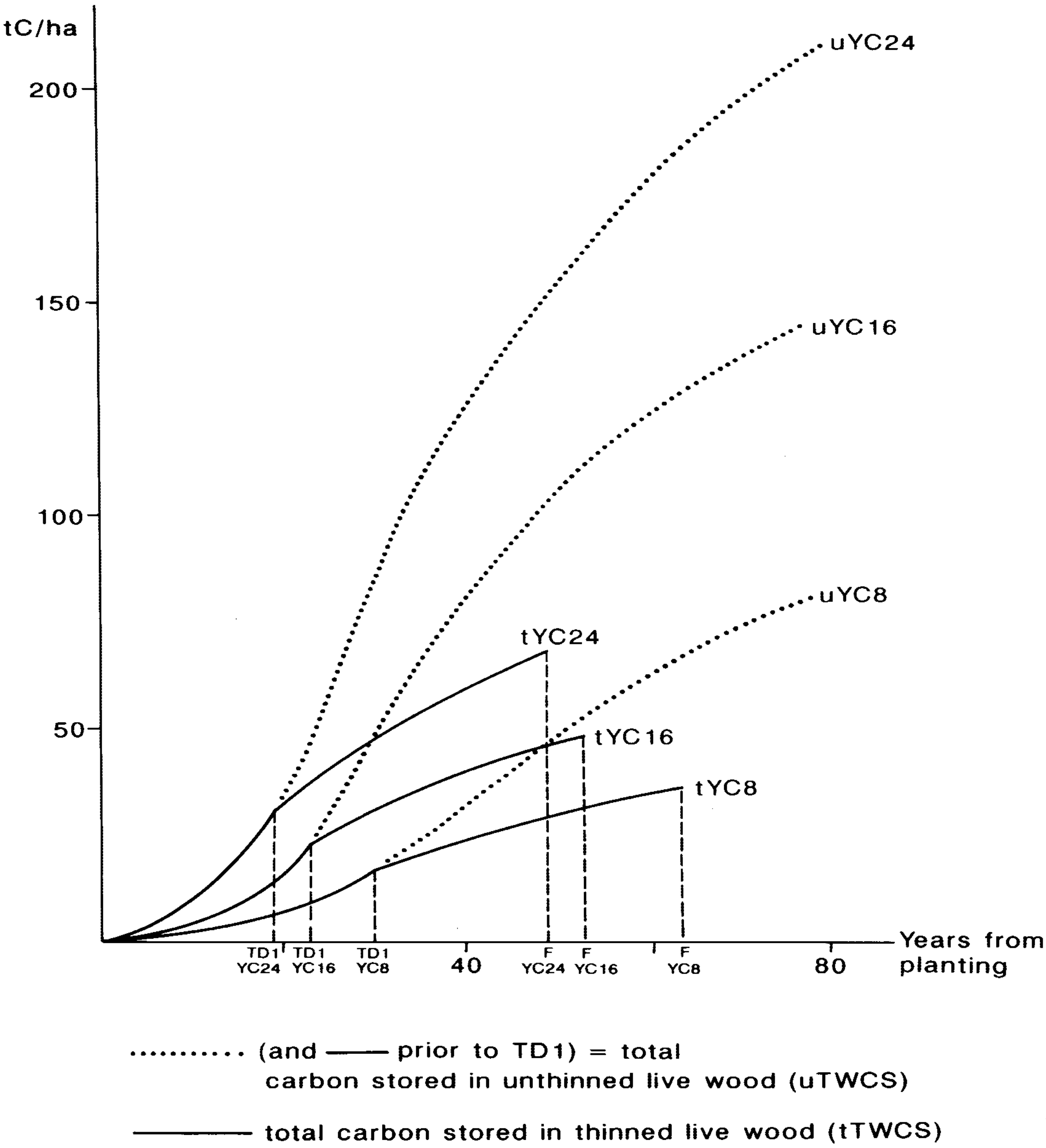
[2] YC 8 refers to a forest subcompartment (the smallest plantation unit) which is growing at an average of $8m^3$/ha/year calculated over an optimal rotation.

[3] This is a characteristic although typically correct. For further discussion and worked examples (under a wide variety of assumptions) see Bateman (1996).

[4] Clearly there is a scale issue here. A change in species mix in one small stand within a plantation is unlikely to generate change in recreation values. Given that woodland recreation is frequently massed around access points, car parks, etc. it would seem that investigation of the relationship between woodland size and recreational value would be well worthwhile. Such work would obviate the common need to adopt somewhat arbitrary assumptions regarding the relationship between per woodland and per hectare recreation values.

product of those decisions. So for example, instances where management is driven purely by the target of maximising the net present value of timber, or instead by the target of minimising land acquisition costs (both of which have been a feature of some historical forestry investment) are unlikely to result in the maximisation of aggregate values.

Figure 8.1: Total carbon storage curves for unthinned and thinned Sitka spruce (discount rate = 5%)



Source: Bateman and Lovett (forthcoming)

- **Research needs**: Assessment of the interactions between values arising from different management regimes would appear to be a research priority that the Forestry Commission should address.

- **Policy gain**: Increase in resource allocation efficiency at the local forest level; and maximisation of NMBs and total economic benefits.

8.4: Identifying the aggregation population: The spatial distribution of values

The value of any forest attribute is measured by individuals' WTP for it. A question arises as to how many individuals hold those values, in order to calculate aggregate value. For market priced products it is not necessary to work out the number of individuals buying these products as all the necessary information is provided by the total revenue generated. Here the FE captures all of the revenue (market price x quantity) from the good. Certainly there may be an excess of WTP over market price (i.e. the consumer surplus)[5] that may be of concern, but the market price should be an acceptable proxy for that value for market goods with close substitutes.

The situation with respect to non-market values is more complex, since these values are not captured by the Forestry Commission. Considering use values first, carbon sequestration benefits are an interesting example of this issue. Here benefit are not captured in entirety by the UK population but shared across the world in terms of reduced greenhouse gases. A decision could be taken that these benefits are valued irrespective of where they fall. However, this is not typically the way in which CBA assessments are conducted (where some cut-off is used to define the relevant benefit population, typically the UK). The Forestry Commission should seek guidance on this point[6].

From an aggregation perspective the most complex of the non-market use values of forestry are likely to be landscape amenity and recreation. Here the aggregation population is not evenly distributed across any given geographical area but instead is clustered around the forest in question. This means that even if those individuals who do value the landscape amenity and recreational services of the forest all hold the same WTP then total values would still decrease with increasing distance away from the site (the 'distance decay' effect; Bateman and Langford, 1997a). However, the assumption of equal WTP amongst those individuals who do value the site is also likely to be erroneous. Considering the example of recreation, those who live near to the site will include some who have deliberately chosen that location precisely because they do hold very high recreation values and wish to minimise travel times[7]. Conversely as we move away from a site so the use value component of individuals' values will tend to diminish (as substitute availability increases) leaving only their non-use value component[8]. Therefore we would expect both the number of users and their individual WTP to decay as we move away from a forest site.

Individuals' WTP statements regarding recreation values may well be contaminated by non-use values such as those related to the provision and preservation of wildlife habitat. This contamination raises the prospect of double counting (i.e. if separate non-use value estimates are added to contaminated 'use value' estimates). However, in the present context there is no clear reason why non-use values should have any systematic spatial distribution, i.e. we do

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[5] For an introduction see Turner et al. (1993).

[6] It could be argued that as carbon sequestration contributes to the UK's international commitments under the Rio and Kyoto treaties that a global benefits assessment is justifiable here.

[7] Parson (1991) identifies this as a problem with many travel cost studies and suggests that explicit incorporation of such capital costs within valuation estimates is called for.

[8] Note that option values (the value for having the option of visiting a previously unvisited site) are also likely to decline with increased distance from a site.

not expect distance decay in either the relevant pure non-use aggregation population or in the WTP values which that population may hold.

An example of these various relationships and illustration of aggregation procedures in their presence is given by Bateman et al. (2000) in a study of WTP values to preserve a nationally important wetland site (the Norfolk Broads) from significant degradation. The fact that this case considers a wetland rather than a forest, and that this is of national rather than local importance (and that we consider a degradation rather than an improvement), is incidental since the concern here is with the methodological principles of aggregation rather than the WTP levels themselves. In this illustration WTP estimates were obtained through a contingent valuation (CV) study administered nationally via a postal survey[9]. Analysis of this data revealed strong distance decay trends in responses as well as significant socio-economic gradients; i.e. more deprived areas are less likely to respond to CV surveys and even when they do they have lower WTP. Response trends are illustrated in Figures 8.2(a) and 8.2(b). The left hand graph of Figure 8.2(a) shows the distribution of population disaggregated by the two factors that were found to significantly determine response rate: distance from the asset and the income level[10] of the area to which a given questionnaire was sent[11]. The right hand graph illustrates the survey response rate for both high and low income groups against distance from the site as predicted by the estimated response function. As expected, as distance increases so response rate falls; however high income areas consistently yield higher response rates than low income areas[12]. Both the distance and income effects are statistically significant in predicting response rates (Bateman and Langford, 1997a). The graph permits non-response to be incorporated into the aggregation process. This is achieved through the very conservative assumption that non-respondents have zero WTP for the asset (although an intermediate approach in which non-respondents have a non-zero WTP should also be investigated).

[9] Further details of the survey are given in Bateman and Langford (1997a).

[10] Income level was proxied through use of Census deprivation variables i.e. the term 'income' is, strictly speaking, rather loose but is retained from clarity of exposition here.

[11] The distribution of population and their socio-economic circumstances can be assumed to be random with respect to the asset in question. This may not be strictly true. First, most environmental assets are not typically located in the centre of high population areas, therefore population will usually rise at some points away from the site, as illustrated here. Second, the travel cost literature gives some indication that, for some assets and locations, the proportion of higher income households may be relatively high in nearby locations (Parson, 1991). However, there are limits on this relationship imposed by the constraint of being able to also get to places of employment for those of employable age. Given this the randomness assumption seems reasonable.

[12] As the graph shows, both the slope and intercept of these functions may differ across income groups (i.e. there is an interaction between the income and distance effects).

Figure 8.3(a): Aggregation by non-response and bid functions - Step (i) Defining the aggregation population

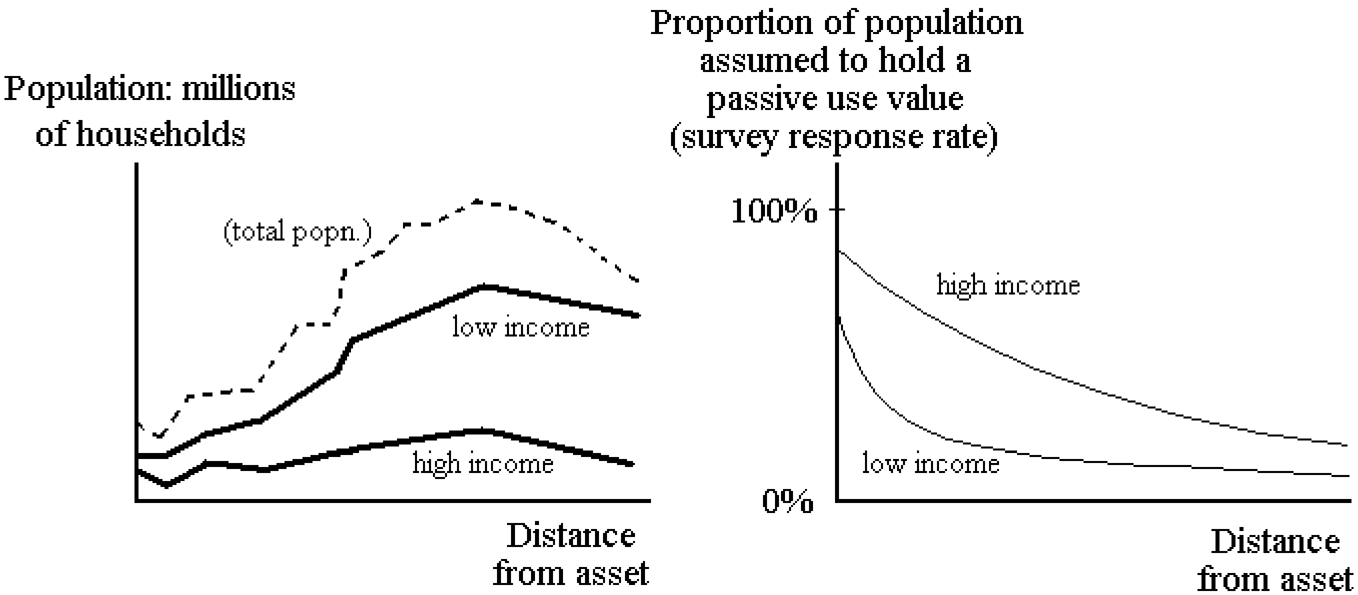

Figure 8.3(b): Aggregation by non-response and bid functions - Step (ii) Defining marginal WTP

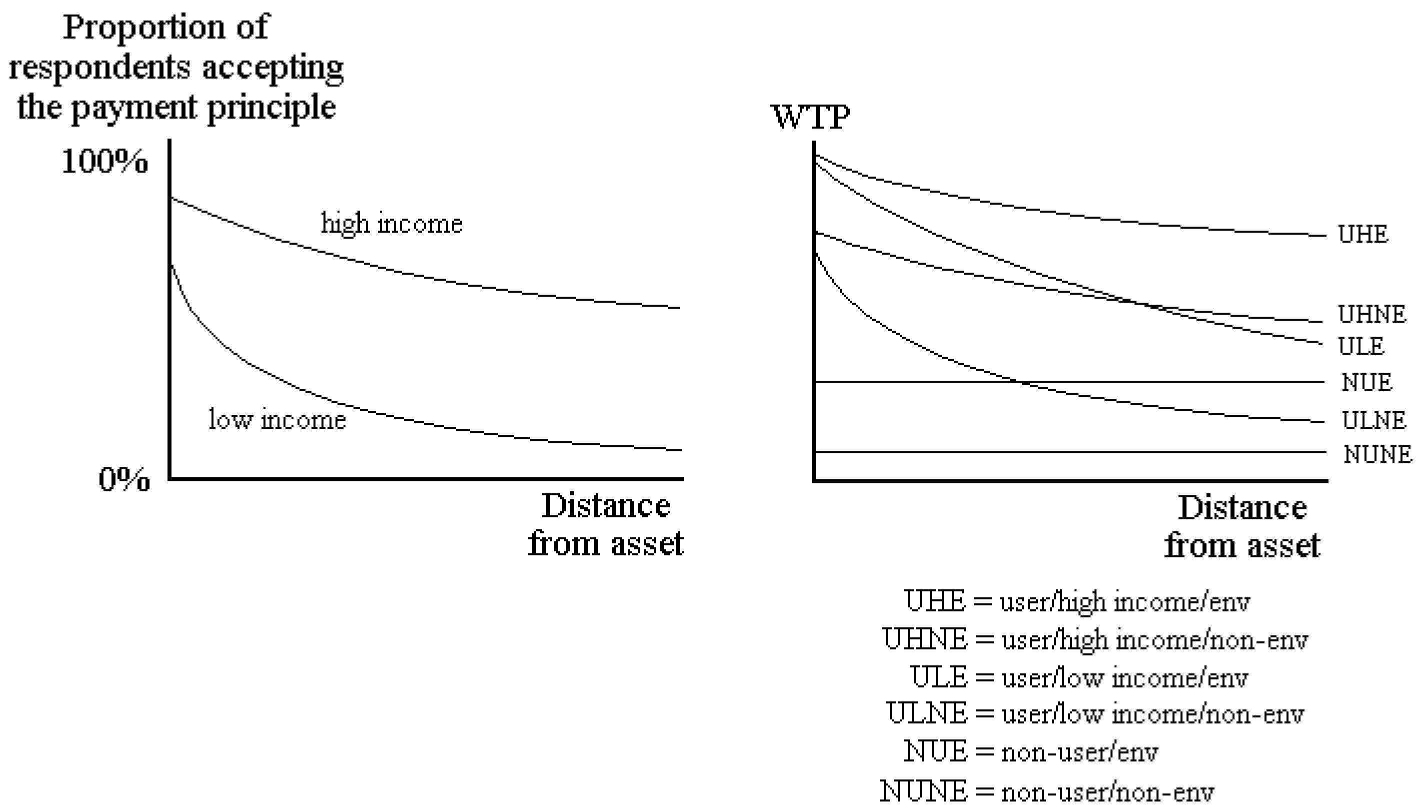

Figure 8.2(b) illustrates the derivation of WTP sums for the aggregation population defined above. The left hand graph shows the proportion of survey respondents who answered positively to a ‘payment principle’ (PP) question[13] asking whether or not they had a positive WTP for the asset in question. Analysis showed that, in line with expectations, this rate fell with increasing distance from the asset and rose with higher income levels. The right hand graph show the relationship of marginal WTP with four factors: distance, income, whether respondents had previously used the area, and whether respondents were members of environmental groups. For previous users of the site, as distance increased so marginal WTP declined; a result that conforms to expectations. *Ceteris paribus*, the marginal WTP of higher income groups exceeds that of lower income groups; and a positive if relatively weaker[14] relationship was also detected with membership of environmental groups. For non-users factors such as income and distance from the site proved not to significantly affect WTP (again in line with prior expectations), whilst environmental group membership was a significant predictor for this group (suggesting that this group holds higher non-use values than the average population). For both users and non-users Bateman et al., (2000) incorporate this effect into their aggregation by using the mean rates of environmental group membership recorded in the sample[15].

Using non-response and bid functions allows the data to define the aggregation population and preserves variation in marginal WTP amounts across that population. As such it provides a substantially more robust approach to aggregation than other simpler approaches. This can be illustrated by comparing aggregation estimates calculated according to the ‘aggregation by functions’ approach with two other approaches: (i) an ‘administrative area’ approach which assumes individuals have a constant (average) WTP across some administratively defined area near to the site (the approach adopted by the Environment Agency in their benefits transfer study for a water abstraction project at Axford on the River Kennet)[16]; (ii) an ‘ad-hoc zonal’ approach which uses a variant of the former method but allows WTP to decay by discrete steps across a series of concentric distance zones.

Table 8.1 compares the results obtained from these various aggregation approaches for the value of preserving the Norfolk Broads from innundation. Both the administrative area and ad-hoc zonal approaches yield estimates that are very much larger than that provided by the

[13] So, taken together with Step (i), we now have that roughly 31% of those sent questionnaires replied and of those 53.5% responded positively to the payment principle. Therefore we have an overall rate of about 16.5% of the total sample holding a positive WTP. However, as Figure 3(a) and 3(b) shows this is primarily motivated by those who live closer to the assets and/or have higher incomes. Therefore it would be incorrect to assume a blanket rate of 16.5% for the whole country. Such an approach would result in an overestimate of aggregate WTP.

[14] $p<0.10$ whereas all other relationships were significant at $p<0.05$ or less

[15] This will be unrepresentative of the entire population of Great Britain but is our best predictor of such membership amongst that portion of the population who are prepared to pay for the good in question (i.e. the aggregation population) and therefore should improve the accuracy of our estimate of total WTP. Bateman et al., (2000) also report separate marginal WTP functions for past users and those who have never visited the site. This analysis suggests that income and distance is not a significant predictor of stated WTP for the latter group for whom values only vary significantly according to whether they are members of environmental groups.

[16] For a commentary see Moran (1999).

non-response and bid function aggregation method. Furthermore the former approaches yield benefits estimates which are sensitive to the area definition adopted[17]. Given this the bid-function based aggregation approach (type (iii) in Table 8.1) is recommended.

Table 8.1: The present non-user's benefits of preserving the present condition of the Norfolk Broads aggregated across Great Britain using various procedures (£ million/annum)

Aggregation approach	Untruncated	Truncated[1]
(i) Administrative area approach: Aggregation using administrative boundary to define payee population (no allowance for non-payers) and sample mean to define WTP	159.7	98.4
(ii) Ad-hoc user defined zones used to define payee population (no allowance for non-payers); WTP level set to mean sample WTP for each zone.	111.1	98.0
(iii) Aggregation using non-response rates to define payee population and bid functions to define WTP:		
(a) using ad-hoc zones[2] to define distance variable and national income level to define income variable for bid functions	27.3	25.3
(b) using county centroids[3] to define distance variable and regional income level to define income variable for bid functions	25.4	24.0

Notes: 1. Truncated results remove the upper and lower 2.5% of WTP responses so as to adjust for possible outlier/ strategic response effects.
2. These are the same zones as used in method (ii).
3. Centroids and distances were calculated using a geographical information system (GIS) although any route mapping software package should provide reasonable measures for large scale assets (the advantages of a GIS may be more apparent where small scale local resources with small aggregation populations are considered).

Source: Bateman et al., (2000)

In summary therefore, we have theoretical expectations regarding distance decay in both the aggregation population and individual level WTP sums appertaining to the use values generated by forestry but not with respect to non-use values. Empirical support for such expectations can be gleaned from valuation studies of comparable goods. This means that relatively unsophisticated approaches to aggregation may cause major errors in the estimation of total value.

- **Research needs**: This area should be a research priority for the FC. Little is known about the distribution of consumer surplus and WTP values for NMBs, especially recreational benefits, over space. Research on recreational benefit models needs to be

[17] For an analogous example showing the use of different area definitions upon travel cost based estimates of woodland recreation values see Bateman et al., (1999a).

developed first, but with due recognition that the recreational benefit estimates will be used to assess the aggregation issue. Research needs to be commissioned to test the accuracy and robustness of aggregation over space.

- **Policy gain**: More accurate assessment of the total value of recreational benefits and how these vary over space in relation to forests. This would inform the location of future new planting, to maximise recreational benefits.

8.5: Marginal WTP values and the quantity of provision

Basic microeconomic theory shows that as an individual's consumption of a good increases so their marginal WTP (the amount they are prepared to pay for an additional unit of that good) declines. The rate of decline is described by the demand curve; and the interaction of the demand and supply curves determines total consumption and price. The Forestry Commission supplies less than a quarter of the total timber consumed in the UK. It has relatively little control over market price (which is essentially determined by the world market). However, this also means that increases in production of timber by the Forestry Commission do not lead to large declines in either marginal WTP or price.

One non-market benefit for which declining marginal WTP is not applicable is carbon sequestration. Relative to the scale of global carbon emissions the ameliorative contribution of the Forestry Commission is very minor (Grayson, 1989). However, this scale issue means that additional carbon sequestration by the Forestry Commission will have an insignificant impact upon its marginal value. In effect therefore the shadow price of carbon can be taken as a constant for aggregation purposes and simply multiplied by the net quantity of carbon stored to yield an estimate of its total value.

However, some non-market benefits of forestry exhibit severe diminishing marginal WTP. The prime example of this effect is recreation benefits. Here, the relevant aggregation population is largely clustered around the site. If a site is subject to severe congestion the provision of additional woodland might only result in a modest decline in marginal WTP. However, in areas where substitutes exist, or where demand is low, the provision of additional woodland might lead to a very significantly declining marginal WTP.

It is likely that similar effects will arise with respect to landscape amenity benefits. Hence, it is vital that the impact of substitutes and other factors that impinge upon marginal WTP are incorporated within aggregation procedures. Section 8.7 outlines some recent research that provides one perspective on how this issue might be addressed.

8.6: Double counting and related issues

Double counting errors occur when a benefit or cost item which is incorporated within one heading of a CBA assessment is also counted under other headings. Typically this is a consequence of an imprecise specification of a particular cost or benefit heading or the contamination of one value with another.

Typical double counting errors are:

(i) *Overlap between non-market value estimates:* A common example of this error arises from the use of expressed preference valuation studies (such as contingent valuation; stated preference/conjoint analysis; choice modelling; etc.), to estimate value for particular forest attributes. For example, there have been many expressed preference studies of UK woodland non-market recreation benefits. However, there exists the lingering concern that the estimates obtained are not purely recreational use values but may also contain elements of other preferences such as recreation option value (Willis et al., 1998), landscape amenity (ENTEC, 1997; Hanley et al., 1999), wildlife habitat and associated biodiversity values (University of Newcastle & ERM, 1996; Garrod and Willis, 1997; Hanley et al., 1999), bequest and existence values. In such an event, double counting is liable to occur if separate estimates of these latter values are then added in to the CBA assessment.

In theory this may be less of a problem with revealed preference value estimates (such as those derived from the travel cost method). Here the focus should be exclusively upon recreational use value and while this may be elevated by the presence of higher landscape, biodiversity, etc. values it should not *per se* cause a double counting error to add separate estimates of the latter to the revealed preference recreational use value estimate. However, this assumes that values for landscape, biodiversity, etc. can be obtained which themselves do not contain elements of recreation value. Given that the former are typically only obtainable via expressed preference methods this seems problematic. While recent advances in expressed preference suggest some hope of obtaining uncontaminated values (e.g. via stated preference/conjoint methods or via the 'cheap talk' contingent valuation approach developed by Cummings et al.) there has, to date, been little application of these techniques to forestry.

One other possible solution is to use expressed preference techniques to estimate total non-market benefits thus avoiding the need to add-up possibly contaminated estimates for individual values. An issue here concerns the remit of values encompassed by such estimates (e.g. while these are likely to include well perceived values such as recreation, landscape amenity and biodiversity, perception of carbon sequestration and certain ecological function values may be much poorer).

(ii) *Ignoring the diminishing marginal WTP issue:* The provision of certain market and non-market benefits increases so their marginal value declines; non-market recreation and landscape amenity benefits being exemplars of this effect. Unless this effect is incorporated into valuations, then for example, the recreational value of new woodlands is liable to be overestimated, potentially by a significant amount. This should be tackled by explicit incorporation of the impact of substitutes upon such values. Brainard et al. (1999) develop a geographical information system (GIS) based approach pioneered by Bateman et al. (1999a) for achieving such incorporation. This uses the spatial analytic power of a GIS to calculate the accessibility of all potential substitute woodlands from a 500m grid of potential outset locations encompassing all of lowland Britain. Statistical analysis of this data shows that the presence of substitutes is a strong predictor of arrivals at any given site. The derived model is used to predict arrivals at 33 woodlands across England. Comparisons of predictions with Forestry Commission estimates of arrivals suggests that the model performs well and is a substantial improvement upon other studies (mainly of US resources) in the literature.

This work is currently being extended by Ian Bateman and Andy Jones at the School of Environmental Sciences, University of East Anglia. This project uses data from recent Forestry Commission visitor surveys[18] and extends the substitute set to include non-woodland sites such as open-access areas, riversides, beaches, cultural assets (e.g. National Trust properties), etc. While still under development this model may contribute towards addressing the substitution and diminishing marginal WTP issue.

(iii) *Ignoring the distance decay effect:* If values such as the use values generated by non-market forest recreation exhibit significant distance decay in terms of the relevant aggregation population and/or individual WTP levels (see earlier discussion in this chapter) then any aggregation procedure which ignores this issue is liable to obtain erroneous estimates of total WTP. Whether these will be over- or under-estimates depends upon the assumptions imposed by the aggregation procedure (the previous discussion of this issue highlights two assumptions both of which lead to overestimation of total values). Aggregation should be data driven such that it can be responsive to the value trends exhibited by individuals. However, assuming that double counting issues identified in (ii) above have been addressed, then no significant distance decay effect should be expected for non-use WTP sums, although arguably the relevant aggregation population may again decline with distance due to reduced awareness and increasing concern for local non-use attributes.

(iv) *Errors in specification of the relevant anthropocentric and temporal accounting unit:* Non-market benefits are frequently estimated using a wide variety of accounting units. For example, recreation benefits may be estimated per person, per party, per vehicle, or per household. Within these definitions different conventions may be adopted regarding who qualifies for inclusion, e.g. taxpayers only, adults only, all persons irrespective of tax or age status. A further complication arises regarding the appropriate temporal period for aggregation. Value estimates may be per visit, per season (particularly where a site is not continuously open), per annum or some analyst defined period.

A related issue concerns the extrapolation from some survey period to the desired accounting period (e.g. per annum). Typically valuation surveys are conducted during a specific, often relatively short, period. However, research shows that visitor flows vary across the seasons and on a daily basis due to factors such as the weather, national holidays, etc.[19] Furthermore, even during a survey period, the survey will not interview all visitors to a site. This happens because visitors arrive at times or on days when surveyors are not present, or there are too many visitors to survey, or individuals refuse to be interviewed.

These issues raise two problems: (a) Extrapolation from the survey period to the temporal accounting period is complex and requires data (e.g. on total visitors) which may or may not be available or reliable. (b) The possibility exists that the individual WTP of those interviewed may be systematically different from those who were not interviewed. This arises because the former group are to some degree self selected

[18] Kindly provided by Simon Gillam, Forestry Commission. This dataset consists of some 22,739 interviews (of which 16,096 have full response sets and outset addresses) across 131 forest sites of which over one-fifth have site facility and quality information.

[19] For an analysis of weekly flows across a two year period with respect to these various factors see Bateman (1996).

(i.e. they agreed to be interviewed) or systematically omitted by dint of the survey strategy (e.g. where a survey only operates within certain hours outside of which a set of visitors arrive who are not adequately represented within the collected sample). This latter problem is a common survey issue and can be to some extent addressed through advanced survey design and administration. However, typically improvements in sample representativeness are not costless.

Further complications may arise due to the differing accounting periods relevant to the various benefit streams generated by forestry. Extreme examples are the contrast between recreation, for which an annual accounting period is reasonable, and timber, for which the natural period of account is the rotation length, which in turn varies according to species, yield class and discount rate[20] but may vary between (at the extreme) less than 40 years or more than 120 years. This is a complex problem as the choice of accounting period will affect calculated net benefits. Simple solutions include standardising upon some set (typically long) NPV period or alternatively calculating annualised equivalent (annuity) values. However, both options have their drawbacks and regrettably sensitivity analysis appears the only reasonable solution here.

For a discussion of all the above issues and some empirical treatment see Bateman (1996). In summary, double counting and related issues are persisting issues affecting the calculation of forestry benefits. The above discussion outlines the major issues and suggests some ways forwards towards tackling these problems.

8.7: Aggregation of the net benefits of forestry: a large area case study

Bateman *et al* (forthcoming) have estimated the aggregate net benefits of forestry in Wales. Their research develops a computer model that takes into account

- Tree species
- Market prices: value of timber and opportunity costs of land to agriculture
- Shadow prices, including adjustments for transfer payments (direct and indirect grants and subsidies)
- Non-market benefits
- Discount rates

NMBs considered in this analysis include carbon sequestration and recreational values. results suggest that for marginal projects recreational values exceed those of carbon sequestration. However, as the former are subject to rapidly diminishing marginal values, aggregate values of carbon sequestration may be of a similar magnitude to those of recreation. A limitation to this research is that it does not consider the landscape and biodiversity values of land-use change.

- **Research needs:** The extension of this type of model to other areas in Great Britain would improve understanding of the total value of the FC estimate, and how the value might change at the margin with changes in recreational provision, landscape architecture, biodiversity, and carbon sequestration objectives.
- **Policy gain**: More robust and accurate estimate of the total NMBs and total economic value of the FC estimate to present to government and HM Treasury.

[20] See tables presented in Bateman (1996).

8.8: Conclusions

The aggregation of net benefits for forestry is a complex process. There are five areas of concern:

(i) The diversity of internal and external costs and benefits (difficulties arising in the valuation of such items are highlighted throughout this report)

(ii) The impact of different management regimes upon resultant values

(iii) The spatial distribution of values and associated issues such as distance decay in both the aggregation population and in individuals WTP amounts

(iv) Diminishing marginal WTP levels as the quantity of provision of certain benefits increases

(v) Double counting and related issues.

The case study on the net benefits of land use conversions from agriculture to multipurpose forestry in Wales (Bateman et al., forthcoming) addresses some although not all of the above issues.

Aggregation is a complex process that requires at least as much research effort as the other areas highlighted in this report. Without such attention the potential for incorrect estimation of values from aggregation errors is probably greater than from any other source.

Chapter 9

CONCLUSIONS AND RECOMMENDATIONS

After 15 years of research effort benefit estimates for a wide range of forest goods and services are now available. The aim of this study was to consider the extent to which these research findings could be used to provide reliable marginal and total NMBs estimates for U.K. forests for policy applications at the forest, regional and national levels.

In order to assess the extent to which this task was both feasible and practical the study team critically reviewed existing valuation research from the U.K. and overseas. The study's main focus has been the economic valuation of the four most important non-market benefits of forestry: recreation, landscape, biodiversity and carbon storage. In addition, a range of other non-market benefits generated by forestry, such as impacts on water quality, human health and air quality, were discussed in Chapter 8.

9.1: Conclusions

The main conclusions are as follows

- Estimates relating to recreation and carbon storage benefits are the most reliable and have greatest potential in terms of providing reliable marginal and total benefit estimates for U.K. forests.
- Landscape and biodiversity benefits are more complex and therefore more difficult to characterise and to value. They are also associated with considerably greater spatial diversity and this complicates any benefit transfer exercise.
- The main challenges to the development of reliable marginal and total benefit estimates for U.K. forests are the problems of embedding, modelling the spatial diversity of outputs, attributing values for different forestry outputs; double counting; and aggregation over relevant populations.
- On the basis of what has been reviewed in this scoping study, it is possible to recommend various options for achieving an estimate of the total non-market value of the economic benefits generated by forestry in the U.K.. However, it is our view that, with further research, it would be particularly cost-effective to develop an approach based on a benefit transfer exercise. This would allow estimates of marginal and total value to be placed on a range of forest management activities at forest, regional and national level.

The accuracy and reliability of the benefit estimates generated by each option would depend on the amount of resources available to conduct such an exercise. In the next section we suggest three options that we feel are suited to the policy requirements and resource constraints of the Forestry Commission.

9.2: Recommended approaches by cost-effectiveness

In this section we outline three main options that are ordered in terms of their cost-effectiveness. All three options aim at meeting the following objectives:

1) to estimate the total value of NMBs of U.K. forests;
2) to estimate the marginal NMBs of a selected range of management operations;
3) to estimate of the NMBs arising from initiatives such as community woodlands or nature woodlands, and the benefits of meeting Biodiversity Action Plan objectives and international targets such as those set by the Kyoto Protocols;
4) to establish a methodology that will achieve the three objectives listed above; that can be used in subsequent studies; and that will both avoid double-counting and correctly identify the population of beneficiaries for aggregation.

In order to achieve these objectives each option would include the following outcomes:

1) the development of a theoretically valid methodology for the task;
2) identification of the relevant forest types and their typical non-market products and services for which value estimates are sought;
3) predictions of selected benefit estimates;
4) checks to establish if predicted values match theoretical expectations;
5) a report of findings and estimates.

Each option would differ primarily with respect to the degree of ancillary analyses required and the level of validation involved. The steps involved in each option are presented in Table 1 with supporting detail in the following pages.

9.3: OPTION 1

9.3.1: General approach.

This option attempts to maximize the use of existing analyses, studies and data to inform the overall estimation process in a desk exercise. The primary advantage of this option is avoiding the need for expensive new surveys and analyses to fill gaps in existing knowledge. The disadvantage is that estimates of NMBs may be somewhat inaccurate or/and incomplete, as existing studies are unlikely to provide sufficient information for a total value estimate. However, the inaccuracy might be limited by taking a cautionary approach (i.e. one that relies on conservative estimates throughout).

9.3.2: Benefit estimate methods

9.3.2.1: Recreation: It is recommended that the benefits arising from individual forest recreation visits be obtained through using benefit estimates from existing studies. This should be achieved either by transferring benefit value estimates to forest sites for which no on-site data are available, or through predictions by means of multi-attribute benefit transfer functions. These can be obtained via meta-analysis studies from both contingent valuation and travel cost data of large scale studies, such as the EU-CAMAR data set and the on-site recreation surveys administered by the Forestry Commission. These transferred estimates would be adjusted by taking into consideration time lags between the time of data collection and the present, as well as forest specific attributes, such as average distance of woodlands from users, type of wood coverage, and the extent of the local market for forest recreation. In order to aggregate over the correct population of recreation beneficiaries, the probability of participation to forest recreation would be estimated from existing data collected in the "Public Opinion of Forestry" and in the "Leisure Day Visits" surveys.

9.3.2.2: Landscape: to some extent landscape values for recreational users can be estimated from recreation benefit studies as the two outputs are often jointly valued in the WTP analysis. Hedonic price information is available for residents, but landscape values of external users such as hill-walkers and commuters have not been estimated and hence cannot not be included in this Option as they would require new studies.

9.3.2.3: Biodiversity: Although biodiversity values have been studied for conifers, there are no equivalent data for broadleaf or native woodland types. These will have to be estimated on the basis of theoretical expectations, relevant studies, and expert opinion.

9.3.2.4: Carbon sink functions: Benefits from carbon sink functions can be estimated from existing information on timber yields, and from DETR's best estimate the benefit of the reduction in carbon emissions (per tonne).

9.3.2.5: Aggregation across all woodland: an aggregate value of the NMBs of woodland could be derived using existing and the limited new information from the above studies. However, the accuracy of the aggregate estimate, without more sophisticated aggregation procedures, would be questionable.

9.3.3: Validation: Validation tests will be restricted to comparing benefit estimates with theoretical expectations and comparable studies.

9.3.4: Expected Cost of Option 1: £30-40,000.

9.3.5: Timescale: 6-8 months.

9.4: OPTION 2

9.4.1: General approach.

As in the previous case, this option relies mainly on existing data and previously completed studies. However, this option would add to existing information by means of new multi-attribute analysis of existing data and it would also involve some new survey work to validate model predictions and assess the robustness of the NMB estimates.

9.4.2: Benefit estimates

9.4.2.1: Recreation: for this category of estimates this Option will provide reliability tests for benefit transfer, as well as new estimates for values that are currently poorly understood and/or not well-mapped geographically. Again, multi-attribute benefit-transfer models can help to provide the main estimates for sites for which no on-site surveys are currently available. The specific NMBs generated by these forest sites will be predicted on the basis of their set of attributes and on other estimates from similar sites. In Option 2, however, a number of transfer-forest sites will be sampled on an *ad hoc* basis in order to carry out on-site surveys that will be used to validate the transfers and obtain a calibration function to increase the robustness of the estimates. The calibration function is a tool by which the transfer estimates can be corrected for bias according to some empirical rule. This will produce more accurate and robust estimates of the recreational benefits of forests that have yet to be studied individually.

9.4.2.2: Landscape: internal landscape values may be considered to be implicitly accounted for in the benefits functions for recreation. Some studies (i.e. EU-CAMAR) have quantitative quality-indices which are meant to capture – amongst other non-measurable factors – benefits from forest landscape. These indices, however, require a structured aesthetic assessment at the single forest level. Forest managers could be trained to conduct this kind of appraisal for the forests they manage, hence producing a landscape value index for each of them, or for uniform landscape categories. A separate benefit-transfer model will be constructed for non-recreational users (e.g. residents) and for different landscape types. Aggregation over the relevant population will be based on whether or not woodland is visible from various view-points along roads, paths and in settlements.

9.4.2.3 Biodiversity: Forest biodiversity can be approximately described by means of plant and animal species counts in representative forests. These counts can be succinctly represented by quantitative diversity indices (i.e. Shannon's indices of species and size diversity) and the marginal value of these quantitative measures may be empirically investigated using existing data via regression analysis and other multi-variate and multi-attribute tools. Small-scale field surveys would supplement and validate this approach.

9.4.2.4: Carbon sink functions: these estimates would not be greatly improved as it is relatively simple to derive them accurately from existing data, as described in option 1.

9.4.2.5: Aggregation across all woodland: the use of new and existing values for the different NMBs would provide a more accurate estimate an aggregate value of the total non-market value of woodland. Care would be needed to avoid double counting, particularly of recreation benefits, between forest catchment areas. The adoption of a more sophisticated aggregation procedure, incorporating distance decay for the probability of visiting a site and for WTP where the forest good was a 'local public good', should permit an reasonably accuracy assessment of the total NMB of woodland.

9.4.3: Validation: As in Option 1 but also includes validation using small scale field surveys and re-estimation of benefit values where necessary.

9.4.4 Estimated Cost: £80-100,000

9.4.5 Estimated Timescale: 16-18 months

9.5: OPTION 3.

9.5.1: General approach.

Option 3 is the most expensive of the three approaches that we recommend. Yet, it is the one which most completely addresses the issues at stake and it will also provide the most accurate and robust set of estimates across the three recommended alternatives. Option 3 is inclusive of the studies described in Option 2, but it requires further investigation and new data collection and analysis.

9.5.2: Benefit estimates

9.5.2.1: Recreation: as this is the category for which the most methodological progress has been made and the one producing the most tangible and indisputable class of NMBs, three different studies are recommended to address the estimation in a cost-effective, yet exhaustive manner:

a) a survey addressing issues of market definition;
b) a study addressing the dynamics of recreation demand;
c) a study addressing the exploitation and rationalization of existing datasets and data collection initiatives with respect to the objective of improving NMBs estimate.

Recreation study 1: the issue of market definition.

Timescale: Short term.

Objective: It is of paramount importance to investigate the issue of market definition. As mentioned before this is also an important for the correct inference of aggregate values and the avoidance of omitted-variable bias in demand systems.

Rationale: To improve the accuracy of total benefit estimates, the aggregation phase must be improved, as this is the main source of error. The extent of the market informs the size of the relevant population of users. Woodlands need to be classified on the basis of the geographical extent of the recreational market they supply (for example in National, Regional and Local).

Approach: For many forest sites market definition can be achieved by investigating the origin of trips of visitors from existing data (i.e. Forestry Commission Forest visitors dataset 1995-98, EU-CAMAR 92), and possibly by new surveys to be conducted on an ad hoc basis. A stratification of the substitute relationships across sites on the basis of distance and supported activities is also needed, so that a clear understanding of the essential elements of market definition in each geographic compartment can be developed. Markets can also be defined by investigating the ignorance of the local population with regards to nearby forest woodlands. In a given market, the extent of residents' knowledge about the local supply of forest recreation opportunities is also important for market definition and would require an ad hoc study. People may perceive the supply as inadequate simply because they have a misperception of the existing supply alternatives. Social benefit may well be increased simply by removing this misperception, i.e. by informing residents and promoting visits to certain, less well known, sites.

Outputs: While the above course of action will produce information that will more correctly characterise the supply side, a similar characterisation is needed for the demand side. Since forests are environments that support various types of activities, various profiles of users can be found. A systematic characterisation of these profiles – by means of cluster analysis for example – can provide us with a better understanding of who is going to which forest and why. This will allow forest managers to better match forest attributes to visitor characteristics, thereby increasing the provision of social benefits.

Costs 1 (using existing data-sets):

6 person months	=	£12,500
		£12,500

Costs 2 (merging existing data-sets with additional surveys):

8 person months	=	£16,000
4 focus groups @ £600 per focus group	=	£2,400
1,200 questionnaire survey	=	£30,000
		£48,400

Recreation study 2: the dynamics of recreation demand.

Timescale: Medium term.

Objective: To complement the static characterisation of demand and supply in the market for forest recreation with a dynamic analysis. To provide seasonal and life-cycle patterns of forest use for recreation. To improve the accuracy of present value benefit estimates used in long-term policy and management decisions.

Rationale: The lengthy time interval between many forest management decisions and the full development of their consequences is all too often ignored by managers and policy makers. Some policies may be correctly valued in terms of their social benefits and costs at one particular moment in time, but if the economic preferences of individuals for forest recreation varies with age, and the relative frequency of different age groups varies over time, then aggregate benefits will also vary. A more accurate aggregation of recreational benefits over a given interval would be achieved by taking account of the evolution of the different age groups. More research effort should therefore be devoted to exploring the dynamic aspects of demand for forest recreation in individual and family life-cycles.

Approach: This research requires the use of a nationwide panel data study based on randomly selected households of forest users, which would investigate their seasonal forest use for at least 3 years. Because of its high cost and the potential interest from the methodological viewpoint in social sciences, it would be advisable to seek co-funding for this study by approaching research councils such as the ESRC.

Output: This type of analysis would improve our understanding of how the demand for forest recreation varies during seasons and throughout an individual's life-cycle, depending on age, family composition and evolving interests.

Costs:

36 person months	=	£90,000
4 focus groups (national level)	=	£2,400
Preliminary framing phone survey 5,000	=	£20,000
1,500 panel questionnaire nation wide surveys	=	£90,000
		£202,400

Recreation study 3: exploiting existing datasets.

Timescale: Short term.

Objective: Conduct forest recreation analysis and valuation for England, Scotland and Wales from existing ,yet not fully exploited, databases.

Rationale: Save additional survey costs by using existing data. Inform further research actions.

Approach: Some existing yet untapped data on Scottish forests from the EU CAMAR project can be put to use for preliminary research on both of the above mentioned priority issues. In summer 1992 travel cost and CV responses were collected for 15 Scottish forest sites from a total of 5,061 completed on-site surveys conducted face-to-face and representing 28,973 recreational trips, with an inference base of over 2 million visit per year. Site selection was informed by a previous Forestry Commission economic advisor Adrian Whitehead. This data is quite rich and is analogous to those from which recent TC and CV-based valuation studies were conducted in the Republic of Ireland and in Northern Ireland (Hutchinson 1999, Hutchinson et al. 2000; Scarpa 1999, Scarpa et al. 2000a, 2000b, 2000c). Similar data for other sites are available from various years of administration of the Forestry Commission Visitors Survey Datasets (1995-2000).Output: It is expected that the wealth of information stored in this data can contribute greatly to estimation of current recreational demand functions in Scotland, and to their associated social benefits. Benefit transfer functions can also be estimated from the data and may save further costs if value or function transfers are found to be statistically reliable (Bateman et al. 1999, Scarpa et al. 2000d). The output of these analyses could also prove relevant for the design of similar research surveys to be conducted in England and Wales for the purpose of supplementing the information from the Forest Commission Visitors Survey Datasets (1995-2000).

Costs:

12 person months	=	£30,000

9.5.2.2 Landscape: For this category of benefits a further study aimed at investigating external landscape values from forests is recommended.

Landscape study 1: valuing external forest landscape types for the U.K..
Timescale: Short term.

Objective: Identify classes of representative forest external landscape points for England, Scotland and Wales and estimate public benefits from common external observation points (railways, motorways, scenic spots, etc.).

Rationale: To supplement existing knowledge on values for internal forest landscapes with information on the benefits of external landscape.

Approach: Forest landscape classification of major forest tracts and representative woodlands, followed by ad hoc conjoint analysis, contingent valuation study or valuation by panel of experts.

Output: Estimates of landscape values by category and observation points. Aggregate estimates over the U.K.

Costs:

12 person months	= £30,000
survey, sample size 400	= £ 7,000
various	= £ 3,000
Visibility census	=£5, 000
Total	£ **45,000**

9.5.2.3 Biodiversity study: the existing studies on the value of biodiversity of forests are mainly centered on coniferous forests. As biodiversity varies considerably with forest types, and people have shown to have strong preferences over them, it is recommended that a specific study be conducted to estimate biodiversity values and their reliability for total NMBs estimates.

Biodiversity values study 1: value of biodiversity for non-coniferous forest types
Timescale: Short/medium term.

Objective: To provide a measurement of the biodiversity benefits of non-commercial woodland to supplement existing information on the benefits of managing commercial plantations to improve biodiversity.

Rationale: The lack of any comprehensive study of the value of biodiversity in British forests is a problem for policy makers. In particular, the nature of non-commercial forestry means that its most important outputs are non-market goods such as biodiversity. This suggests the need for a thorough study to value the biodiversity benefits of non-commercial, and in particular native, woodland compared with conifer plantations. This will allow managers to assess the benefits of replanting or restoring areas of native woodland.

Biodiversity is a complex issue and particular strategies are required to provide robust benefit estimates. In particular, there is little to be gained in asking the general public to value the more esoteric species found in forests. Similarly, conventional economic techniques are not well-suited to estimating the costs of irreversible damage to biodiversity so the study should concentrate on public WTP to increase or maintain levels of biodiversity.

Approach:
The first stage will therefore concentrate on understanding what is required if the public is to place reliable and robust values on particular 'headline' species or on generic indicators of biodiversity. This would be achieved using a series of at least four focus groups carried out in different areas of the U.K. and covering different levels of interest and understanding across the general public.

Based on the findings of Stage 1, the second phase of the study would develop scenarios depicting a number of alternative biodiversity standards that have to be compared and valued, each with different combinations and quantities of flora and fauna. The standards would reflect the actual choices that managers face in terms of planting decisions. A choice experiment approach could then be adopted to value the various management standards. In each choice experiment respondents in a national survey of 800 individuals would be faced with choosing between two alternative FC management configurations. These configurations would differ in terms of the quantity of different biodiversity standards offered across the U.K. (e.g. area of replanted/restored native woodland; area of commercial plantation; open areas and heathland; areas of amenity/recreational forestry; etc.) and the cost to taxpayers. The quantities used to define the configurations would reflect current and possible future states of forestry in the U.K.: these would be determined in consultation with the FC. Modeling respondent choices would reveal their WTP for the various biodiversity standards.

Output: Transferable total and marginal benefit estimates for areas of forestry under particular biodiversity standards.

Costs:

12 person months	=	£30,000
4 focus groups (national level)	=	£2,400
National in-person survey of 800 households	=	£24,000
Total		**£56,400**

9.5.2.4 Carbon sequestration study: although good carbon sequestration value estimates exist, these can be improved and refined for the purpose of total value estimation of NMBs from forestry.

Carbon sequestration study 1: assessment of carbon storage and its variations
Timescale: Short term.

Objective: To assess more accurately the amount of carbon in the total stock; and also to assess how this is changing with rotation, and forest restructuring i.e. to estimate marginal changes.

Rationale: There is a specific need for deriving carbon sequestration values to take into account more accurately the distribution of tree species, and potential changes future species mix as forests age and are replanted or diversified in the interests of biodiversity and recreational values.

Approach: The methodology presented by Bateman and Lovett (2000) could be applied to produce estimates to assess the NMBs of afforestation and planting at new sites. This involves developing a spatially referenced model at a km^2 level that will estimate for different species mix

1. timber yield of live wood
2. carbon liberation from wood products
3. carbon flux in soils
4. forest restructuring
5. discount rate and net present values of carbon sequestration

Output: A set of tables of net present value estimates for each major species, by yield classes cross-tabulated by discount rates. This would permit a direct estimation of the total value of the FE estate; and provide forest managers with set of values for carbon sequestration that would document the consequences of different forest design strategies.

Cost: This project would take about 15 man-months of work to complete. It is comprised almost exclusively of labour costs integrating existing data and estimating the various models to derive spatial variations in the value of carbon sequestration, and the total value of carbon sequestration for the FE estate. Estimated cost *circa* £37,500.

Costs**:**

15 person months (approx.)	=	£37,500
Total		**£37,500**

9.5.2.4: Aggregation study: although an aggregate value for NMBs for woodland as a whole can be derived, such an estimate could be improved by ensuring aggregation takes into account a distance decay effect where appropriate, and by avoiding double counting of NMBs.

Aggregation study 1: assessment of distance decay effects for local public goods

Timescale: medium term.

Objectives: To test the accuracy and robustness of aggregation procedures over space as little is known about the distribution of consumer surplus and WTP values for NMBs of 'local public goods' such as recreation.

Rationale: Inappropriate aggregation of local public good NMBs is likely to lead to the over-estimation of total NMB values of forests. It is thus important to derive accurate aggregate estimates of NMBs, especially where substitution and embedding effects are strong, and there are distance decay effects. However, data for assessing distance decay effects in aggregation should come from new recreational benefit models of forestry. Hence, these projects are precursors to this one.

Approach: The project should explore the effect of different procedures for aggregating data, on the total aggregation estimates. Existing data can be used on this project, namely data from the Census of Population and WTP data from the project assessing the recreational value of forests. The increased information base obtained by using GIS can be put to good use here in order to estimate distance decay functions in zonal travel cost models which also account for other benefits, such as landscape effects.

Output: A recommended procedure for aggregating local public good NMBs subject to distance decay effects.

Costs (based on existing datasets)**:**

4 person months	=	£10,000
		£10,000

Aggregation study 2: aggregation of NMB estimates for all NMBs

Timescale: medium to long term.

Objectives: To provide an overall total estimate of NMBs of woodland and document spatial variations in its value.

Rationale: For the purpose of justifying public expenditure support to managing agencies and to look a distributional effects of the spending.

Approach: Bateman et al. (forthcoming) present a study estimating the most of the net benefits of forestry for Wales, and they outline an approach which could be improved and adopted to address this issue. Based on a flexible computerised model, the study considers some of the major market and non-market benefits and costs of forestry including those related to timber, recreation, carbon sequestration and the opportunity cost of forestry, which in the study area is typically agriculture.

Such a project to estimate the net aggregate NMBs for the entire FE estate would be relatively expensive. It would still largely employ existing data sets, e.g. from the ITE and the FC, but it would be dependent upon deriving accurate estimates of the recreational value of the FE estate throughout Britain.

Output: Specifically it permits common unit incorporation of a wider set of market and non-market benefits and costs than typically included (although this is not fully inclusive: landscape amenity and biodiversity values being notable omissions). The spatial distribution and diminishing marginal nature of values can also be addressed.

Costs (based on existing datasets)**:**

18 person months	=	£45,000
		£45,000

9.6: Directions for Future Research

The recommendations made above should provide the FC with a valuable research direction for the next five years. Following this, it would be logical to extend the trajectory suggested in this report by implementing large scale recreational surveys in England and Wales to supplement those already conducted in Scotland and Northern Ireland. This would permit any advances made from these proposed studies to be drawn upon, while allowing any innovative new research methodologies, that have been developed in the interim, to be applied to the new datasets. The resulting datasets and estimates of NMBs should provide the FC with a fund of useful information upon which to develop their funding strategies beyond the current seven-year lifespan of the Rural Development Plans for England, Scotland and Wales.

Some of the research avenues developed in this report have the potential to interest the academic community at large. For this reason, whenever deemed appropriate external funding should be sought from research councils and other funding bodies such as the EU.

WORK PROGRAMME

TASK	OPTION			COMMENTS
	1	2	3	
DEVELOP THEORETICALLY VALID METHODOLOGY				
IDENTIFY RELEVANT FOREST TYPES AND THEIR CHARACTERISTIC NON-MARKET PRODUCTS				RANGE OF FOREST TYPES AGREED WITH STEERING GROUP
RE-ANALYSE EXISTING DATA AND REFINE MODELS				
DEVELOP BENEFIT TRANSFER MODELS				THIS MAY INVOLVE DEVELOPING A NESTED SERIES OF MODELS. E.G. ONE FOR FOREST OR LANDSCAPE TYPE
IDENTIFY GAPS/PROBLEMS IN DATA				FOR EXAMPLE, WHERE NO DATA EXISTS OR PREVIOUS ESTIMATES UNSUITABLE
INITIATE NEW SURVEYS TO SOLVE GAPS/ PROBLEMS				FOR EXAMPLE, TO ESTABLISH EXTERNAL LANDSCAPE/BIODIVERSITY VALUES FOR NATIVE FORESTS
ANALYSE NEW DATA AND DEVELOP MODELS				
PREDICT VALUES AND LEVEL OF CONFIDENCE				IT MAY NOT BE POSSIBLE TO EXPRESS CONFIDENCE IN STATISTICAL TERMS BUT SOME ASSESSMENT OF RELIABILITY WILL BE GIVEN
CHECK PREDICTED VALUES MATCH THEORETICAL EXPECTATIONS / VALIDATION CHECKS				VALIDATION WILL INCLUDE CROSS-CHECKING WITH PREVIOUS STUDIES AND INTERNAL VALIDATION TESTS
CARRY OUT SMALL SCALE VALIDATION SURVEYS				
CHECK PREDICTED VALUES MATCH SURVEY ESTIMATES				

RE-ESTIMATE VALUES AND LEVEL OF CONFIDENCE				
REPORT FINDINGS AND ESTIMATES				

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APPENDICES

Appendix 2.1: Dose-response or opportunity cost method of estimating the value of conserving the northern spotted owl

Appendix 2.2: Brief for Spadeadam Design Plan within Kielder FD

Appendix 2.1

Dose-response or opportunity cost method of estimating the value of conserving the northern spotted owl

The opportunity cost of preserving the northern spotted owl, which inhabits old growth redwood forests in the northern California, Oregon, Washington, British Columbia, can be related to the opportunity value of timber forgone. One pair of spotted owls requires at least 3,000 acres of old growth forest for their survival. The total size of old growth forest to conserve in aggregate, depends upon the desired probability of species preservation. This can be modelled in terms of a probabilistic supply of the form:

$$S(C) = Prob[Y(T_0) > Y_{min} \mid C]$$

where C = quantity of protected habitat to protect, in terms of species numbers; $Y(T)$ = population size at T the chosen time horizon; Y_{min} = a chosen minimum population size. The estimated cost of biodiversity or species protection is thus dependent upon the choice of T and Y_{min}. Each habitat area can be characterised by its potential contribution to species habitat capacity, c_i, and by its potential contribution to an annual public timber stumpage supply, q_i. The ratio q_i/c_i gives the physical price per ‘owl’ associated with that habitat tract. Y_{min} was assumed to be 500 pairs (biologists believe the survival rate would be zero for less than 500 birds over 150 years). Survival probability simulation models and stumpage supply reduction in critical habitat areas indicates that for the US Department of Interior’s recovery plan of 1,600 owl pairs, (designed to ensure an estimated 82% chance of survival), the welfare loss in foregone timber products would be $21 billion, with a marginal cost per unit of probability of $0.6 billion. Increasing habitat capacity to 1,900 pairs increases the chance of survival to 91%, at a cost of $33 billion, and a marginal cost of $1.4 billion per unit of probability; whilst increasing numbers to 2,400 pairs increases survival probability to 0.95, at a cost of $46 billion, and a marginal cost of $3.8 billion per unit of probability (e.g. to increase the chance of survival from 94% to 95%). A decision can then be taken about whether it is worth $12 billion to increase the chance of the owl’s survival from 82% to 91% and whether it is worth an additional $13 billion to increase the chance of its survival from 91% to 95%.

Appendix 2.2

Brief for Spadeadam Design Plan within Kielder FD

The strongest influences on the future management of Spadeadam Forest are the Border Mire and the restrictions on public access necessitated by the presence of the RAF (see strategic plan under Kielder main block). This means that the main objectives of management are timber production and nature conservation. Landscape and 'people' sensitivities are very low, and are not likely to change for the duration of this plan.

Economic Issues

- Felling plans should aim for a sustained production of about 20,000 tonnes p.a.
- Restocking should focus on the most productive species while delivering the conservation objectives outlined below

Social Issues

- This is a flat, rolling, large-scale landscape with few external viewpoints. Coupes should be smooth, rounded shapes and should average 30 ha but may go as high as 90 ha where landform and site conditions are appropriate
- SAM plans to be followed

Environmental Issues

- The sites of specific conservation interest tend to focus on wetlands and surrounding habitats. The Waterhead area is of special interest for deer management research, and specialist advice should be sought on proposals for this area. Refer to SSSI management plans.
- The remainder of the area is designated as a red squirrel protection area, and management should aim to ensure that:
- large seeded broadleaves are kept out of the forest
- the age class structure at any time is roughly 30% age 0-15; 30% age 15-30; and 40% older than 30
- seed producing areas are connected by continuous areas of trees older than 15

Other

- Restocking plans should favour SS, with LP on the wetter peats. Opportunities should be sought for incorporating NS on better sites. Species proportions should aim for 55% SS; 15% LP; 2% NS; 5% BL; and 22% open space
- There is little scope for thinning or continuous cover management due to the very wet soils and high windthrow hazard

Consultation

- RAF and Cumbria Wildlife Trust to be invited to discuss concept and approve final plan. Residents of Greenhead to be asked whether they want to be involved, and at what stage.

Source: Forestry Commission (1998).

Glossary and abbreviations

Attributising: finding a way to represent forest attributes that is practical and meaningful in applied economic modelling.

Choice experiment (C.E.): method of inference of economic preference based on an experimentally designed set of hypothetical choices.

Contingent valuation (C.V.): method of inference of economic preference based on hypothetical choices in contingent (simulated) markets.

NMBs : Non-market benefits are benefits from an economic activity that do not accrue to the person or firm controlling that activity. These benefits accrue to the general public, and people cannot normally be charged for their individual consumption of these goods. A NMB is an effect on production or welfare that is not priced through the market

Reliability (of benefit transfer): property of a benefit estimate or of a benefit estimation method obtained on the basis of choices collected on study sites to accurately predict the benefit values in the policy site(s).

Revealed preference (S.P.): economic preference inferred from observed economic choices.

Robustness: property of estimated value or results which is shown when the value or results does not show sensitivity on the assumptions employed in its derivation.

Stated preference (S.P.): economic preference inferred from statements about intended behaviour on economic choices.

Substitutes: set of alternatives with the ability to satisfy the same economic preference.

Validation: process by which estimates of economic parameters (i.e. value of benefits) obtained by stated intentions are supported by alternative estimates from revealed preference.