The Economic Contribution of the Public Forest Estate in England

For Forestry Commission England

11 January 2010

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Acknowledgements

The study team would like to thank Tayo Adebowale, Hilary Allison, Tanya Arkle, William Armitage, Mark Broadmeadow, Rob Cooke, Lynn Crowe, Pauline Dear, Dominic Driver, Gillian Diggins, Simon Gillam, Stuart Goodall, Lesley Halsall, David Harris, David Hunter, Martin Key, Brian Mahony, Jennifer McVey, Nick Phillips, Pat Snowdon, John Tewson, Sheila Ward, Joe Watts, Mike Wood.

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Executive Summary

This report sets out the methodology and findings from research aiming "to use economic valuation techniques to analyse the social, economic, and environmental contribution to public benefit of the Public Forest Estate (PFE) managed by the Forestry Commission (FC) in England and identify ways of increasing this contribution".

In executing this remit the report proposes a simplifying typology of English woods and forests based on five characteristics:

- Forest/woodland ecology
  - broadleaved/mixed
  - coniferous
  - open habitat
- Proximity to users
  - urban community woodland
  - peri-urban
  - rural
- Management
  - low intensity
  - primarily for timber
  - multiple objectives
- Access
  - no public access
  - encouraged, low facilities
  - encouraged, high facilities
- Biodiversity
  - BAP priority
  - non-BAP priority

There are 88 feasible combinations of these characteristics, and for each of these, basic estimates are made of the costs of management and the ecosystem services provided, on a per hectare basis, based on a review of evidence on ecosystem service values and management costs for English forestry.

An evaluation framework is developed for applying the typology and the cost and value assumptions to the appraisal of possible futures for the Public Forest Estate; this framework could also be applied to English woodlands more generally but this is not attempted here.

Results are presented for several scenarios for the Public Forest Estate. All the scenarios are over-simplifications of a very complex situation, and are designed only to be indicative of possible value changes under different general approaches to managing the Public Forest Estate.

- the present (maintain Public Forest Estate as it is);

- future as currently planned;

- the recent past (prior to emphasis on community woodlands and recreation facilities);
- recreation focus (more community woodlands and recreation facilities);
- Habitat Action Plan focus, with emphasis on open habitats creation within the PFE;
- focus on restoration of Plantations on Ancient Woodland Sites (PAWS); and
- timber production focus.

Under the assumptions used in this report, the main sources of value from the forest estate are recreation, greenhouse gas regulation and aesthetic value. Overall, benefits are an order of magnitude greater than costs, in all scenarios.

The best performing scenario under economic valuation is “recreation focus” which achieves high values due to the aesthetic and recreational importance of urban community woodlands, and the recreation benefits of woodlands with significant investments in leisure facilities due to the number of visitors. Recreation on the PFE is estimated to be have an economic valuation of around £160m per year at present (working out at an average value of £4 per visit) and this rises to around £260m per year under the recreation focus scenario.

Not surprisingly, the timber focus scenario performs well on timber values (but these are a relatively minor part of total economic values); it also performs well on greenhouse gas regulation, because under this scenario there is no restoration of PAWS or creation of open habitats, both of which lead to reduced rates of carbon sequestration and substitution. However the losses in recreation and aesthetic values overshadow the gains.

The two conservation-oriented scenarios – PAWS restoration and (especially) open habitats restoration - suffer significantly from a decline in greenhouse gas sequestration and substitution, through the reduction in tree cover, or growth and harvest. Using the values and assumptions in this model, this makes these scenarios look non-beneficial. However there is great uncertainty about the biodiversity values used. In addition there are many ways of improving woodland biodiversity through altered management practices that we have not been able to incorporate in the model framework. Therefore the results can not be interpreted as suggesting that biodiversity conservation in woodlands is not cost-beneficial. However it is reasonable to conclude that there is a trade-off between open habitat restoration to meet Habitat Action Plan targets, and the carbon sequestration service of forest areas.

is important to note that the trade-offs identified relate to scenarios representing strategies for the form and management of the entire PFE, and not to the management of any individual woodland. A large proportion of the estimated value changes, including for greenhouse gases, derive from assumed changes in the ecological portfolio (proportions of broadleaved/mixed, conifer, open habitat) and to some extent location (notably the recreation focus, which involves more urban community woodlands that are assumed to sequester less carbon), and not to any major extent from changes in management practices.

The scenarios are not mutually exclusive but rather aim to give an indication of the costs and benefits arising under different broad themes for the development of the Public Forest Estate. It would be possible to construct other scenarios combining elements of all those modelled here. Investments in recreation facilities and urban woodlands could take place alongside open habitats creation and PAWS restoration, and some rural areas might be kept in high timber production.

Specific possible futures could be modelled and tested to find “optimal” solutions for social value arising from the PFE, but this would require more detailed data and a spatial framework for analysis.

PART 1: Introduction, Results and Policy Implications

1. Introduction

1.1 Purpose

The key objective of this research is "use economic valuation techniques to analyse the social, economic, and environmental contribution to social welfare of the Public Forest Estate managed by the Forestry Commission (FC) in England and identify ways of increasing this contribution". Steps towards this goal identified in the terms of reference included:

- Review existing studies and methodologies for valuing marketed and non-marketed goods and services from woodland areas;
- Estimate changes in values over time;
- Compare the values provided by the Public Forest Estate with those from private forests; and
- Examine the implications of policy scenarios.

This report:

- sets out the framework that explains a proposed typology of English woods and forests;
- presents a review of evidence on ecosystem service values and management costs for English forestry; and
- develops the evaluation framework for carrying out appraisal of forestry's contribution to social welfare, and of options for enhancing value.

1.2 Overview of issues

There are approximately 1,128,000 ha of woodlands in England, most of it broadleaves mainly held in the private sector. The Public Forest Estate (PFE) managed by the FC, includes 201,000 ha of woodland (mostly conifers, but with substantial areas of broadleaves) and 57,000 ha of other land either within woodlands or as part of large scale areas of non-wooded habitat. The defining characteristics of the PFE are that it is:

- managed for multiple objectives (including timber, recreation and biodiversity conservation motives). This is in contrast to *some* non-FC woodlands many of which are under very little management, although many other forest owners do manage under multiple objectives;
- covered by long-term Forest Design Plans developed through a multi-factorial consideration of the potential for public benefit and wide ranging consultation;

- independently certified through the UK Woodland Assurance Standard (UKWAS). UKWAS is a voluntary audit protocol that gives access to the international certification schemes. All of the PFE in England is currently certified to the FSC (Forest Stewardship Council) certification scheme. For non-FC woodlands in England, 16% or 139,000ha are similarly certified. This includes all National Trust and Woodland Trust holdings. In all woodland, forest management has to comply with the UK Forestry Standard (the Government standard for sustainable forestry); this is a condition of receiving a licence for the operations, as well as for any grant-aid from the Forestry Commission;

- typically much larger woodlands: almost 150ha on average, compared to approximately 14ha for other ownership (National Inventory, 2001; note that these are figures only for woods over 2ha, and almost 75% of woods are under 2ha)

- much more likely to be accessible to the public: the PFE represents about 18% of woodlands in England, but about 44% of the accessible woodland in England is managed by the FC. Access is encouraged (except on some leasehold land where the lease restricts access) and various levels of facilities are provided on many sites;

- consistent with the above points, the FC makes significant expenditures and investments that may not be incurred by *some* other woodland owners, for example those who do not encourage public access or who do not manage actively.

Given these differences, it is of interest to ask "what is the value added of FC management?" and "how might this be enhanced?". The FC incurs additional costs to yield enhanced non-market benefits, compared with hands-off management, or a purely commercial approach to forestry. Non-market benefits of forestry include biodiversity conservation, greenhouse gas regulation, water regulation and purification, aesthetic and recreational values, and so on. The assessment aims to consider the value of benefits generated by timber and by non-marketed products and services alongside the additional costs.

It is important to note that many of the products and services are also provided by woodlands in other ownership. To a greater or lesser extent these benefits are dependent on management practices, and any differences in values of the products and services are the result of forest structure and management, not of ownership per se. Other landowners who manage for multiple objectives, encourage access, and so on, will also create significant product and service values. However there may also be significant value associated with public trust, security, and accountability – value associated with the FC "brand", and with some other organisations (for example National Trust, Woodland Trust). These values are not reflected directly in this report but further research here may be warranted. There are also values associated with the advantages of single ownership/management, such as ability to adopt a strategic approach to forest planning and risk management at a wide geographical scale – these values are not reflected directly here, but are inherent in the discussion of strategic scenarios for management of the PFE.

1.3 Report Structure

This report is structured to provide firstly the main conclusions of policy interest, followed by details of the methods and calculations underlying the results. More general theoretical information is presented in an annex.

- PART 1 provides the analysis, results and policy conclusions:
    - This introductory section provides brief details of the background to the research, the structure of the report, and a sketch outline of the methods that are discussed in more detail in sections 5 to 7;
    - Section 2 describes the scenarios assessed for the PFE, the assumptions underlying them, and the results of applying the valuation framework and typology;
    - Section 3 presents four case studies illustrating further potential for applying the methodology in different contexts;
    - Section 4 discusses the results, the strengths and weaknesses of the methodology, and the conclusions for policy and future research.
- PART 2 presents in more detail the assumptions and methods underlying the valuation framework:
    - Section 5 describes the development of a forest typology, including data availability and the process of attribute selection leading to the framework providing the basis for valuation work;
    - Section 6 reviews the methodology and sources for determining the costs associated with various approaches to forest management;
    - Section 7 discusses the ecosystem goods and services of the Public Forest Estate, and of other English woods and forests, and presents methods and evidence for measuring the total economic value of these benefits.
- ANNEX 1 briefly presents the theoretical background for economic valuation of environmental goods and services and the incorporation of valuation evidence in appraisal frameworks.

1.4 Sketch of the methods used

The full discussion of methods is presented in Sections 5 to 7 below. However understanding of the results presented in Part 1 of the report will be facilitated by the following brief outline.

The basic approach is to consider the PFE as composed of areas of specific 'types' of woodland. Each type of woodland is associated with particular costs of management, and particular benefits to society. The woodland typology has been developed in order to strike a balance between accurate reflection of different kinds of woodland area, and manageability of the resulting matrix of forest types, costs and benefits. The typology adopted represents woodland areas via five key characteristics, as shown in Table 1; the rationale behind this framework is presented in Section 5.

Table 1: Short-list Woodland Typology

Attribute	Indicator
Forest / Woodland Ecology	Broadleaved/Mixed Coniferous Open habitat
Proximity to users	Urban community Peri-urban Rural
Management	Low intensity management Managed primarily for timber Managed for multiple objectives
Access	No public access Access encouraged with low level of facilities Access encouraged with high level of facilities
Biodiversity	BAP priority habitat Not BAP priority habitat

The management costs per hectare associated with each type are estimated as explained in Section 6, based on assessment of actual costs for the current estate. The cost categories are:

- Land management: costs of forestry operations;
- Access provision: costs associated with providing access and facilities for recreation;
- Conservation and heritage: costs relating to biodiversity protection and other natural or human heritage conservation; and
- Community engagement: costs associated with consultation and community involvement in woodland management.

Benefits per hectare are estimated as explained in Section 7. The service categories for which benefits are estimated are:

- Timber/fuelwood: the main tangible good provided by forests and woodlands, valued at market prices;
- Greenhouse gas regulation: an important regulating service contributing to the combat against climate change, valued at official government values;

- Recreation: a key public use of woodland areas, valued based on review of values from travel cost studies and some stated preference studies;
- Aesthetic values: the visual impact of woodland areas, valued based on previous studies using hedonic or stated preference methods; and
- Biodiversity: valued very approximately based on literature values, but with the weakness that we can not clearly link different forest “types” to defined biodiversity outcomes.

We do not separately consider employment in forestry or associated industries such as forest tourism or timber processing. Timber production plays a small but significant role in supporting jobs in rural areas, with approximately 42,000 jobs in forestry and primary wood processing in the UK overall (Forestry Commission 2009). Visitor facilities and the resulting tourism revenues also support employment, both directly and indirectly (for example local restaurants and shops). These are important impacts from a social policy perspective, but insofar as an economic analysis is concerned, employment is not directly a benefit but rather a cost (the cost of labour), although where unemployment is significant the economic cost of labour may be much lower than the financial cost (because the “alternative use” of the labour is unemployment). Similarly, expenditure within local communities is important for those communities, but from a national perspective largely represents transfer from other expenditures in other areas

The framework is applied to scenarios for the PFE, by estimating the areas of each woodland type present within each scenario, and multiplying the areas of each type by the associated costs and benefits per hectare. This is done in two related ways:

- a comparative static calculation, looking at value flows within a single future year for the PFE in different configurations; and
- a calculation of net present value, based on assumptions about the evolution of the PFE from today’s status to a future equilibrium.

This approach gives a reasonable approximation of the magnitude of costs and benefits to be expected under different strategies for the PFE. It is however very broad brush, in particular because it does not consider details of the spatial configuration of the estate. This is a particular weakness for recreation values, which are not well reflected by per-hectare calculations, although steps have been taken to minimise the problem (see below). Spatial modelling would be more complex but essentially feasible within a Geographic Information System (GIS) framework. This could draw on work being undertaken elsewhere to analyse the characteristics of the PFE landholding, “portfolio analysis”.

2. Scenarios

The scenarios assessed are intended to cover the key management issues being examined with respect to the management of the estate. The scenarios are evaluated independently and compared against a baseline: this is either the current situation or the future as currently planned, depending on the context. Alternative baselines are discussed in the Annex.

Scenarios:

I. Present (*status quo*): maintain Public Forest Estate as it is.

II. Future as planned: based on the figures supplied from the current set of Forest Design Plans.

III. The Recent Past: prior to emphasis on community woodlands and recreation facilities.

IV. Recreation focused: alternative to III with enhanced emphasis on providing recreation and other services to the general public.

V. HAP focus: alternative to III with enhanced emphasis on conversion to open habitats

VI. PAWS focus: alternative to III with enhanced emphasis on restoration of PAWS.

VII. Timber focused: alternative to III with emphasis on timber production and revenues.

2.1 Scenarios

The seven scenarios are intended to demonstrate possible configurations for the PFE: recent past, present, and five possible futures.

Although the costs and benefits of different forestry scenarios will change along with global change and population change, we have not directly accounted for this. The values are in any case uncertain approximations and attempting to make ad hoc adjustments for changed costs or benefits would not be justified at this level of analysis.

The starting point for developing the scenarios is the current configuration of the PFE, and existing plans for its evolution. However we have some variability of data on the precise breakdown of PFE land from official statistics and from planning documents, and need to make adjustments in order to compare like with like and ensure that the same definitions are used across all scenarios, as well as assumptions about how to match data categories to the typology and how to deal with uncertain cases. The figures used here for “present” and in particular “past” are therefore slightly different from those in official statistics for any particular year. The purpose of all the scenarios is to represent the key features of general themes or patterns for managing the PFE, and not to make a specific valuation for a particular year.

Figure 1 shows the current and planned composition of basic forest types for the PFE. It is necessary to adjust for the category "other" (which in the original data is composed of two categories, "other" and "insufficient data"). By and large these categories relate to areas that are earmarked for natural succession, where it is not yet clear what they will become. Although we could simply omit these uncertain areas from the analysis, this would cause a problem in comparing performance across years, which would not then be on a basis of a consistent number of hectares: the area of "other" more than doubles over the period of the plan. The solution adopted is to split the "other" area across the three modelled categories – open, coniferous and broadleaved – in proportion to their areas. At the same time, we make a slight adjustment so that the total areas remain constant over the life of the plan – this is to ensure we compare like with like, and because we do not consider any costs for land purchase or revenues from sales. The adjusted areas are presented in Table 2.

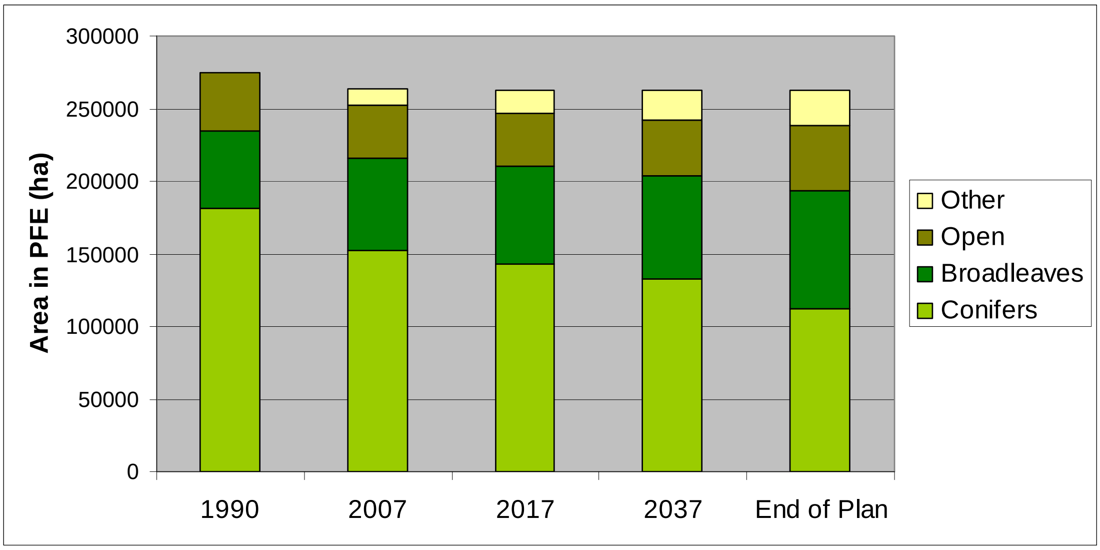


Figure 1: Areas of basic types in PFE: past, current and planned (from FC data).

Table 2: Adjusted areas of basic forest types, 1990 to End of Plan

Adjusted areas (ha)	Open	Coniferous	Broadleaved	Total
1990	38,158	172,665	51,513	262337
2007	37,662	158,773	65,902	262337
2017	39,306	151,528	71,503	262337
2037	41,108	144,139	77,091	262337
End of Plan	49,173	123,417	89,747	262337

Scenario I: Present (Status Quo)

This scenario examines the status quo management of the public forest estate, and assumes this management continues into the future. In the current calculations, this is used as the base case for comparison. For the status quo scenario, we take the areas from 2007, adjusted as discussed above.

This gives only one characteristic from the typology, the basic ecology type. It is then necessary to work out how these areas should be sub-divided across the remaining types. With few data on which to base calculations, this has inevitably involved many guesses and assumptions. These are set out below.

Management: : we have assumed that all PFE is currently managed under multiple objectives. This reflects: the FC approach; the Delivery Plan for the Strategy for England's Trees, Woods and Forests (ETWF) with its five aims (sustainable resource, climate change, quality of life, business & markets, natural environment); and the FSC certification to UKWAS of the entire estate.

Proximity: we have data for the distance of FC woodland areas from large urban areas (defined as population 100,000 or more), approximately 4% of woodlands being within 500m of these areas, 40% within 10km and 56% beyond that. This gives us our working assumption for the urban / peri-urban / rural split; though it is noted that many urban woodlands are in smaller towns. Within these categories, we assume that the proportion of open habitats is constant across the proximity categories (≈14.4%), that urban woodlands are entirely composed of broadleaved/mixed and open habitats, and that the peri-urban woodlands are 50-50 conifer and broadleaved/mixed. The rural split is then determined so as to make the total areas add up within each category. These are crude assumptions that represent best working estimates on the basis of existing data without undertaking extensive additional analysis. The outcome is shown in Table 3.

Table 3: Assumed subdivision of ecology and proximity categories: 2010

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	1,506	0	8,987	10,493
Peri-urban	15,065	44,935	44,935	104,935
Rural	21,091	113,838	11,980	146,909
Total	37,662	158,773	65,902	262,337

Access: we have assumed that all PFE woodlands in the urban category have 100% access. We split the area of the estate without access evenly over the peri-urban and rural categories, with 17.4% of those areas not accessible. The urban woodlands are all assumed to be "low facilities" – although these woodlands are expensive to operate, they are not generally furnished with visitor centres, toilets and car parks, and they are not generally sites for whole day trips. We assume that there are approximately 50 sites in England that can be considered "high facilities" (see Figure 21) and that the majority of visitors to these sites stay within an area of about 500ha around the centre. We assume the total area of 25,000ha thereby considered "high facilities" divides evenly between rural and peri-urban sites.

Again, these are crude assumptions making best use of available data without attempting detailed spatial analysis of the PFE.

Biodiversity: from habitat reporting, we assume that approximately 60% of broadleaved woodland is priority native woodland as defined by the UK Biodiversity Action Plan. For open habitats, around 40% are priority habitats – mostly lowland heath, upland heath or blanket bog – however most of the remaining open habitat is listed as "unknown". It is also necessary to allow for some high biodiversity value in certain conifer areas, for example Thetford Forest, designated a Site of Specific Scientific Interest (SSSI). The very broad assumption we make is that 70% of broadleaved areas, 50% of open habitats, and 20% of coniferous areas, are of "high" biodiversity value. Although urban community woodlands are not likely to fall in the categories listed for the biodiversity criterion (see Section 5.7) nevertheless we assume the same split applies there, reflecting the particular importance of green space to urban biodiversity.

Making all the above assumptions allows us to split the total area of the estate into the types in the forest typology. As noted previously, the assumptions made are crude in many respects, due in part to a lack of detailed data on the make-up of the PFE, and largely to the inherent over-simplification involved in a typology that divides a very diverse range of real situations into a small number of idealised types. This will inevitably mean that the resulting value estimates are only gross approximations.

Scenario II: Future as planned

This scenario represents current plans for the evolution of the Public Estate, based on the figures supplied from the current set of Forest Design Plans: see Figure 1. The problem of the "other" category is resolved by splitting these areas proportionately across the other categories, as noted above.

The "End of Plan" is not a specific year, but rather a variable date depending on each particular piece of land and the time until the next end of rotation. By and large, it is reasonably representative to interpret the "End of Plan" figures as corresponding to the present vision of the PFE for 60 years hence. In the spreadsheet, we estimate areas for each type in the woodland typology for the years 2010, 2020, 2040 and 2070 (making the simplifying assumption that the figures available to for 2007, 2017... apply to 2010, 2020...). The results for the End of Plan (2070) are presented in Table 4 (for intermediate years, refer to spreadsheet).

Table 4: Assumed subdivision of ecology and proximity categories: 2070

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	1,967	0	8,527	10,493
Peri-urban	19,669	42,633	42,633	104,935
Rural	27,537	80,784	38,587	146,909
Total	49,173	123,417	89,747	262,337

The basic pattern in the scenario / plan is a big reduction in the area of conifers, from restructuring through normal restockings (more broadleaves and open space after harvest), and partly through restoration of PAWS to broadleaves, and partly through restoration/expansion of open habitats. Other than that, we assume no difference in the broad make-up of the estate, keeping the same assumptions as in Scenario 1 / Baseline regarding the urban/peri-urban/rural split, and so on. This may not be an accurate reflection of FC plans overall, and in particular we make no allowance for any land disposals or for land acquisition for new community woodlands. This is in order to continue comparing like with like in so far as the total area of the PFE is held constant across all the scenarios. We defer discussion of the question of creating additional community woodland until the policy conclusions.

There is a recommendation within the FC that areas being cleared of conifers for PAWS restoration should where ever possible be done by gradual thinning, retaining an element of conifers in the crop for many years. This is difficult to represent directly in the typology, since we have to determine if an area is “conifer” or “broadleaved/mixed”, and there is no space in the typology for the intermediate stages. However the effect is approximated by assuming a gradual (linear) change from the current areas to the future areas.

It is also noted that the average Yield Classes of conifer crops may be partly offset by increases in productivity, particularly in Sitka areas given improved planting stock and replacement of poor Lodgepole pine and other similar crops. This is not reflected in the model at present and so the timber performance may be slightly better than accounted for here.

Scenario III: The Recent Past

This scenario is designed to illustrate how the PFE in England has changed over the last 20 years. However, the total area of the PFE has declined somewhat (7% between 1988 and 2008), and in order to compare like with like, the areas have been adjusted proportionally in order to keep the same total area as the other scenarios

The main distinction between the past and the present scenarios is the absence of community woodlands, which are a more recent innovation on the PFE. There has been a significant increase in the availability of PFE woodlands within 500m, 4km and 10km of population centroids. Figure 2 shows this trend. The populations newly served by PFE woodlands are almost entirely in urban areas, and the increase is particularly marked for more socially deprived areas. More generally, major investments in recreation facilities, and an increasing focus on multiple-objective management, are both features of the last 20 years.

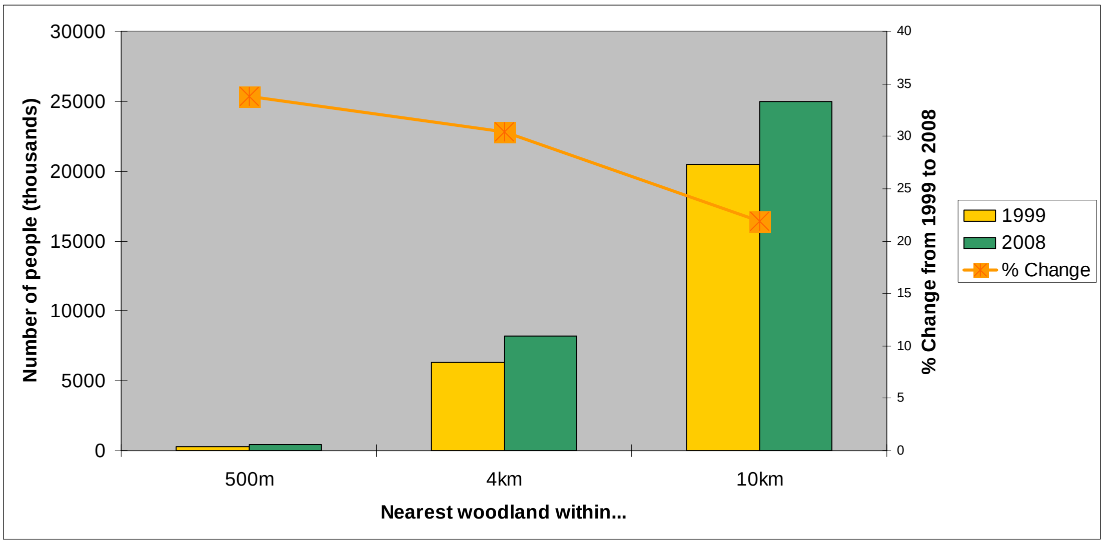


Figure 2: Change in populations "served" by PFE areas, 1999 to 2008.

Notes: all figures estimated from Census 2001. No allowance for population changes such as migration. Therefore, changes noted are due to the pattern of acquisitions and disposals. The figures for 2008 also reflect land "managed" by Forestry Commission but owned by others

The populations newly served by PFE woodlands (see Figure 2) are almost entirely in urban areas, and the increase is particularly marked for more socially deprived areas. There is a social value associated with this change that will not be reflected directly in the values used in this study, which are based on willingness to pay (WTP) and considered as averages across England. WTP based estimates would actually be lower in deprived areas (since WTP is constrained by ability to pay and hence strongly influenced by income). So a spatially disaggregated assessment of recreation and aesthetic values would give lower than average estimates in deprived areas; any social value or fairness considerations could in principle then be reflected via higher weights on the values of low-income households, though in practice cost-benefit analysis rarely includes distributional weights. But by applying a constant average value across England, we are in effect weighting lower-income values more highly than if we measured them directly, so the social benefit of providing facilities to deprived communities is reflected indirectly.

The total area of the PFE has changed slightly over the recent past, and we do not have any information relating to the opportunity cost of the land brought into the estate (nor in detail about the fate of land removed from it, though this was mostly rural conifer plantations, and we assume that these have not changed significantly in land-use under new ownership). Because the areas are different, the 'total values' for the past and present scenarios are not strictly comparable. The change is small (about 1.5% decline in total area) and in order to compare like with like we have scaled down all areas by the same proportion, to keep the total area the same as in the other scenarios. Again, the objective is not to derive an accurate estimate of values at a specific point 20 years ago, but rather to compare, on a consistent basis, the values associated with different possible general themes or forms for the PFE.

In estimating the areas and proportions, we make the following specific assumptions in adjusting the 'current' scenario to derive the 'recent past' scenarios:

- no urban community woodlands;
- no 'high' facility provision – there was of course a lot of access and recreation in FC forests 20 years ago, but for the purposes of argument we assume that the focus on providing 'high' facilities is a more recent innovation;
- general focus on timber production
- 36,158 ha of open habitats, 172,665 ha of conifers, and 51,513 ha of broadleaves
- woodlands (not including open habitat) in peri-urban areas were approximately half-and-half coniferous and broadleaved/mixed.

For comparison with the present and future scenarios (Table 3 and Table 4) the ecology and proximity distributions for the 'recent past' scenario are presented in Table 5.

Table 5: Ecology and proximity categories: Scenario III (adjusted areas)

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	0	0	0	0
Peri	14,560	42,771	42,771	100,103
Rural	23,598	129,894	8,742	162,234
Total	38,158	172,665	51,513	262,337

Note: as explained above, these are adjusted figures, to take account of the previous larger size of the PFE.

Scenario IV: Recreation-focused estate

This scenario aims to illustrate a possible recreation-focused future for the PFE. The development of the estate is guided by actions aiming to enhance social and rural development values. The main changes envisaged in this scenario relate to increased provision of recreational facilities compared with the current plans:

- Doubling of 'high' facilities forests in peri-urban and rural areas. We do not attempt directly to assess issues of additionality, but assume that it is possible to site new centres strategically in such a way as to maximise the additional catchment populations provided with high facility woodlands.
- Doubling of urban community woodlands; in order to keep total area constant, this is compensated by a small reduction in rural conifers.
- It must be noted that neither the cost of new (often brownfield) sites in urban areas, nor any proceeds from selling rural land, are considered in the scenario. The ecosystem services – notably greenhouse gas regulation –

associated with the land sold are no longer counted in the PFE value estimates. In reality the reduced rural conifer would still be rural conifer, but under different ownership. Hence the values associated with that land would continue. However, the focus of this study is the PFE and we do not consider these values (or associated management costs), just as we do not consider the opportunity costs of land brought in to the PFE.

- Increased investments in recreation will be direct sources of employment, and there will be indirect employment benefits associated with tourism spend in local economies. As noted elsewhere, we do not separately account for employment other than through the cost estimates, and we do not account for incidental expenditures beyond the value estimates for recreation. Although locally these could be important, on a national scale they are generally diversions from other expenditures; but a more detailed analysis would be required in order to take full account of these indirect effects.

The basic form of the PFE resulting from these assumptions is presented in Table 6

Table 6: Ecology and proximity categories: people-focused scenario, 2070

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	3,934	0	17,053	20,987
Peri-urban	19,669	42,633	42,633	104,935
Rural	25,570	75,014	35,831	136,415
Total	49,173	117,647	95,517	262,337

Note on conservation scenarios

Initially we had aimed to include a “biodiversity” scenario in which the estate develops towards even greater consideration for biodiversity within the PFE. Very broadly, there are three forms this could take:

- a move towards creating open habitats on the PFE (noting that this is a change in land-use, recorded as deforestation);
- a focus on native species and in particular on the restoration of PAWS (Plantations on Ancient Woodland Sites); and
- more general alterations in forestry practices aiming to ensure that these take opportunities to enhance biodiversity conservation where possible.

The first two categories can be represented within the forest typology because they involve changes in basic type, from coniferous to broadleaved or to open. The third however can not be captured in the typology other than through the management characteristic, but we have not included a specific “managed for biodiversity” category, including this under “multiple objectives” instead. All PFE woodlands, and any woodlands receiving public grants, must comply with the UK Forestry Standard, and in effect the simple model developed here assumes that multiple objectives management already includes a certain level of biodiversity-sensitive practices. However the model is not capable of distinguishing different levels of this.

Therefore it is not possible to present a single “biodiversity” scenario without risking misleading interpretations. Instead we have developed two narrower scenarios with a focus on two specific aspects of conservation. Scenario V examines a focus on Habitat Action Plans, via conversion of woodlands to open habitats, and Scenario VI focuses on restoration of Plantations on Ancient Woodland Sites (PAWS). It must be stressed that these scenarios, and conclusions arising from them, relate to those specific changes, and not to “biodiversity” overall.

Scenario V: Habitat Action Plan-focused estate

This scenario outlines a strategy maximising the conversion to open habitats within woodland areas, as one means of enhancing biodiversity values in the PFE.

Spencer and Edwards (2009) state that a further 54,674ha of plantation and woodland could be restored to open habitat, beyond what is currently planned. This covers 36,958ha of freehold land and 17,516ha of leasehold land. Subsequent analysis is focussed on the freehold land because of the constraints on most leasehold land. Of the potential habitat on the freehold areas of the estate, some 10% (c. 3,800) could probably be restored with little risk of adverse reaction from current public users of the Public Forest Estate. About 32% (some 11,800ha) would probably generate adverse reaction from users of the Public Forest Estate. Across the remaining 57% (c. 21,700ha in total) extensive restoration would probably not generate such significant adverse reaction (Spencer and Edwards 2009).

We assume for the open habitats focused scenario that an additional 25,000ha would be converted to open space – i.e. most of the area that could potentially be converted without significant adverse public reaction. One-off restoration costs are estimated at £1,350 per hectare (Spencer and Edwards 2009).

The main assumptions in this scenario are therefore:

- conversion of additional 25,000 ha of woodland habitat to a mix of high and low priority open habitats.
- these changes take place in peri-urban and rural areas only

Table 7: Ecology and proximity categories: HAP focus, 2070

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	1,967	0	8,527	10,493
Peri-urban	30,086	28,815	50,506	109,408
Rural	42,120	54,602	45,714	142,436
Total	74,173	83,417	104,747	262,337

Scenario VI: PAWS restoration

This scenario outlines a strategy maximising the restoration of PAWS: that is, a reduction in conifer area and the creation of high biodiversity value broadleaf areas. The main assumptions in this scenario are therefore:

- conversion of additional 15,000 ha of PAWS to broadleaves
- these changes take place in peri-urban and rural areas only

Table 8: Ecology and proximity categories: Plantations on ancient woodland site restoration focus, 2070

(areas in ha)	Open	Coniferous	Broadleaved	Total
Urban	1,967	0	8,527	10,493
Peri	30,086	28,815	50,506	109,408
Rural	42,120	54,602	45,714	142,436
Total	74,173	83,417	104,747	262,337

Scenario VII: Timber-focused estate

This scenario involves 'no frills' management, focusing on timber production and basic access and conservation, but without any of the additional biodiversity or public access investment that characterises the existing management of the public forest estate.

The assumptions made for this scenario are:

- no changes in habitat types: the planned increases in open habitat areas and in broadleaves do not occur;
- shift towards management primarily for timber on wooded habitats;
- open habitat switch to low intensity management;
- no provision of high facilities for access;
- these changes occur over a 30 year period.

Since there is no change in habitat types, the areas in this scenario remain the same as at present – see Table 3.

2.2 Results of Scenarios

The results of assessing these scenarios using the typology and valuation framework are show in Figure 3 and Figure 4, and Table 9, on the following pages. The figures are presented on the basis of an "equilibrium" estate: by this we mean that time has been allowed for the changes to work through fully, so that it is legitimate to consider averaged costs and benefits across the estate, as the model does. Although it is possible to use the model to produce net present value estimates, this is not advisable since we do not take account of land purchase costs or sale revenues, or of any other one-off costs (or revenues, e.g. from clear-felling) involved in transforming the estate from one pattern to a new one.

In other words, the results presented here compare the PFE in "condition A" against the PFE in "condition B", but do not consider the transitional costs of moving from one condition to the other. They do consider the ongoing annual costs of managing the estate in any given condition, as well as the annual flow of benefits.

The results presented here are undiscounted, that is they are "current values"[1] representing the flows in a particular year from the perspective of that year. This is an appropriate way in which to compare individual years; calculating a net present value would of course require discounting in order to add up across different years.

Figure 4 shows the proportional breakdown of costs and benefits across the PFE in the current year. This shows that the costs are quite a small fraction of the benefits – a little over 10% - when the non-market impacts are taken into account.

The timber benefits alone are less than 50% of the costs; allowing for a similar level of income from recreation and other sources, the model is suggesting that the PFE would fall a little short of breaking even under current conditions. Note that this is an output of this particular model, not a statement of fact.

The model suggests that the PFE provides non-market benefits an order of magnitude greater than the costs, providing a substantial subsidy to the nation in the form of non-market benefits, most notably recreation, which is the biggest single benefit at present, and greenhouse gas regulation, which is set to become the largest benefit sometime around 2030, not because of physical changes but because the official value of carbon (DECC 2009) rises steeply over time (to reflect the rising damage costs of emissions as atmospheric greenhouse gas concentrations increase). The substantial greenhouse gas regulation benefits arise both through direct absorption/sequestration of carbon by growing vegetation, and through substitution benefits when timber is harvested and used for buildings and products that would otherwise be produced with non-renewable and more energy intensive materials.

The results suggest that the recreation-focused strategy performs best: this is a direct result of the high values placed on recreation and to a lesser extent aesthetic value. Even if recreation values per hectare are cut by a factor of 5, however, this scenario stays on top.

The other key factor is greenhouse gas regulation, and the 'open habitats' scenario in particular show losses associated with reduced greenhouse gas absorption and substitution, due primarily to the increase in open habitat at the expense of

[1] "Current values" means that the values are not discounted and are therefore expressed from the perspective of the future year, and not as "present values" discounted back to today. Discounting is essential when summing up across years, but is not necessary for comparing outcomes within a single future year. Note that this has nothing to do with price levels or inflation – all the valuation is done at today's prices (values) unless there are good reasons to assume that relative prices will change. Similarly, discounting is for time preference, and has nothing to do with inflation.

wooded areas. This is particularly important later in the plans, as shown in the snapshot for 2070, because the official value for carbon rises substantially over time. The timber focused estate scenario is the only one to maintain greenhouse gas regulation values on the estate.

It is important to note that a large proportion of the value changes, including for greenhouse gases, derive from changes in the ecological portfolio (proportions of broadleaved/mixed, conifer, open habitat) and to some extent location (notably the recreation focus, which involves more urban community woodlands that are assumed to sequester less carbon), and not to any major extent from changes in management practices. Thus, the recreation scenario performs slightly less well on greenhouse gas regulation than the current plan because of the reduction of rural woodlands in favour of urban woodlands, and not because of any direct effect of providing access. The trade-offs identified relate to strategies for the form and management of the entire PFE, and not to the management of any individual woodland.

It should also be noted that these scenarios are not mutually exclusive – it would be perfectly possible to combine elements of the "recreation focused" scenario with both open habitats and PAWS restoration, for example, although there is evidence that open habitats can be less resilient to heavy recreation pressure than woodland. A detailed assessment of specific plans for all different parts of the PFE would be possible, though data intensive; the analysis here is at a much broader level seeking to show general tendencies arising from alternative themes for running the PFE.

2.3 Sensitivities

Of course the results presented here are entirely dependent on the assumptions used in deriving them. There are three main sources of uncertainty and possible error:

- Reducing the complex reality of all the different woodlands in the PFE to a simplifying typology involves errors in the determination of how much of each idealised type of forest is present in the PFE, and averaging errors in having to select single unit estimates to represent diverse situations covered within a type. These errors could be reduced by more detailed modelling of forest characteristics, ideally through spatially explicit models, and through using a greater number of types, but these options would also result in increased complexity.

- Errors in determining physical service estimates. Many of the services are rather uncertain, and the determination of physical unit values can be difficult. This means that some values have not been included at all, while others are very crude – biodiversity, in particular, is included only as "high" or "low" priority. Aesthetic values are not assessed in physical terms at all, but only through assumptions based on monetary valuation studies. This is also important for greenhouse gas regulation, since although there is quite detailed work on specific yield classes of specific forest types (ADAS 2009, Read et al 2009) the typology used here does not match exactly with the categories used in those sources, being at a more aggregated/averaged level. For recreation, the physical unit is visits and this is a key source of uncertainty, as discussed further below.

- Errors in monetary value estimates. The monetary values associated with cost estimates, timber and greenhouse gas regulation are the least uncertain, though they remain approximate averages within the typology. The aesthetic and in particular biodiversity values are even more uncertain, based on such valuation evidence as is available, but really no more than ballpark indications of possible values. Recreation values are also uncertain, as discussed below.

- Recreation values are derived from a large evidence base, but while there is good justification for the levels used, there is also significant uncertainty about unit values. In fact the uncertainty in recreation values arises from four sources: uncertainty about numbers of trips to sites, uncertainty about values per visit, and uncertainty about substitution effects, and errors involved in translating from visit "centres" to per hectare values. A key problem here is that we have not accounted fully for substitution effects when new facilities become available. The model is tuned to the assumed current level of visits, so this problem does not influence values for the current scenario, but is a potential problem for scenarios with different levels of provision, in particular the "recreation focus" scenario. The changes in recreation values between scenarios might be interpreted as maximum changes, and if there are significant substitution effects the changes in values would need to be scaled back appropriately. Although some level of scaling back is probably required, the results are robust to very significant changes – even with a five-fold reduction in additional recreation values the recreation-focused estate is easily the best performer, even ignoring the aesthetic benefits associated with investments in urban forests.

- Given the above points, it is very clear that the values presented here are only very approximate estimates. But even allowing for these uncertainties, the general thrust of the conclusions is unlikely to change. Taking into account non-market services, the benefits of woodlands are much greater than the costs of management, to the extent that this result is robust to significant scaling back of the benefits estimates. The general principles that greenhouse gas regulation and recreation are highly important services is also secure.

- However there remains significant uncertainty regarding biodiversity values in particular. It is possible that the "true" social value of the PFE's role in supporting biodiversity could be much greater. But as the typology is set up, this would not matter much, since in any case there is relatively little variation in biodiversity values across the scenarios. There is only a very simple distinction in the typology between "high" and "low" biodiversity priority types, and there are not enough hectares changing category to drive major difference in the scenarios. But further work here is clearly required.

- Aesthetic values are similarly uncertain, and also suffer from error in the conversion to per hectare values. For all the above issues, a major improvement could be achieved by implementation of a full spatial model, taking account of linear features, human population densities, and substitution effects. There will remain substantial uncertainty about the non-market values of biodiversity and aesthetics in particular, and although further studies could refine estimates, full and accurate valuation of these impacts may not be possible. Nevertheless, provided appropriate caveats are made, it remains preferable to attempt to derive best estimates of these important services, in order that their rough ranges of values can be considered alongside other benefits in evaluating policy options.

Table 9: Headline results of the scenarios: value flows (£million) for costs and benefits of the PFE in year 2070

SCENARIOS	STATUS QUO	CURRENT PLAN	PAST	RECREATION FOCUS	HABITATS ACTION PLANS	PAWS RESTORATION	TIMBER FOCUS
BENEFITS							
Timber/fuelwood	20	16	22	16	13	15	22
GHG regulation	298	257	315	247	216	243	298
Recreation	160	160	58	262	161	162	83
Aesthetic	90	90	32	131	90	91	53
Biodiversity	34.0	38.1	32.1	38.9	40.2	40.2	34.0
TOTAL BENEFITS	602	562	459	695	522	550	490
COSTS							
Land management	27	26	26	27	24	25	26
Access	8	8	1	14	8	8	1
Conservation and heritage	6	7	3	7	9	7	0
Community engagement	4	4	1	6	4	4	1
TOTAL COSTS	45	45	31	54	44	44	29
BENEFITS MINUS COSTS	557	517	428	642	477	506	461
DIFFERENCE IN BENEFITS		-40	-143	93	-80	-52	-112
DIFFERENCE IN COSTS		1	14	-8	1	1	16
DIFFERENCE IN NET VALUE		-40	-129	85	-79	-51	-96
Net value per ha (£/ha)	2,122	1,971	1,631	2,446	1,820	1,928	1,756
Change in net value (£/ha)		-151	-491	324	-302	-194	-366

Figure 3: Differences in benefits and costs in the year 2070, compared with the current plan for the future.

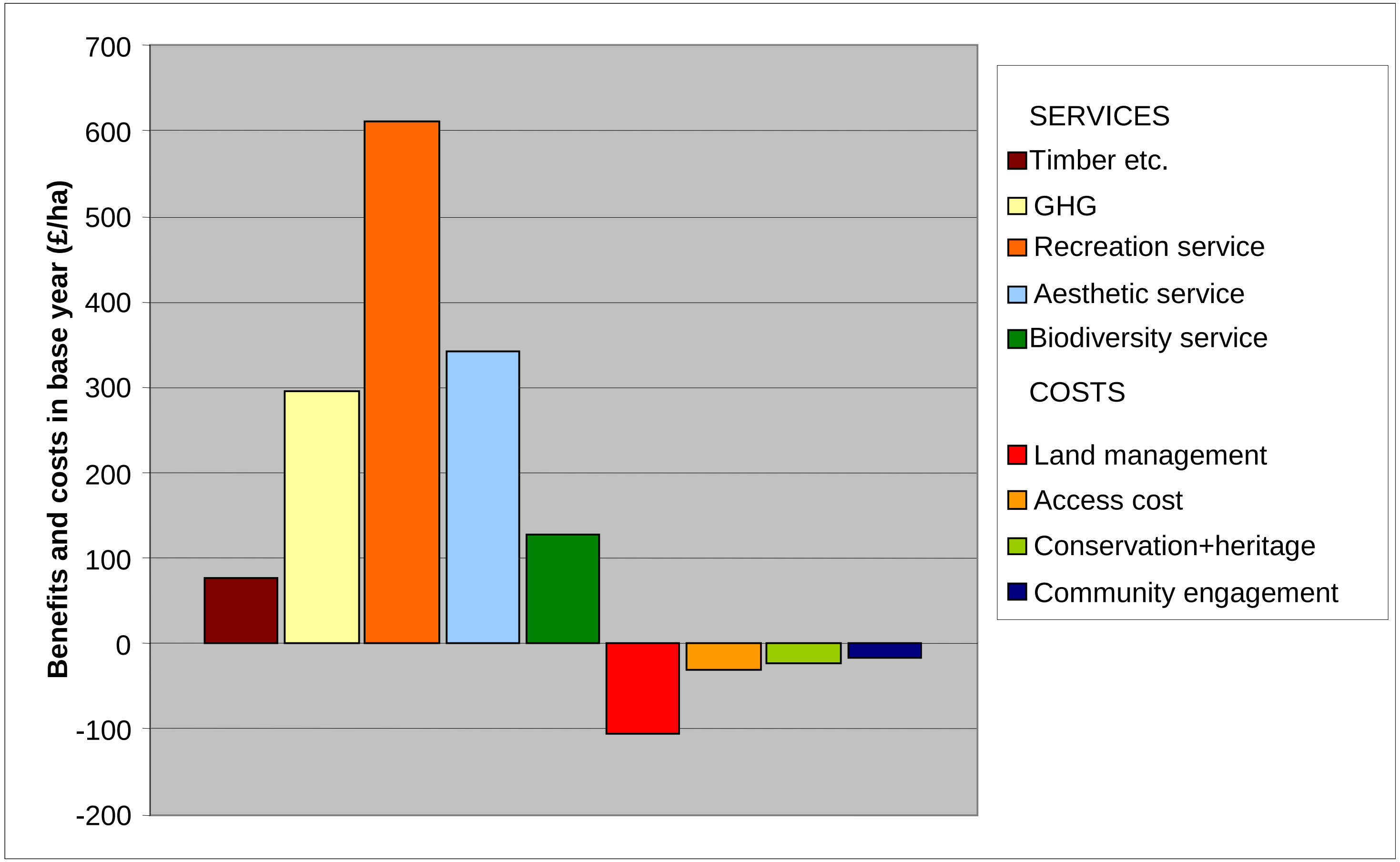


Figure 4: Breakdown of benefits and costs in current year of base case: average per hectare across PFE

3. Case Studies

As noted above, the application to the whole PFE is just one possible use of the framework developed. It can also be applied at other scales, for example to all English woodlands, or to specific individual woodlands or forest sites. The framework is not limited to the PFE.

In any specific case, of course, there may be arguments for modifying particular cost or value estimates to reflect local conditions. Indeed, the application of the model to individual case studies highlights that local conditions are likely to be very important; the model used at a local scale can only be a first broad-brush attempt at assessment, but may prove useful in flagging likely outcomes and areas for deeper analysis. At the national or regional scale, these local peculiarities tend to average out and the application of a broad-brush model is more robust.

The case studies presented in this Section illustrate the application to specific areas. The case studies are:

A. Kemphill Moor Copse: example of private woodland management.

B. Mersey Forest: an urban-edge regeneration.

C. High Lodge Visitor Centre: a major recreation site

D. Wild Ennerdale: a remote high-biodiversity-value site

Each of these is described briefly below. It must be stressed that these case studies have been carried out as desk-studies, based on published information about the cases, and intended to illustrate how the methodology developed here might be applied as a basic, rapid analysis of individual cases. The case studies are not detailed assessments of these specific cases. Indeed, one of the conclusions discussed below is that the methods presented here, while well-suited to a broad national-level analysis, are not particularly appropriate for addressing specific sites, since they are based on national averages and are not flexible enough to deal with locally-specific conditions. Hence, each of the cases discussed here has particular features that are not fully represented in the analysis, and the results should therefore be read in that light, as initial broad-brush assessments and illustrations of the method, but not as full and detailed investigations of the cases.

3.1 Case Study A: Private Woodland Management (Kemphill Moor Copse)

Kemphill Moor Copse is located approximately four miles east of Newport on the Isle of Wight. The copse was sold by the Forestry Commission to an adjacent landowner at the beginning of 2009 and the new owner has received grants (of approximately the same amount as the sale price) for undertaking various management interventions (FC 2009).

Although on the face of it this may seem a comparison of FC and private ownership, in fact the anticipated impacts are more a reflection of recommencing active management rather than of a change to private management per se: the FC could have carried out the same work under PFE management.

The copse forms 20 hectares of a larger complex of ancient woodland sites. Almost half of the mixed woodland is designated as plantation on ancient woodland site (PAWS) sites and public access is available along a public right of way and under the CROW act (FC 2005, 2009).

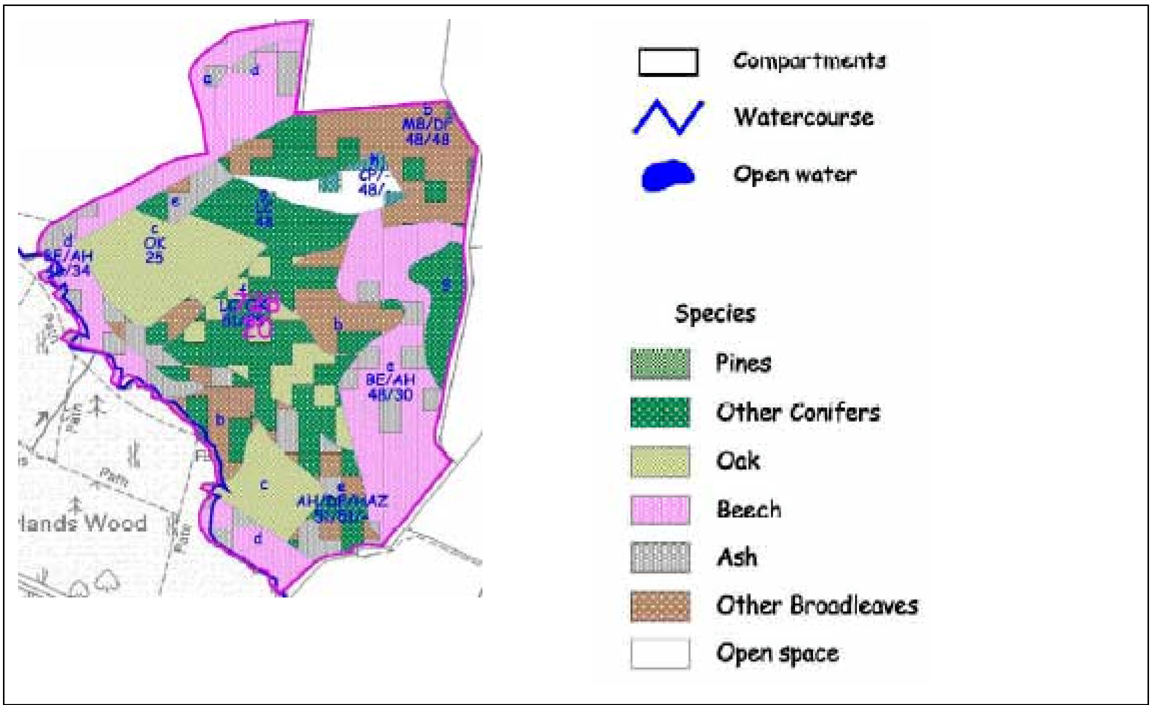


Figure 5: Habitat types forming Kemphill Moor Copse

For the 60 years prior to the 2009 transfer of ownership, the FC was responsible for management of the forest. However active management was limited due to poor machine and haulage access, limited local markets for the predominantly low value growing stock and high transport costs to mainland markets (FC 2009). As a result, the woodland became poorly structured with dark overgrown rutted rides, and aside from a public footpath, there were no formal recreation facilities (FC 2009).

Private ownership plans are to bring Kemphill Moor Corpse under an increased level of management. The 20-year plan has received support form the FC English Woodland Grant Scheme (EWGS), and will contribute towards the construction of a timber stacking area, forwarder access tracks, ride widening, coppicing, invasive species control and drainage maintenance (FC 2009). These sustainable management practices are expected to provide long-term restoration of PAWS with associated biodiversity benefits including increased populations of red squirrels and dormice (FC 2009). Through forest thinning further benefits can be accrued to local woodfuel markets and nearby residents who use the area for recreation.

This case is represented in the model by switching the management category from "low-intensity" to "multiple objectives", and by increasing the area of broadleaves and of open habitat at the expense of conifers.

The results are shown in Figure 6 (benefits) and Figure 7 (costs). These show the average annual flows of value for the forest "in equilibrium" (in the model, this means years 2070 and onwards).

The model suggests that through the change in management the greenhouse gas and biodiversity values would increase significantly, and timber values would also rise. Recreation values do not change in the model, because they are represented by the level of access and proximity to population centres (low facilities and peri-urban in this case) and these have not changed. In reality it is likely that the recreation values would increase somewhat through improved access conditions, but the slight changes envisaged can not be represented in the forest typology model.

The single largest change is the increase in greenhouse gas sequestration values. This is due to bringing the land into management, with the assumption that timber harvests will allow ongoing sequestration and substitution benefits from the timber. This is partly offset by the switch from conifers to broadleaves and (in particular) open habitats. The values are large because we are considering the long-term for which the unit value is £200/tCO2e. The importance of the greenhouse gas category would be lower in the immediate future when the official carbon values are lower.

Overall the benefits increase by about £9,000 per year on average in equilibrium as a result of the change in management practices, most of this arising through the greenhouse gas impact. The costs increase too, but only by £2,500, primarily through costs associated with land management, and the conservation costs associated in particular with the open habitats. This is driven by the switch from "low intensity" to "multiple objectives". Overall therefore the model suggests that the change involves a significant gain compared with the current situation. In net present value terms, the difference is approximately £100,000.

These can not be considered firm conclusions, however, since the actual costs and benefits might be quite different from the national averages used here, which are in any case approximations. In particular, the results will be sensitive to the particular assumptions used regarding carbon sequestration and substitution, and this would need to be examined in more detail.

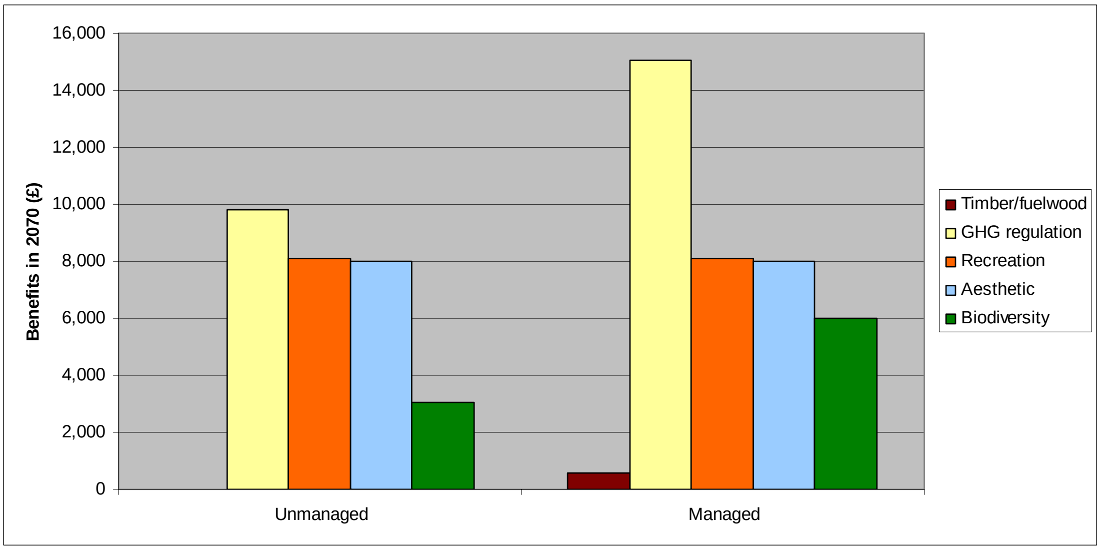


Figure 6: Average annual benefits in equilibrium, Kemphill Moor Copse

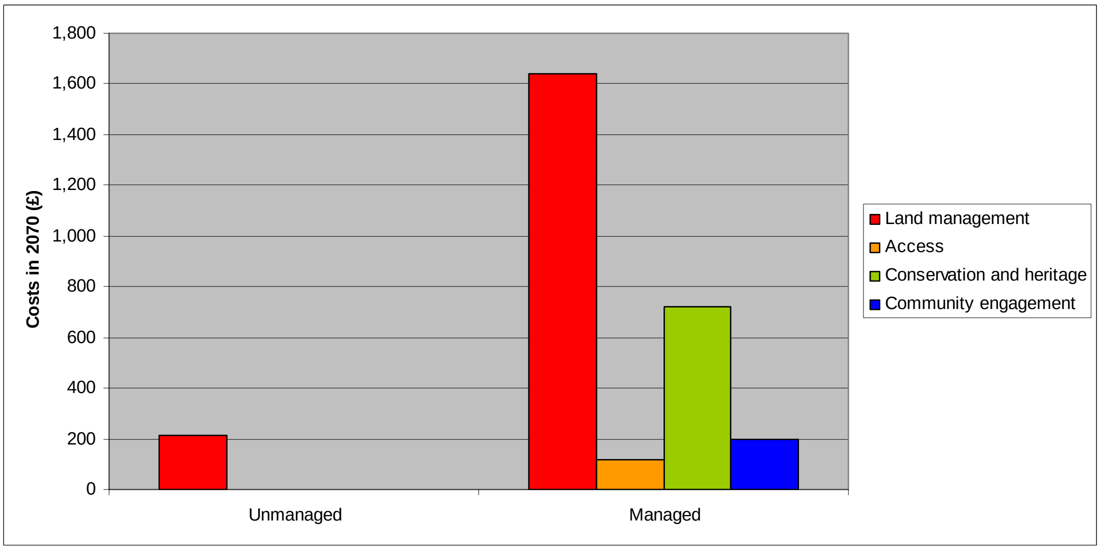


Figure 7: Average annual costs in equilibrium, Kemphill Moor Copse

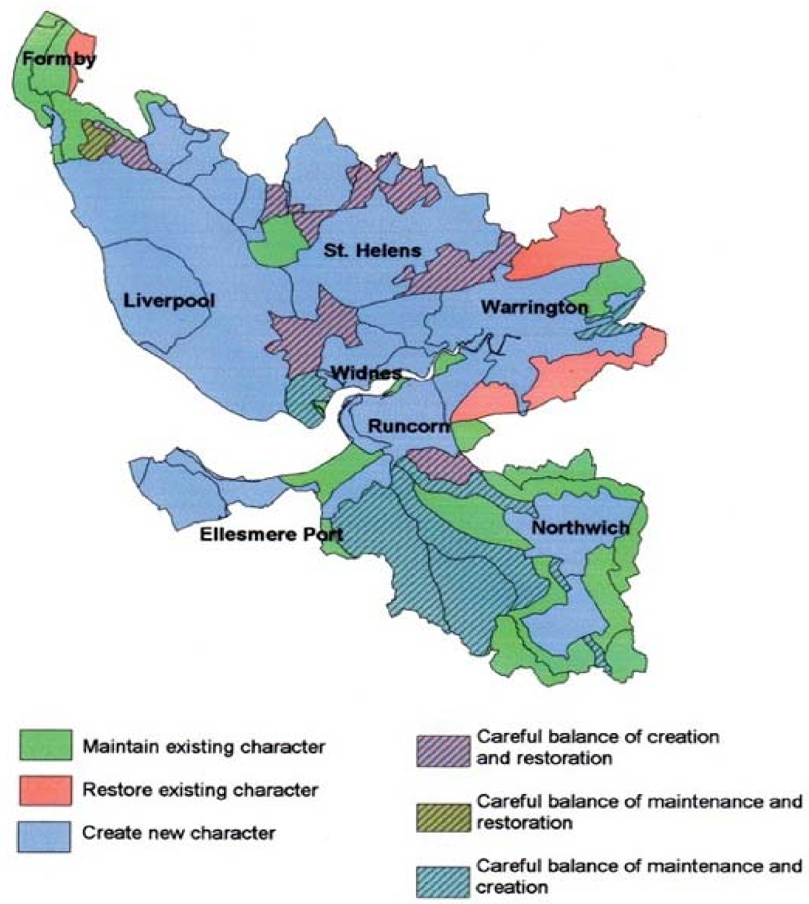
3.2 Case Study B: Urban-edge regeneration (Mersey Forest).

The Mersey Community Forest is formed by a patchwork of wooded and open habitat areas spread across a region of 92,500 hectares. It is a partnership between two national organizations (Natural England and the Forestry Commission), 7 local authorities (Cheshire West and Chester, Liverpool, Knowsley, St. Helens, Warrington, Sefton and Halton Borough), and several private businesses. The partnership's 30 year objective is to create 8000 hectares of new woodlands and improve green open spaces for people. As of 2009 over 6000 hectares and other habitats have been created (Mersey Forest 2009). This case study evaluates the move to urban-edge forests for regeneration purposes

Figure 8: Location of Mersey Community Forest

Since 1994 over 70% of the 3700 ha of existing woodlands in Mersey Forest has been brought under management and the main justification for this ambitious program was to enhance the provision of community benefits (Mersey Forest 2009; TEP 2006). These benefits, derived either directly or indirectly from woodland cover, are related to access and recreation, culture and learning, health and environment, and local economies. Over the past decade and a half the Mersey partnership has provided new access, local employment and thousands of community events and campaigns.

Of the planting within the Mersey Community Forest, 228 hectares were regenerated from brownfield sites and 66.2% occurred within 300 metres of urban areas (TEP 2006). This results in a greater number of people having local access to woodlands for recreation, and also aesthetic benefits, and the value of this is evidenced by increased property values (Mansfield et al. 2005). The activities of the partnership were also linked to the Mersey Forest Biodiversity Action Plan and also included other non woodland habitats (TEP 2006). There are 1,786 hectares of non woodland habitat creation within Mersey plus 5,579 km of linear non woodland habitats (for example, along railways or river banks) (TEP 2006). The forest is well used by local people, with 60% of people living in The Mersey Forest visiting the woodlands and nearly 20% visiting at least once a week (Mersey Forest 2009).



The forest also has a vital role in the area's overall regeneration strategy, but this is expected to remain intangible. The key features of the case study are to explore a new urban-edge/ regeneration zone broadleaved/mixed forest, managed for multiple objectives. Mersey Community Forest has low level access provision, for communities without previous local access to woodlands.

Representing this case study in the model is difficult, because the existing typology does not account for non-woodland land-uses such as brownfield sites. Therefore the model can not estimate costs and benefits associated with the counterfactual scenario (i.e. not creating the Mersey Forest). However we can represent the forest itself within the model, as a mixture of broadleaved/mixed (6000ha) and open habitats (2000ha), in urban (50%) and periurban (50%) locations, managed for multiple objectives, with low facilities access, and 50% "high" biodiversity value.

Making these assumptions, the model results (Figure 9) suggest that the most important source of value for the Mersey Forests is aesthetic, followed by recreation. This is a result of the largely urban location – the same forest area transported to a rural location would show entirely different results. Again, these are estimates of values arising from the forest area but are not net benefits, since there is no consideration of the opportunity costs of land.

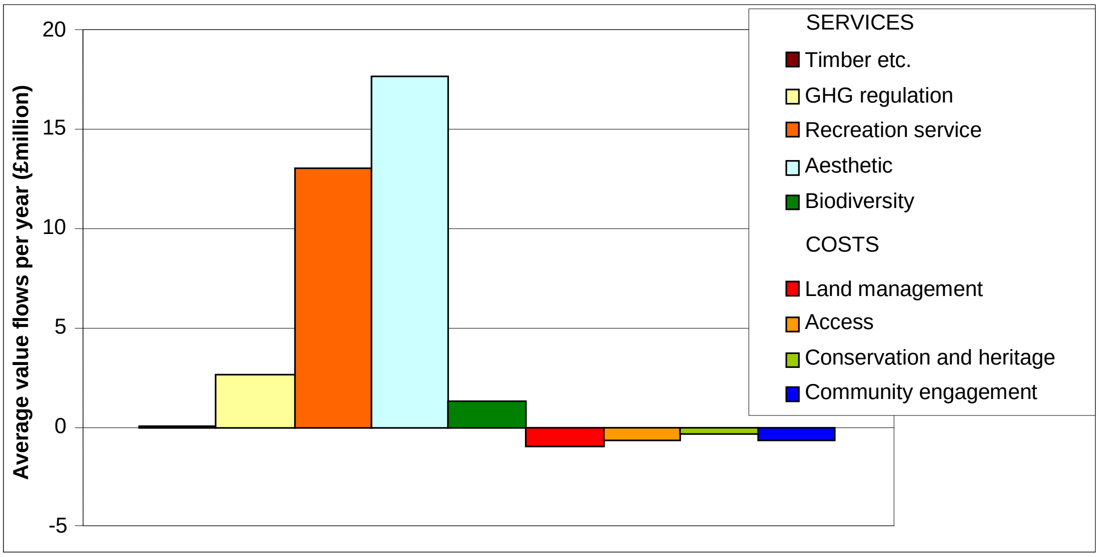


Figure 9: Average future value flows from the Mersey Forest

This case study illustrates the values of a new urban-edge/ regeneration zone broadleaved/mixed forest, managed for multiple objectives with low level access provision for communities without previous local access to woodlands. It suggests that the annual benefit flows in the established Mersey Forest could be very significant, and much greater than any costs, but it must be noted that the model has not considered any one-off costs associated with converting existing brownfield and greenfield sites to woodland, nor does it account for the opportunity cost of land.

3.3 Case Study C: Multifunctional recreation site (High Lodge)

This case evaluates the development of a major visitor centre. The High Lodge Forest Centre has multiple features, representing the high-level access option within a multi-objective management forest.

Located in Thetford Forest Park, an area of over 18,500 hectares, High Lodge is the Forestry Commission's foremost recreation centre in East Anglia. The Forest Centre was opened in 1992 and attracted around 140,000 visitors in 1999 (FC 2000). Thetford Forest is the largest pine forest in lowland Britain. The main species is Corsican pine (60 %), followed by Scots pine (22 %), with other conifers comprising a further 5 % and broadleaves making up the balance of 13 % (FC 2000). The entire area is an SSSI/Special Protection Area (SPA) due to the high populations of wood lark and night jar that like to settle after areas have been felled (Magic 2009).

The major change in management is that from a pine forest plantation to a recreation based site. There are numerous activities and facilities available for all forest visitors including parking for 800 cars, barbeques, buildings for hire, way-marked walks, cycle trails, picnic areas and a 100-seat restaurant. There is also a cycle hire and sales facility, Bike Art, and a popular forest adventure course, Go Ape. During the summer season High Lodge hosts a number of arts events, concerts and 'What's On' activities such as deer safaris and children's craft days.

There is an access charge for all vehicles entering High Lodge, which varies according to the season and the length of time spent onsite. Access is free for visitors on foot, but this is impractical for most due to the distance from population centres (estimates are 92% by car, 4% by minibus/coach, 3% cycle, 1% on foot: FC "High Lodge Visitor Survey 2000").

The High Lodge area can be modelled by contrasting the Lodge with a “no-Lodge” counterfactual. For the counterfactual scenario, we do not look at the pre-1992 status (which might involve assuming management primarily for timber) but rather at a multiple-objective forest with high biodiversity value, that is, how the area might be managed at present and in the future if there were no Lodge. This means that the only difference being examined is the introduction of high facilities for access.

Rather than assume that the entire 3400ha area is “high facilities”, we count only 500ha in this category. This relates back to the way in which the recreation values have been derived (see Section 7.3), involving the assumption of 50 high facilities areas of 500ha each. Applying the value per hectare derived from that calculation across the whole 3400ha would risk seriously overestimating the value of recreation at Thetford.

This can be cross-checked against the visit numbers, assumed to be 325,000 per year (2008/9): valuing these at £12.50 per visit, as in the model assumptions, gives a shade over £4 million, more than double the £1,783,000 predicted by the model. This may reflect that Thetford is a particularly attractive site, or nearer larger populations (e.g. easy day trip from North London), or some other difference. A key problem in valuing forest recreation is estimating the number of visits to a site, and the model developed here does this only at a very basic level.

The model assumes that since the entire area is SSSI/SPA, it is all in the “high” biodiversity value category. However this may result in exaggerated biodiversity value estimates: the SPA designation is for specific bird species, and while there are other important biodiversity features (e.g. plants, invertebrates) within the site, the designation does not necessarily reflect a very high contribution to biodiversity from each ha of the total area.

The results of modelling these assumptions are shown in Figure 10 and Figure 11. Nothing changes except the recreation values and the costs of providing access. The net benefit is around £1,000,000 per year. The difference in net present value is about £28.5 million, though this does not consider one-off costs associated with the creation of the centre. However it is important to note that this is just the result of a simple model, that uses England-wide averages and does not take into account specific details of the case.

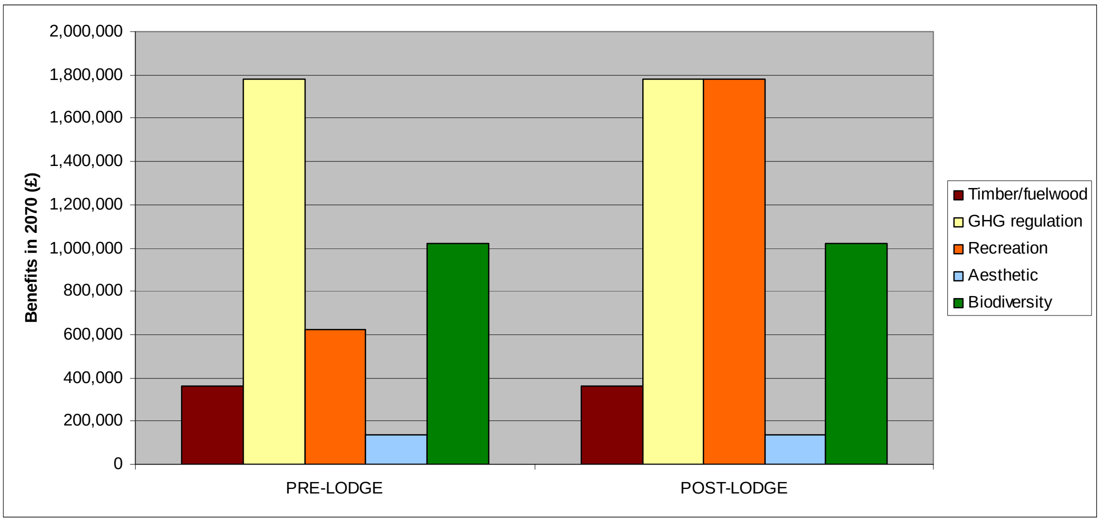


Figure 10: Modelled flow of benefits in 2010 for High Lodge

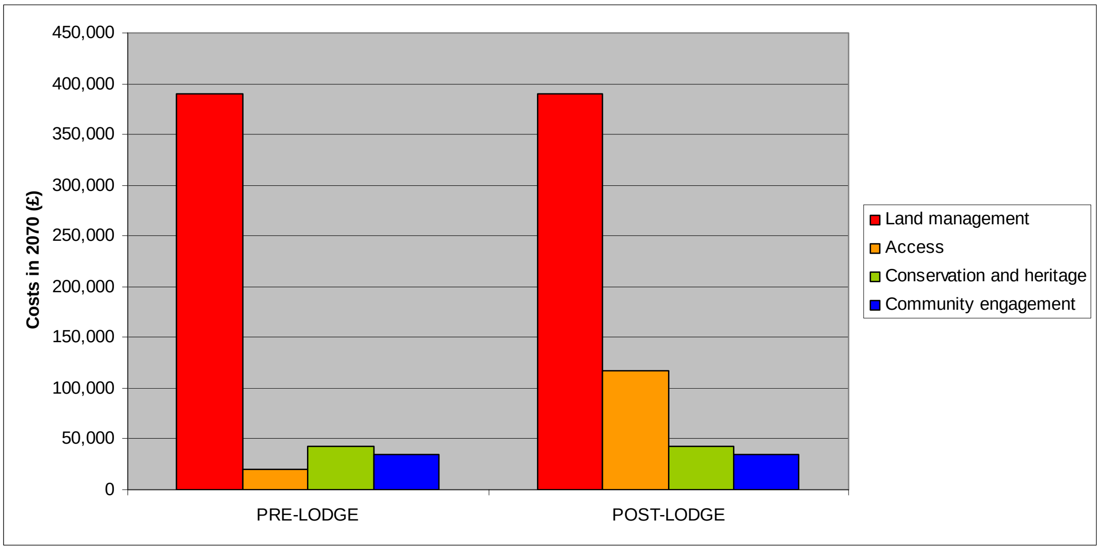


Figure 11: Modelled costs in 2010 for High Lodge

3.4 Case Study D: Wild-Biodiversity site (Wild Ennerdale)

This case study is intended to illustrate delivering biodiversity priority habitat and providing access through mainly low-level facilities to a large area of remote countryside. The remote rural mixed/broadleaved forest has multi-objective management, but with an emphasis on biodiversity and wilderness. It will illustrate the biodiversity objectives and ecosystem services provision.

Ennerdale is a remote Cumbrian valley covering 4,711 hectares and is located on the western edge of the Lake District National park (FC 2007). The valley is surrounded by some of the highest summits in Lakeland: Green Gable, Great Gable, Pillar, Kirk Fell and Steeple.

The Forestry Commission, National Trust and United Utilities partnership owns 4,300 hectares of the valley (Partnership 2006). Of this land, the FC holds approximately 3,100 hectares, the National Trust holds 862 hectares and United Utilities hold 338 hectares including Ennerdale Water (Magic 2009). The typology analysis will only focus on FC land as it makes up most of the land.

Ennerdale Water supplies 60,000 customers with daily drinking water and is located at the western tip of the valley (FC 2007). There are a host of vegetation types from lakeshore to mountain tops and from woodlands to open habitats. Internationally or regionally important habitats for flora and fauna, as well as rich archaeological remains are among the valley's highlights.

More than 40% of Wild Ennerdale is designated as a SSSI and Special Area of Conservation (SAC). Wild Ennerdale has approximately 150 hectares of Ancient and Semi-Natural Woodland and approximately 70 hectares of PAWS (MAGIC 2009).

The valley is managed by the "Wild Ennerdale" partnership, which was established in 2002 and includes the Forestry Commission, National Trust and United Utilities. The partnership was created with the principle "to adopt a unique and radical approach to management, which challenges the conventions of traditional land management practice and ownership boundaries" (FC 2007). The objective of such a management approach is to give sovereignty over landscape development back to natural processes and also to allow people an opportunity to experience true wilderness.

Wild Ennerdale will also provide information regarding the process of vegetation and habitat change, as well as local forestry employment, education and recreation. Key features of the case study will include the delivery of priority habitats, and enhancement of ecosystem services. There are low-level access facilities, but extensive accessible area of wild land.

This case study compares Ennerdale under rewilding with a counterfactual of "business as usual". The Stewardship plan states explicitly that it is not known what Ennerdale will look like in 50, 100 or 200 years. However, some broad assumptions can be made: there will be a series of evolving ecosystems and farming and forestry will continue to be present in the valley, subject to ecology and landscape value maximization. The following activities are among those identified as crucial to "wilding":

- Conservation Management
    - Introduce extensive year round naturalistic grazing by large herbivores (cattle) to create and maintain structural diversity and open areas within the valley.
    - Allow Red Deer to establish as a herd. Maintain culling as there are no natural predators.
    - Deliver the SSSI conservation objectives for the designated areas and remove rhododendron from the valley.

  - Monitor the heritage features within the valley and consider management recommendations from the Historic Landscape Report.

- Forestry
  - Control Sitka spruce population;
  - Reduce mechanized forestry operations;
  - Discontinue restocking clearfells,
  - Plant native broadleaves and Juniper; and
  - Thin mature forest to provide more open habitat.
- Recreation & Access
  - Open-access continues with few way-marked routes or signage; and
  - No public road beyond the entrance.
  - Tourism Provision & Infrastructure
  - Limited infrastructure; and
  - Designated 'Quiet Area'.

Clearly the many nuances in this specific case can not be represented accurately in the broad model. We have assumed that broadleaves expand from 145ha to 400ha, conifers reduce from 1000ha to 745ha, and open habitat area remains constant.

The main problem is that there is no management category really reflecting what is involved in rewilding – it is not really "low intensity" as there are some quite expensive interventions required in order to re-establish more natural processes. Within the typology, we can either assume that management changes from "multiple objectives" to "low intensity", or remains "multiple objectives". Both are clearly inadequate descriptions of rewilding. We model this as 50% low intensity, 50% multiple objectives but this is not very satisfactory. However, it does at least represent the reduction of timber production, and associated changes in management costs and greenhouse gas benefits.

The results are presented in Figure 12 and Figure 13. Under the assumptions used here, and the way the rewilding has been represented in the model, there is a decline in greenhouse gas regulation benefits and timber values, partly offset by a decline in management costs, while other benefits remain the same. However this is perhaps better interpreted as an indication of the inability of the typology framework to deal with the case-specific details of Wild Ennerdale, than as a valuation of the specific case.

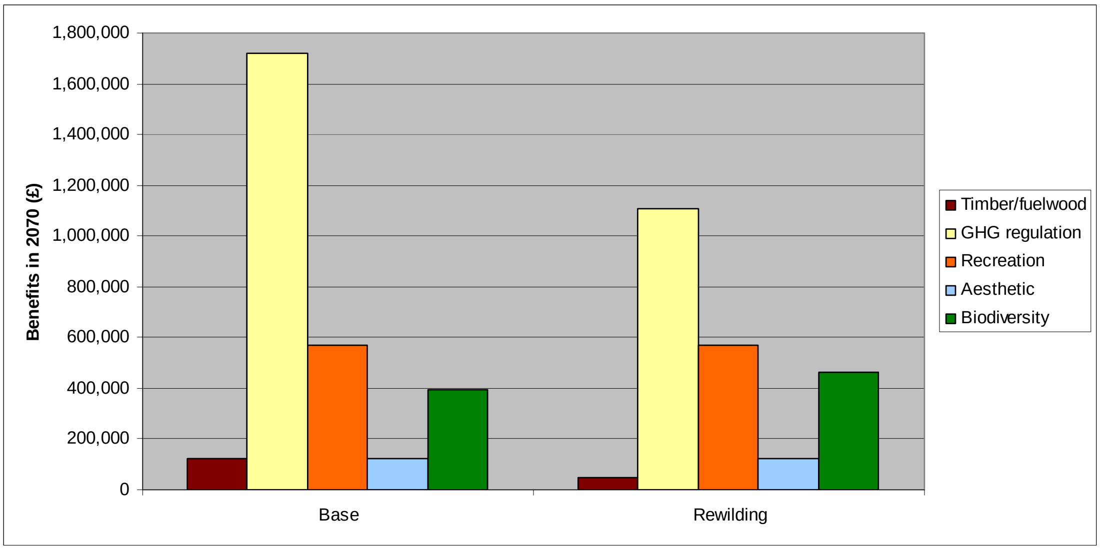


Figure 12: Modelled average benefits per year in long term, Ennerdale

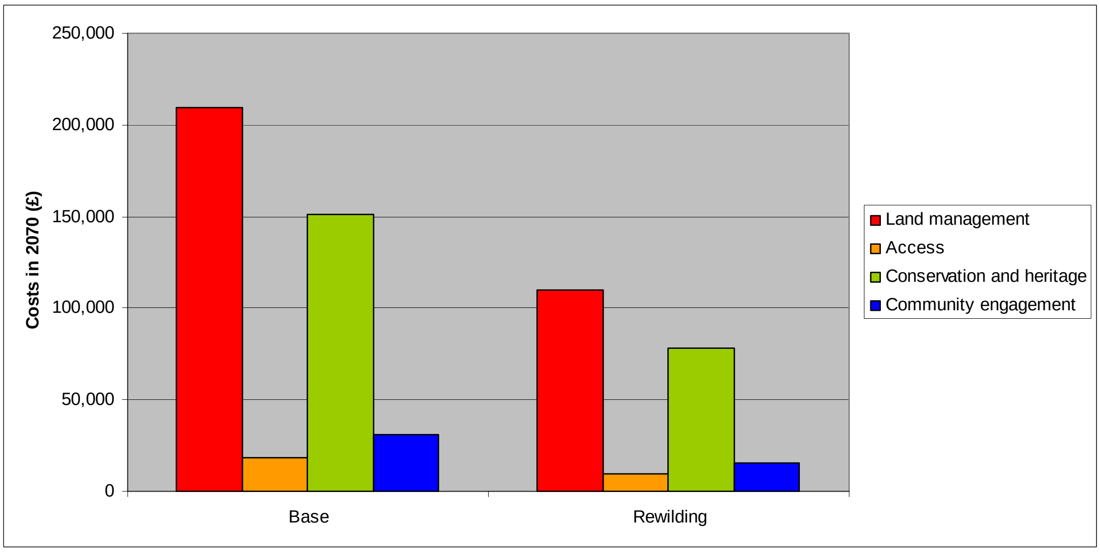


Figure 13: Modelled average costs per year in long term, Ennerdale

3.5 Conclusions from Case studies

The individual case studies show how certain management changes can be reflected in the typology, and allow some tentative conclusions:

- Bringing woodlands into management: this is the scenario represented by the Kemphill Moor Copse case. The model reflects the changes by shifting woodland from "low intensity" to "multiple purpose" management, along with some changes in ecology types, and the results show the possible improvements in greenhouse gas, timber, aesthetic and biodiversity values, and the offsetting increase in management costs. In the model, recreation values do not change, though in reality they may increase. The model does not reflect the details of the case, but applies a very simplifying structure that is nonetheless able to highlight some key potential changes.

- Broad investment in community woodlands: the model is able to represent large areas of woodlands under the Mersey Forest case, but lacks the ability to provide a full cost-benefit analysis, because the typology does not cover the opportunity costs of the alternative land uses (brownfield and agricultural sites). This could be addressed with further work. The model represents the Mersey Forest in a highly simplified fashion, focusing on total areas of different habitat types, and does not take into account the spatial distribution of woodlands in relation to each other and to human populations. Obviously this spatial detail will be important for aesthetic, recreation and biodiversity values, and a full analysis would need to take this into account. However, the model is able to show ballpark estimates for the key values, and highlights that, if the assumptions made here are correct, the key values for this kind of forest are likely to be aesthetic and recreational.

- Investment in high facilities recreation sites: the model reflects the investment at High Lodge by shifting 500ha of woodland from "low" facilities to "high" facilities. This results in a large increase in recreation values, without any change in the other values, and a relatively modest increase in access provision costs. The model is representing the key salient feature of this investment/change, but is doing so in a highly simplified fashion, based on national averages and assumptions. A full study here or at any similar site would require a much more detailed analysis of population catchments and visitor numbers.

- Rewilding: the special case of rewilding proves difficult to reflect in the model. This rather unique management approach can not be properly represented in the existing typology. Our attempt to fit it in does pick up aspects of the trade-off between timber management costs and timber harvests/greenhouse gas regulation in remote areas, but does not fully reflect the specific biodiversity and cultural/non-use justifications for the rewilding concept. One option for further work here would be to define "rewilding" as a separate management type in the typology, requiring separate estimation of associated management costs and ecosystem service benefits.

So the model does allow some broad-brush conclusions from case studies. But it must be noted that the typology based framework is not very well suited to detailed case study work. The typology aims to represent broad average types of woodland across England, and the average costs and benefits associated with these. This is a good approach to assessing flows of costs and benefits over large areas – a region, England, or the PFE. But in case studies we are dealing with much smaller areas, with specific features of interest, and often these can not be represented very well in the typology. The values and assumptions used are intended to represent national averages and can not simply be scaled down to individual sites. Hence, for example, open habitat restoration on peat is a very different matter from open habitat restoration on mineral soils; for any individual woodland, the age and yield class of the trees is likely to be important; and so on - the existing typology does not reflect these details.

Hence the application of this methodology at the site level should be seen just as a first-cut indication of possible orders of magnitude of impacts. The results may guide further research and valuation efforts, flagging up where possible critical issues exist, but should not be interpreted as a full valuation of the specific case.

4. Discussion and Policy conclusions

The results presented above, based on the typology and valuation framework developed in Part II of the report, lead to some conclusions relevant to future research and policy development. We consider first the strengths and weaknesses of the approach presented, and then the implications for future research and policy.

4.1 Strengths of the methodology

The main strength of the method is that it provides a simple approach to modelling multiple types of woodland areas. This facilitates broad assessments across large areas, allowing a complex reality to be broken down into a vector of areas of a manageable number of types. These types are associated with various categories of estimated average costs and benefits, and the combination of the typology with the average values allows an approximate assessment of total woodland-related cost and benefit flows across the area under study.

The method is applicable across different scales. Here we have focused on the PFE, and a small number of case studies, but the method could be applied to other sets (woodlands in a given region, in England, or owned by a particular organisation, for example) and could in principle be transferred to other countries, with modifications to the values and costs as appropriate.

The method is easy to modify insofar as the value and cost estimates associated with each forest type are concerned. This makes it straightforward to explore the implications of changing assumptions about values.

Additional forest types can be added by adding new possible values for existing variables (for example, “management for biodiversity conservation” or “management for raw water quality” could be new management type variables) or by adding new categories (for example, “soil type”), but this is more complicated.

4.2 Shortcomings in the methodology

There are also several weaknesses in the methods, mostly related to the above strengths, in the sense that the ease of application and simplification brought by using broad averages and a moderate number of basic types reduces the accuracy of the estimates and the ability to represent specific details.

There is a general problem that the typology presents some quite cut and dried distinctions between characteristics that in fact are more fuzzy variables. For example management is described as “low intensity”, “primarily for timber”, or “multiple objectives”. Clearly this involves some rather arbitrary distinctions in a rather fuzzy area. This is an inevitable result of using an approach that involves categorising and aggregating forest types rather than assessing each woodland area individually, and is the price to be paid for a method capable of deriving broad assessments rapidly from aggregate data.

There are various problems related to the use of per hectare values and more generally the lack of a spatially explicit framework.

- Linear features and edge effects are not taken into account. This is particularly important for aesthetic values, which depend mostly on the wooded area being visible from residential areas, commercial and work environments and transport routes. This depends on edges more than areas, and is also highly spatially specific. So the use of per hectare values here is a gross approximation.

- There is no consideration of spatial substitution effects. This is particularly relevant to recreation, where (for example) the introduction of a second high-facilities woodland near an existing one will not double the number of visitors or the recreation value. This is not a problem for the base scenario, since we have estimated values per hectare based on estimated current visit numbers to the PFE, but it is a problem for scenarios involving big changes in facilities provision. The problem is reduced if we can assume that new facilities can be sited in currently poorly-served areas, and this is probably a reasonable assumption for new urban community woodlands.

- More generally we are assuming constant per hectare values where in fact values may be non-linear function of area. Recreation has already been noted; biodiversity conservation is another clear example in which the marginal value per hectare may be expected to decline significantly as more and more hectares are protected/provided (and conversely, to increase significantly if hectares are lost).

- Associated with this is the observation that, if we accept that values are non-linearly related to total area, then it is no longer adequate to focus on subsets of wooded areas (such as the PFE) – this is not a problem specific to the methods employed here, but rather a general point, that if values are non-linear in area, then to assess values for a subset of the area, it is nevertheless necessary to measure the entire area.

There is no consideration of age and yield class details. This is a similar issue to the problem of a non-spatially explicit model, and essentially means that the model is not temporally explicit either – it does not consider when exactly a particular hectare was planted, or is to be thinned or harvested. In both the spatial and the temporal contexts, the approach of averaging out across the Public Forest Estate is appropriate for valuing costs and benefits within the estate, but it is less suitable for scenarios or case studies involving planting of new areas, or focusing on particular changes in specific case studies. For such cases, we need to reflect that significant costs for planting etc. will occur well in advance of benefits. Timber harvests will clearly occur much later, but other benefits such as aesthetic and biodiversity values may also take a little time to establish. This could be incorporated in a fuller application of the method within a spatially explicit framework, where it would be possible to track the ages of specific wooded areas.

There is limited consideration of opportunity costs within the model. Where changes are between types within the typology, the opportunity costs are included in the sense that the counterfactual includes costs and benefits of the land in condition A, which represent the opportunity cost of having the land in condition B under the scenario being assessed. But where the woodland area is converted from agriculture, or brownfield sites, this is not possible within the model, since it does not include land use types corresponding to these uses. This could be rectified reasonably simply, but at a very approximate level, by adding a handful of new types to reflect these alternative land uses.

The valuation evidence generally is not very strong, in particular for biodiversity and non-use values, and for aesthetic values. Although further research continues in these areas, it may be that the prospects for robust valuation of biodiversity non-use values are limited. One alternative here would be to consider cost-effectiveness estimates for meeting biodiversity targets or other reference levels of biodiversity.

Values for recreation and for greenhouse gases are better known, though there remain problems with estimating the physical links from specific forest types to levels of services – for example visit numbers. Overall the value estimates can not be considered precise; on the other hand, they can be interpreted as order of magnitude indications that clearly show the high importance of non-timber forest values in England.

Several value categories are omitted from the model – most importantly, impacts on water supply quantity and quality, flood risk, and air pollution. Health impacts are not explicitly included, though these will be reflected to some extent in the recreation values. The omitted values are very likely substantially smaller overall than the categories that have been valued, but could be locally very important, and further assessment may be warranted here in a spatial model.

Applying the typology requires good data on the basic characteristics included. The difficulty here is that it is not enough to know proportions for each characteristic individually, we need to know this for all possible *combinations* of characteristics. This has been very challenging with existing data, and some strong assumptions have been required. However the methods have been developed with a view to future alignment with ongoing portfolio analysis.

The portfolio analysis should provide the basic data necessary to fill out the typology in some detail (perhaps with some modifications) and this would significantly improve the results of the model. At the same time, switching the typology and framework to a spatial setting would significantly improve options for using valuation evidence. Particular value evidence gaps within the spatial framework could if necessary be addressed via original valuation studies designed for the purpose.

4.3 Conclusions

The analysis outlined here provides a useful method for broad-brush assessment of woodland and forest costs and benefits across large areas such as the PFE in England, and as a first-step rapid analysis of specific case studies. Several improvements would be desirable, most importantly linking with a geographically references analysis of forest areas and characteristics.

But, despite the shortcomings in the data, uncertainties and omissions in the value estimates, and the simplified, non-spatial methodology, the application of the model to the PFE yields a useful broad assessment of values arising under different scenarios. Key points are summarised below.

- The model suggests that recreation and aesthetic values are substantial, and the highest values arising are in the "recreation focused" scenario. This result is driven by the focus on urban community woodlands in that scenario, and by the investment in high facilities recreation areas. It is of course sensitive to assumptions used regarding these values. Overall, the sensitivity analysis suggests that within quite a broad range of possible unit values, these non-market benefits are likely to form a large part of total values, in particular in urban and peri-urban areas.

- There may be some overestimation of recreation values under the "recreation focused" scenario, since the recreation values do not take into account substitution effects, whereas in fact values per hectare may fall as more facilities are provided. On the other hand this probably does not apply so much to the new urban community woodlands in that scenario, which we assume can be sited in currently under-served areas, although there remain issues here regarding the split between displacement of other recreation activities (e.g. going for a walk in the woodland instead of watching TV) and improvement in value of existing activities (e.g. walking dog now in a woodland instead of just down the street).

- Greenhouse gas regulation appears as a very important service in all scenarios. There is a particular feature here that the relative value of greenhouse gas regulation is rising sharply over the next 40 years, because the values used derive from Department for Energy and Climate Change (2009) guidance that includes a rising carbon value. Figure 14 shows the proportion of benefits arising through greenhouse gas regulation in the base scenario (the PFE in its current structure): the model estimates 20% in 2010, rising to 49% in 2050 and subsequent years. In this report we have assumed the carbon value stabilises beyond 2050, at the proposed £200/tCO2e; an alternative assumption that it continues to rise would make greenhouse gases appear even more important.

- This rising dominance of greenhouse gas values drives several results in the scenarios. In particular it helps the "timber focus" and "past" scenarios to compensate somewhat for their lower recreation and aesthetic values, though not enough to make them appear more beneficial than current plans.

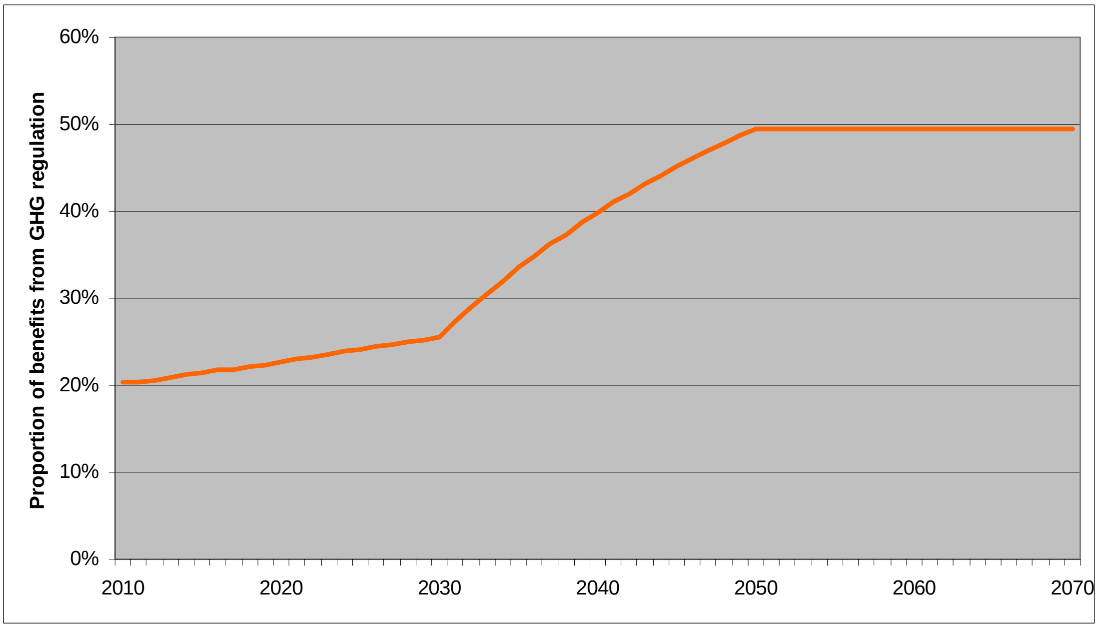


Figure 14: Proportion of benefits arising through greenhouse gas regulation, base case

- The greenhouse gas dominance also makes the two "conservation" scenarios look less beneficial. This is particularly true of the "open habitats" scenario, because the open habitats are assumed to be approximately neutral in their impact on greenhouse gases, compared with major sequestration/substitution effects by growing trees and using timber. The issue also arises for the PAWS restoration scenario, because broadleaves are assumed to absorb CO2 less quickly than conifers, but the effect is much less important.

- With reference to the previous point, of course the assumption of carbon-neutrality for open habitats is very crude, lumping together diverse habitats and soil types (including peat soils) under a single category. Further work examining how the diversity of open habitats could be better represented in a typology would enable more accurate results here.

- Similarly, given the importance of the greenhouse gas service, future work using the kind of framework presented here should consider using categories in the typology that reflect more closely different carbon profiles for specific forest types. This might involve the inclusion of additional types, but an alternative way would be to include a management type, "management for carbon sequestration" (these are not mutually exclusive options).

- The same reasons make the scenario of maintaining the PFE in its present condition look more beneficial than the future plan: the reduced greenhouse gas service provided given the planned increases in open habitats and broadleaves. Given the increasing importance of the greenhouse gas regulation service, further detailed work on the carbon balances of different types in the woodland typology would be warranted. There is of course a significant body of work on the carbon balance of woodlands, most recently Read et al (2009); what would be needed is work explicitly aiming to link the carbon balance estimates with the ecological and management types in the typology, with consideration given to modifications to the typology better to reflect differences in carbon sequestration or substitution outcomes.

- The biodiversity and non-use category moves as expected in the different scenarios, being highest in the open habitats scenario (though this does not represent *woodland* biodiversity) and lowest in the past scenario. However the level of values assessed, and the range of variation across the scenarios, are both small in comparison to the other values and changes at stake. This can not be considered a strong conclusion because the value evidence is rather weak, and the assumptions relating woodland areas to biodiversity values are approximate. In addition, there are many options for improving biodiversity in woodlands via sensitive management practices that we have not been able to reflect in our broad typology: the two “conservation” scenarios presented here are rough reflections of only two facets of a much more intricate reality. It should also be kept in mind that much of the value of biodiversity arises through its supporting function – it is supporting other services, including recreation and aesthetic values, that are highly valued – and here we are discussing only the non-use component. Further research into the non-use values of specific types of woodland, non-wooded habitat, and associated biodiversity would be useful in reducing the uncertainty about the values in this category. Given the difficulties of deriving estimates of non-use values for biodiversity, the alternative approach of deriving proxy values based on cost-effectiveness estimates of costs for meeting biodiversity targets merits consideration.

- Costs play a minor role in the analysis, being an order of magnitude less than the benefits in all scenarios. Changes in costs can be proportionately quite large - the costs in “timber focused” are modelled as only about 60% of the costs in “recreation focused” – but these differences are swamped by differences in the benefits.

- If instead of considering costs and benefits we were to consider costs and revenues, a rather different picture would emerge: such a *financial* appraisal would show that most forestry scenarios are not financially profitable. The *economic* appraisal presented here shows that the taxpayer nevertheless derives a very significant return from forestry investment, due to the high level of non-market benefits.

- It must be noted that we have not modelled any one-off costs associated with transforming the PFE, for example land purchase and restoration costs for new urban community woodlands, nor have we considered opportunity costs for land in other possible uses than woodland or associated open space. Although land purchase (and sale) prices can be considered transfer payments from the perspective of English society, the opportunity costs would need to be considered for a full calculation of net present values of scenarios.

Overall the analysis illustrates the huge non-timber benefits provided by the PFE, and in particular by recreational access and facilities within it, by carbon sequestration, and by the natural beauty of wooded areas. This last category is especially important in and near urban areas, and, along with recreational values, provides a powerful justification for investments in urban community woodlands. There are also social justice reasons for making such investments in deprived areas, and these have not been included in value calculations in this research.

Of course it must also be kept in mind that these conclusions are driven by the assumptions used about ecosystem service impacts and unit values for costs and benefits. These have been derived from the best evidence available, but as noted above there remain substantial uncertainties, meaning that some services have not been valued at all, while for some others the assumptions required to derive values are not ideal. The ability to derive accurate value estimates for the costs and benefits of the PFE is constrained by the data available, in particular the estimates of impacts and values.

The ongoing portfolio analysis should go some way towards addressing these problems, providing geographically referenced information about woodlands and their specific characteristics. Other work will help to develop more accurate estimates of values (for example ongoing work for Defra and Natural England on the scope for using recreation survey data to improve estimates of recreation values and better account for substitution effects). The next step in developing an improved methodology for valuing the cost and benefits of the PFE and other woodlands would be to integrate the framework with the portfolio analysis, adapting the typology as required, and considering non-linear and spatially-referenced functional forms for estimating particular categories of cost and benefit.

PART 2: Details of Methods and Data

5. Typology Development

Individual valuations of management options for particular woods and forests can be undertaken on a case-by-case basis, but a workable framework for evaluating the contribution of the FC estate, and for analysing policy options at the national level, requires a simplifying typology through which key types of forest can be associated with typical ecosystem service levels and values. Constrained by data availability and practical feasibility, this approach is necessarily broad-brush, although it is possible to design the valuation framework in such a way as to permit the inclusion of greater detail and precision for more locally specific and/or more labour- and data-intensive applications.

The first step in our research was therefore to develop a multi-dimensional forest typology to reflect the different forest types characterising English woodlands. The aim here is to have a number of woodland types that allow us to identify typical ranges of service values and of costs for each category in the typology, and to strike the right balance between the precision of estimated ranges of values and of costs on the one hand, and the number of forest types on the other. The extremes on this continuum are a typology with a type for each woodland in England (very complex, allowing precise estimates of cost and service levels) and a typology with a single forest type (very simple, with average costs and services for all English woodlands). Both extremes are equally useless for analytical purposes; the task is to identify the appropriate point in between at which the most useful framework can be devised.

In finding this appropriate point, the initial choice was between a simple list of forest types or a menu of forest features. The obvious starting point from the literature was 'biodiversity forest types' adapted from Hanley et al. (2002), which has advantages of simplicity and wide application in existing research (see also Willis et al. 2003). The types are:

- Upland conifer forests;
- Upland native broadleaved woodland;
- Upland new native broadleaved woodland;
- Lowland conifer forest;
- Lowland ancient semi-natural broadleaved wood; and
- Lowland new broadleaved native woodland.

However, although the typology served the purposes of the Hanley et al. (2002) study, the authors themselves acknowledged that the typology does not represent the full range of forest types in the UK – essential for a comprehensive valuation. In particular, criticisms focused on the narrow range of ancient forest types and also the lack of reference to UK Biodiversity Action Plans (BAPs) (Hanley et al., 2002). Taking into account the breadth of information required for ecosystem services valuation, the typology rapidly developed into a long list of forest features.

5.1 Long-list Woodland Typology

The iterative development of the forest typology list began with a 'Long-list Typology' that encompassed a wide range of relevant forest features for which data were potentially available (Table 10). This list was compiled based on assessment of data availability from FC and other sources, and our judgement regarding factors that would be likely to be relevant in determining service levels.

Table 10: Long-list Woodland Typology

Attribute	Short-listed?	Comments
Vegetation type: broadleaf/ conifer/open habitat/ other	Included in the attribute, 'Woodland Ecology' type.	The FC reports and data, as well as much of the literature, distinguish between broadleaf and conifer. Several of the articles contained within the literature review (see Hanley et al. 2002 and Willis et al. 2003) have adopted the broadleaf/conifer split. The UKBAP broad classification distinguishes between 'Broadleaved, mixed and yew woodland' and 'Coniferous Woodland'. 'Open habitat' is increasingly seen as important for biodiversity/conservation reasons.
Upland/ lowland	Not included	Several of the articles contained within the literature review (see Hanley et al. 2002 and Willis et al. 2003) have adopted the upland/ lowland split, but it is somewhat arbitrary, and primarily used as a proxy for other environmental characteristics such as soil type, temperature and wind.
Slope and aspect	Not included	Although these can be assessed via GIS, and will influence services and costs, they can also vary greatly within a forest unit. At the broad scale of application envisaged, these characteristics cannot be taken into account, though at a very local scale they will be relevant, and may need to be considered in individual cases.
Ancient/Secondary	This has been excluded from 'Woodland Ecology' type, instead being considered under biodiversity.	Several of the articles contained within the literature review (see Hanley et al. 2002 and Willis et al. 2003) have differentiated between ancient and new. A forest is 'ancient' if it is 400 years or older, otherwise it is a 'secondary' forest.

Table 10: Long-list Woodland Typology		
Attribute	**Short-listed?**	**Comments**
Location and Size	A location (with respect to human population) is included in the short-list typology. Other location aspects are not included. Size has been excluded.	A key aspect of the location and size attributes is that many services and costs, measured per hectare, are size and location independent. Some others however cannot be expressed per hectare but rather accrue per forest or in a non-linear relationship with size. There can also be threshold effects (e.g. a minimum size to support a viable population of some bird species). These issues could be addressed via the units used for cost and value estimates. Size/area could be important in any specific valuation exercise, but are not included in the broad forest typology. A GIS framework could allow a more sophisticated approach here.
Setting (urban/peri-urban/rural)	The location dimension is based on these types.	Proximity to population is an important indicator for different types of use values. A basic assessment is incorporated in the typology; more detailed analysis would be possible with GIS.
Availability of alternatives	This has been excluded from the typology but could be assessed on a case-by-case basis.	This attribute is not relevant to all service categories and is also correlated with scale/location. For categories where alternatives are relevant, the presence of alternatives will influence the value of the services, but not the physical nature of the services. This remains a problem for valuation, and might be considered in a GIS framework.
Age/class	This is excluded from the typology but may need to be assessed on a case-by-case basis.	Age/class is clearly relevant – to timber production, greenhouse gas storage and other categories - however at the broad scale of assessment envisaged age and class are likely to average out within forest types. For specific applications to small areas it may be necessary to take this into account separately.
Species	Species has not been directly included in the typology, but is partly considered via the basic woodland ecology type and biodiversity indicators	Categorising species individually would lead to an excessively large typology; the most important aspects can be captured via the broadleaf/conifer distinction and the biodiversity priority category.

Table 10: Long-list Woodland Typology

Attribute	Short-listed?	Comments
BAP priority habitats	Partly included under the biodiversity indicator	In preference to detailed consideration of species or habitats, we use a binary indicator: high biodiversity priority or not.
ASNW, PAWS, OSNW[2]	These are partly reflected under the biodiversity indicator	These characteristics reflect whether or not woodland is ancient and/or semi-natural, both being important for biodiversity and cultural services.
Alternative Habitats; Soil Type	These were not explicitly included in the short-list typology.	Issues with data availability, necessity of GIS and the practical problem of including numerous categories make this too complex for a basic typology. But 'Woodland Ecology Type' is highly correlated and provides an indication of their relevance to valuation. Furthermore, the biodiversity category partly reflects the 'naturalness' of the forest, which is a relevant factor in the evaluation.
Management practices	These are partly included in the short-list typology, though only a limited list of alternatives reflecting the most important aspects.	Long-term forest strategies provide an indication of relevant services for valuation. But practices may differ from objectives: this criterion is about what is actually the state of forest management, including future plans over a rotation, so although plans are relevant, a forest would not be classified (for example) as 'access encouraged, high facilities' merely on the basis of a stated aim, if in fact there are no facilities.
Ownership	This was not included in the short-list because it is thought that the identification of possible persistent differences between private and public woods and forests should be a conclusion of the research rather than an assumption.	Ownership type and funding form a central part of the typology used in Cogentsi and PACEC 2004. A particular issue is that many estate woods under leasehold may behave more like private woods due to a legal restriction on access. However this is dealt with under the 'public access' indicator.
Public access	This is included in the short list	The availability of public access is a key feature for recreation services.
Facilities and accommodation	Partly included under the access dimension.	This attribute is highly correlated with recreation and tourism. Major recreation centres such as Forest Holidays cabins and campsites need to be considered as special cases.

[2] ASNW (Ancient Semi-Natural Woodlands); **restored** PAWS (Plantations on Ancient Woodland Sites: ancient, but not semi-natural unless restored) (see Figure 16); OSNW (Other Semi-Natural Woodlands: semi-natural, but not ancient).

Table 10: Long-list Woodland Typology		
Attribute	**Short-listed?**	**Comments**
Certification	Not included in the typology at present.	1.3 million hectares of woodland in the UK were certified in March 2009, under the Forest Stewardship Council (FSC). This represented 45% of the total UK woodland area Forestry Commission 2009. These woodlands will be managed in particular ways that enhance their service values, for example biodiversity values.
Recreation activities; Number of visitors; Field sports; Community groups; Timber production	Not included in the typology	These are an output of, rather than an input to, the typology: the typology should help to estimate what these services are likely to be, but they do not themselves form part of the typology.
Watershed; regulation; Wind regulation; Carbon sequestration	Not included in the typology	These regulating services are outputs of forest type – the typology should help to estimate what these services are likely to be, but they do not themselves form part of the typology.

5.2 Developing the Short-list Woodland Typology

Clearly it is not possible to develop a useful typology that takes into account all of these different features – the number of possible types would be enormous, and the job of assessing the typical benefits and costs of each type would be unmanageable. It is therefore necessary to separate out those key features that are most important to include in the typology, and those that can for one reason or another be omitted.

Table 10 above describes the specific justifications for including or omitting certain variables. Overall, the purpose of the typology is to provide an indication of the types and levels of services associated with particular forest types.

Several of the categories in Table 10 are direct estimates of ecosystem services that could better be dealt with as *outputs* of a forest typology: they are not determinants of forest type, but result from forest type. Examples include carbon sequestration and number of visits. Such service categories are therefore omitted from the typology, and will be presented as typical service levels for specific forest types.

Within the remaining categories, there is wide scope for varying levels of precision. For example, the typology could go into substantial detail on specific kinds of recreation and access infrastructure and use. This would be useful in detailed analysis of recreation in woods and forests – for example, a typology focusing on recreation in upland coniferous forests would probably need to do this. However for the broader scope of assessing ecosystem services from English woods and forests, we need to take a higher-level approach, in order to keep the number of types manageable. Therefore the typology needs to indicate more basic features: is the forest managed for public access, and how close to people is it? This will be sufficient to pin the level of service down to a certain range, while leaving the possibility of further sub-division to increase precision where this is required.

These and similar arguments resulted in the long list being reduced to a short list typology, summarised in Table 1 (on page 13).

5.3 Woodland ecology

The first dimension broadly distinguishes woodland areas according to basic ecology:

- Broadleaved, mixed and yew woodland;
- Predominantly coniferous woodland; and
- Open habitat.

This classification has been developed from one widely used in the existing literature (see Hanley et al. 2002; Willis et al, 2003), aiming to match with the UK BAP broad habitats classification, and to account for the increasing importance given to open habitats within woodland areas and more generally. The ancient/secondary split is dropped, since this is in effect separately included under ‘Biodiversity’, because any ancient woodlands will be considered as priority habitats. The upland/lowland division is dropped as there is no obvious point at which to draw the arbitrary distinction, and it is not itself a fundamental determinant of the services provided by different types of woodland.

5.4 Proximity to users

The second dimension classifies woods and forests according to location with respect to human user populations, both residents and tourists:

- Urban community woodland (within 500m of population centres);
- Peri-urban woods and forests (up to 10km from population centres); and
- Rural woods and forests.

The ‘proximity’ attribute gives further indication regarding potential for certain cultural services, particularly recreation, without having to include all of the long-list indicators (distance from population, urban, peri-urban and rural, catchment population, number of visitors per year, etc.). These factors will all be important in economic valuation; however they are not required to be explicitly stated in the typology. The typology here does not include any factors associated with access conditions, because that is dealt with separately.

It would be possible to extend this dimension to allow finer distinctions (for example to take into account catchment population size more accurately) but for the practical reason of keeping the number of forest ‘types’ workable, and because it would be difficult to do this without a spatially explicit model, we have decided not to do this at present.

5.5 Management practices

The third dimension has been added to reflect management practices.

- Low intensity management;
- Managed primarily for timber; and
- Managed for multiple objectives.

Note that 'low intensity management' would only apply to those woods and forests that are under little or no forestry administration. These woods and forests currently account for about 500,000 ha out of 1.1m ha in England, and are predominantly broadleaved & small woodlands. They can be considered to be among the most important challenges facing forestry in England. Some other areas are managed primarily for timber production with limited effort to enhance or protect other ecosystem values. Hence despite restricting this dimension to three categories, and lumping together a diverse range of objectives in the third category (and all FC managed land will appear there), this split manages to capture important fundamental distinctions among forest types in England.

It is important to note that putting all FC managed land under the 'managed for multiple objectives' category does not imply that the land is not managed with timber production as a high priority. The intention is rather to make a distinction between land managed for timber and other objectives (public access – not necessarily with facilities – and conservation goals) and land managed *solely* with a view to timber benefits (where other non-market benefits may arise, but are not considered in management decisions).

5.6 Public access

A fourth dimension reflects the public access status of the forest:

- No public access;
- Access encouraged with low level of facilities; and
- Access encouraged with high level of facilities.

This dimension picks up on the main features associated with recreation services: can people get in, and what is provided for them on site? 'Low' facilities means restricted to paths and minor interventions to facilitate access; 'high' facilities means at least provision of toilets and car parking (for which there may be a charge), and also covers more intensive provision at visitors centres and so on. The category is also related to what McKernan and Grose (2007) refer to as "the feeling of being welcome in a site", and 'unwelcoming' sites (e.g. 'keep out' signs) might be considered as 'no public access' for valuation purposes, even if there are in fact rights of way over the land. Of course tying a wide range of provision types into a single category means that true values in any specific case may be quite different from the 'average' costs and benefits covered in the typology, and therefore departures from the average values should be considered as appropriate if working on specific cases. See Figure 15 for a distribution of access types across PFE forests.

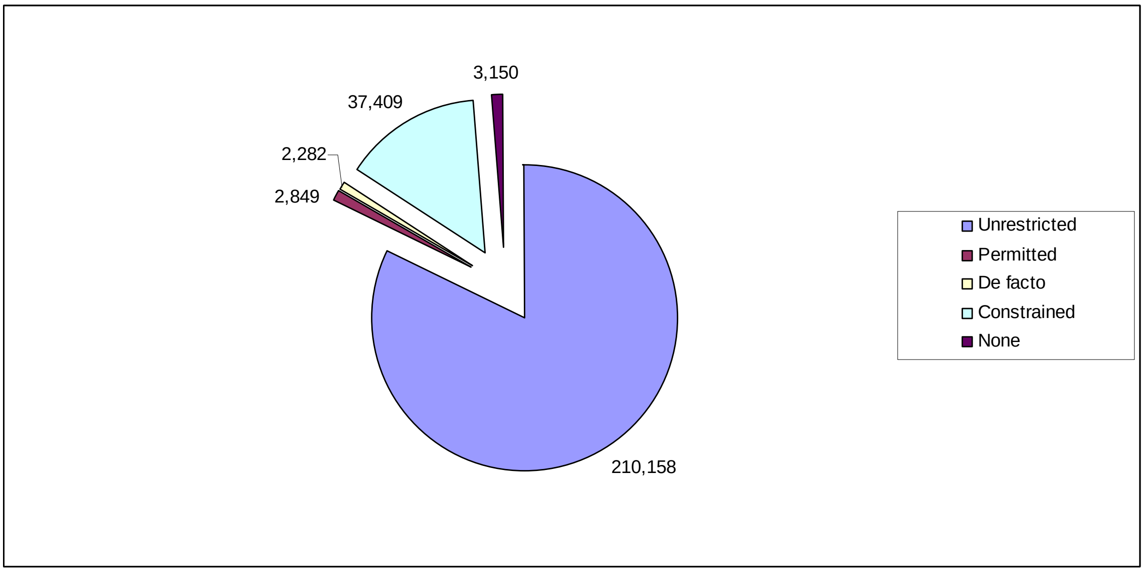


Figure 15: Public access types on PFE (hectares)

5.7 Biodiversity

A final dimension to the typology seeks to assess the biodiversity importance of different woodland areas. This is a complex area and we do not have detailed information on which to base assessment. We take a very simple approach that divides woodlands into 'higher' and 'lower' biodiversity importance. 'Higher' importance includes woods and forests that represent at least one of the following categories:

- UKBAP priority categories (including wet woodland, lowland wood-pasture and parks, upland oakwood, upland mixed ashwoods, native pine woodlands, lowland beech and yew woodland);
- ASNW (Ancient Semi-Natural Woodlands);
- **restored** PAWS (Plantations on Ancient Woodland Sites: ancient, but not semi-natural until restored) (see Figure 16);
- OSNW (Other Semi-Natural Woodlands: semi-natural, but not ancient);
- Areas designated as SPA/SAC or SSSI.

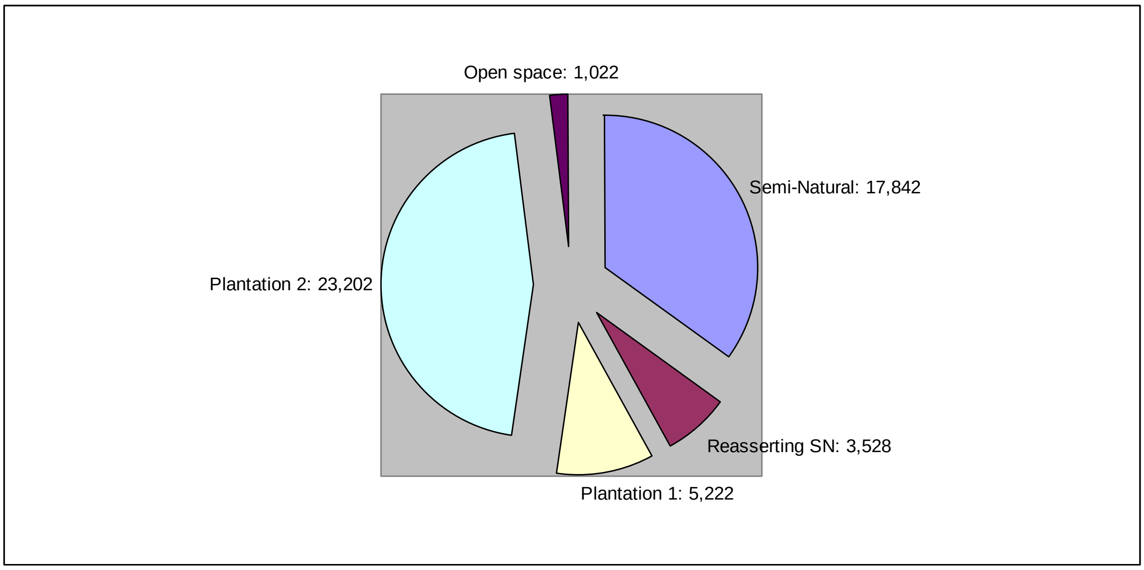


Figure 16:Area of Plantations on Ancient Woodland Sites (PAWS) in PFE, classified by semi-naturalness status (hectares)

The emphasis on restored PAWS reflects that intensive/non-native plantations on these ancient sites do not represent 'high' biodiversity values. By 'restored', we mean semi-natural or reasserting semi-natural (see Figure 16); the ‘plantation’ categories can include beech woodland outside its natural range, and these would be considered as ‘lower’ biodiversity value unless one of the other categories applied.

To keep the typology manageable, we have not included the above categories individually within the typology, but rather identified simply whether or not the woodland is in one of these priority categories, referring to this as ‘higher’ biodiversity value. This focus on biodiversity is intended to addresses the critiques of the Hanley et al. typology by providing a clear, but very simple, indicator of relative biodiversity importance. The approach is clearly very approximate and does not take into account numerous geographical and ecological characteristics that may influence biodiversity values; nor does it consider additionality or substitution effects.

It is important to note that the classification is in no way intended to suggest that areas identified as ‘lower’ biodiversity value have little or no value. In particular, we are conscious that conifer plantations are important for certain species of bird, fungi, invertebrates, and red squirrels, and that modern plantation management is more benign for biodiversity than older styles of management. There is no fundamental inconsistency between ‘conifer plantation’ and significant biodiversity importance – for example, Thetford forest and the pine plantations in the Thames basin heath areas have EU conservation designations because of their modern forestry management, and the “State of the UK’s Birds 2008” (RSPB 2009) shows woodlark and nightjar populations have exceeded BAP targets “largely due to forestry practices”. The special case of designated areas is taken into account by the categories above. Beyond that, for assessing the overall value of the biodiversity conservation service we do need to recognise the importance of declining marginal values (for valuation of biodiversity, see Section 7.2) and the fact is that there is a great deal more conifer plantation in the PFE than there is anything else (see Figure 17). On the other hand when thinking about marginal values we need to consider not just the PFE but rather the areas of each habitat type across the country, and here we can observe that although there is a lot of conifer plantation, there is also a lot of upland heathland, and so on. Nevertheless we consider that the biodiversity conservation value per hectare, **on average** across England, is likely to be higher for the categories identified above (UK BAP priority, ASNW, restored PAWS and OSNW) than for other wooded areas. This is appropriate for broad-scale assessment, but for specific case studies it may be necessary to consider arguments for modifying the categories or values to reflect particularities of the local situation.

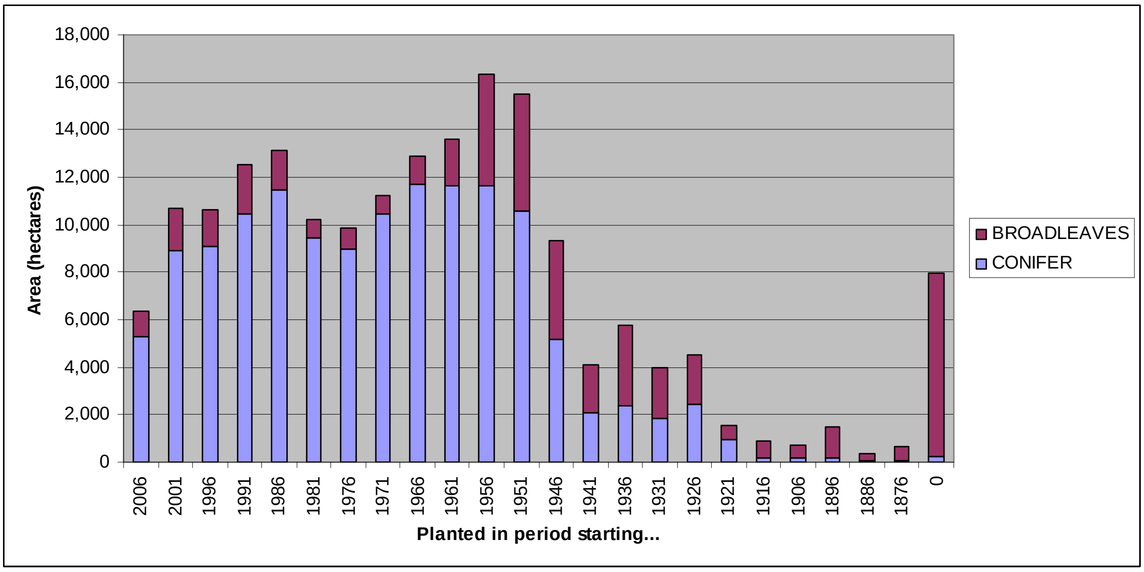


Figure 17: Areas of conifers and broadleaves in Public Forest Estate

This approach was considered more practical than other possible methods of teasing out the age-class-species-habitat combinations to expose the biodiversity structure. It ensures that the 'ancientness'/biodiversity character of the forest is touched on in the typology. Admittedly this is very imprecise, but in any case, biodiversity valuation is a very difficult question (see Section 7.2): there is little point in constructing a more complex typology to account for biodiversity characteristics in more detail, when we would not in fact be able to maintain meaningful distinctions through the valuation stages. This could be relaxed for more detailed work, in particular if considering new primary valuation studies on forest biodiversity. Fundamentally, however, the concern remains that there is little evidence supporting any *quantified* link between biodiversity and the various forest and open habitat types.

5.8 Review of Typology

As noted above, a primary objective was to create a set of categories that were sufficiently detailed to distinguish between the main activities contributing welfare from the English woodlands, and in particular the FC estate, whilst working inside the practical constraints imposed by available data and typology length. This has, inevitably, resulted in the omission of some possibly relevant attributes from the typology. The main concern is the lack of reference to scale and availability of substitutes, both of which are relevant to certain ecosystem services. On the other hand, there is also an important advantage in developing a typology that excludes these factors, because it makes the typology scale independent. In other words, the forest type does not change if we consider a whole forest or a component part of it, provided the basic ecology type is the same.

Using a full factorial design, the typology generates a large number of possible woodland and forest types: with three 'Woodland Ecology' types, three 'Proximity' types, three 'Management' types, three 'Access' types and two 'Biodiversity' types, 3x3x3x3x2=162 possible combinations. However in practice some of these categories are contradictory (e.g. low intensity management cannot combine with high facilities), some do not exist in England, or are extremely rare (e.g. urban community managed primarily for timber). So far as reducing the number of basic types is concerned, the following rules can be applied:

- Low intensity management is inconsistent with high facilities for access;
- Management primarily for timber is inconsistent with high facilities for access;
- Open habitat type is inconsistent with management primarily for timber; and
- Urban community forest has to be multiple objective and is inconsistent with zero access.

Together, these reduce the number of feasible basic types from 162 to 88. Of these, several are closely related in the typology, in the sense that most of their ecosystem services and/or costs can be considered as very similar or identical. These related types often differ only in regards to specific services, and in particular the 'public access' dimension will only have a major impact on recreation services. This means that the final number of different 'woodland type – service level' and 'woodland type – management costs' mappings deriving from the typology can remain at a manageable level.

6. Management Costs

Management costs are inputs to the management of woods and forests by FC estate and private foresters. The review focuses on establishing ranges of generic costs for forest management, including the broad circumstances under which they occur and the ways in which they vary within and between the main forest typologies.

The full economic cost of running woods and forests includes all expenditures, irrespective of who pays. Government intervention in forestry policy is undertaken by the Forestry Commission and Defra. The intervention falls under four mechanisms (CJC Consulting et al. 2005):

- Management of public woods and forests and associated land by Forestry Commission;
- Grant aid primarily for woodland creation and changes to forest management aimed at supporting the delivery of public goods (i.e. English Woodlands Grant Scheme (EWGS), FWPS (Farm Woodland Premium Scheme), challenge funding, and also Natural England grants and other instruments of the Rural Development Plan for England);
- Regulation of woods and forests and forest health; and
- Forest research and training.

This study is focused on the first mechanism listed above, the management of the Public Forest Estate by the Forestry Commission. The cost of managing the Public Forest Estate is the net public expenditure incurred. Here, however, we are interested not in the net public expenditure (total spending less revenue from timber, recreation etc) but with gross costs, since the values of timber and other ecosystem goods and services are considered separately. The main drivers of costs are:

- Forest Planning;
- Operating expenses: harvesting and marketing, establishment, protection and maintenance, and management and development;
- Recreation, conservation and heritage; and
- Administrative fees, salaries and pensions;
- Cost of capital.

Unlike benefits, the management costs are, generally, straightforward market-based items and can be evaluated using simple accounting procedures. There are exceptions and, in particular, we would ideally consider the costs of carbon emissions arising from forestry activities on the costs side of the assessment, and the value of carbon sequestration on the benefits side. It can also be necessary in some cases to correct for the presence of taxes which, as transfer payments, are not part of the true economic cost.

A major difference between public and private forest estates is the mechanism for intervention. Many of the costs of private forest management are supported by grants and subsidies. Funding for non-FC woodland mainly comes from the FC but other bodies are also important sources of grants and subsidies. The main incentive payments for woodland creation in England are the English Woodlands Grant Scheme (EWGS) and the Farm Woodland Premium Scheme (FWPS). The EWGS, operated by the FC, consists of six grants for the developing and maintaining woodlands (see Table 11).

Table 11: Grants under the English Woodlands Grant Scheme

Grant Type	Payment Rates
Woodland Planning Grant (WPG)	£20/ha for the first 100 hectares, £10/ha thereafter, minimum payment of £1,000
Woodland Assessment Grant (WAG)	Ecological Assessment £5.60 per hectare (min £300) Landscape Design Plan £2.80 per hectare (min £300) Historical & Cultural Heritage £5.60 per hectare (min £300) Determining Stakeholder Interests £300 per assessment (min £300)
Woodland Regeneration Grant (WRG)	Ancient Woodland Sites • Conifer PAWS Native woodland £1,760 • Broadleaved woodland £950 • Conifer species nil • Broadleaved PAWS Native woodland £1,760 • Broadleaved woodland £950 • ASNW/OSNW Native woodland £1,100 Secondary Woodland Sites • Conifer plantation Native species £1,100 • Broadleaved plantation £950 • Conifer plantation £360 • Broadleaf plantation Native species £1,100 • Broadleaved plantation £950 • Wide-spaced broadleaves £350
Woodland Management Grant (WMG)	£30/ha per year on the eligible area
Woodland Creation Grant (WCG)	Woodland Creation Grant contributes to the cost of woodland creation. Payment rates are £1,800/ha Broadleaf, £1,200/ha Conifer and £700/ha Special Broadleaves. An Additional Contribution of £2,000 will be paid for all applications that meet national or regional priorities. Farm Woodland Payments (FWP) can be paid on top of WCG to compensate for the loss of agricultural income as a result of creating woodland on agricultural land. They are payable for up to 15 years and farmers can continue to claim Single Farm Payments.
Woodland Improvement Grant (WIG)	There are 4 national funds available: **SSSI WIG** - 80% contribution towards work that will help a SSSI woodland achieve or maintain favourable condition. **BAP WIG** - 50% contribution to deliver the UK Biodiversity Action Plan for priority woodland habitats and species, e.g. restoring Plantations on Ancient Woodland Sites (PAWS). **Red squirrel WIG** - 80% contribution for conservation work in Red squirrel reserves and buffer zones. **Public Access WIG** - 50 or 80% contributions for the provision and improvement of public access facilities where there is a need. Higher contributions are available in regional priority areas, e.g. Social Regeneration Priority Areas.

The Farm Woodlands Premium Scheme (FWPS) has the objective to plant farm woodlands to improve the landscape, provide new habitats and enhance biodiversity. Table 12 outlines the payment rates for this scheme.

Table 12: Grants under the Farm Woodlands Premium Scheme

Land Type	Location	Payment Rate
Arable Land	Outside Less Favoured Areas	£300 per hectare per annum
	Disadvantaged Areas of Less Favoured Areas	£230 per hectare per annum
	Severely Disadvantaged Areas of Less Favoured Areas	£160 per hectare per annum
Other Improved Land	Outside Less Favoured Areas	£260 per hectare per annum
	Disadvantaged Areas of Less Favoured Areas	£200 per hectare per annum
	Severely Disadvantaged Areas of Less Favoured Areas	£140 per hectare per annum
Unimproved Land	Less Favoured Areas (whether Severely Disadvantaged or Disadvantaged Areas)	£60 per hectare per annum

6.1 Using costs in the typology

There are two potential data sources for estimating costs for each woodland type in the typology. Firstly, data can be drawn from the standard costs used to calculate grant payments to the private sector. However, there is a problem in moving from the grant payments to cost estimates at any one site or for a change to the estate based on the typology. Some grant payments are for specific operations, and we do not know exactly how much of each are needed on average for each forest type, and at what times in forest cycles. Most grant payments are also one-off or available over a limited time.

Secondly, we can use the average payments from FC data for the average costs per ha per year for established forests. This would even out the variations described above, and provide appropriate data for ongoing management of a particular forest type. The problem with this data is that it hides short term changes to costs relating to changes to the forest estate. These changes are important to the analysis of marginal changes in the management of the estate, which are a major issue for analysis in this study.

Therefore, a two-tiered cost approach is suggested:

- Average costs from FC data (see Table 13 below) will be used for the *average costs per year* for established forests.
- Changes to forests will be analysed using the payment rates for the EWGS and the FWPS outlined in Table 11 and Table 12. For example, to calculate costs for forest establishment and/or for a complete change in type (e.g. replacing conifers with broadleaves).

This approach to costing can be applied without changing the typology and will only require specific attention when applied to the case studies and scenarios. Due to the fact that with new plantations benefits lag behind establishment it will be important to identify the timing of changes, apply different costs and discount accordingly.

The time consideration is important, because the actual costs of woodland and forest management, and the benefits, vary greatly over a rotation. But the typology developed does not include time, age or yield class characteristics – these could be added, but would add substantially to the complexity of the work. Because we are looking at the total value of the estate rather than disaggregating to any given forest, the approximation is acceptable, however this does limit the applicability of the framework *in unmodified form* to individual forests

An alternative approach is to consider actual representative cost estimates for managing woodlands. This removes the need to consider in detail all the different operations, and instead it is possible to look at broad categories of cost. It is also possible to 'tune' unit cost estimates to ensure these match with total costs, as explained below. And, by looking at averages across the estate, we can in effect ignore the timing issue by smoothing out across woodlands of all different ages and classes, on the assumption that these are represented evenly in the underlying data. While these are clearly simplifying assumptions, this top-down approach sits better with the overall typology and valuation framework than a more detailed bottom-up estimation based on grants for specific actions. There is one main caveat, and that is that the focus on average costs across the life-cycle could give misleading results for scenarios involving major changes in land-use – for example significant new forest planting – because the costs are front-loaded and the benefits come later.

Wherever possible, costs should be calculated on a per hectare basis. The main exception to this is recreation/access costs, which may need to be calculated on a per forest (centre) basis, since recreation costs derive primarily from the running and maintenance of visitor centres, and it is often not clear over what area visitor centre costs should be applied. At present, however, we have estimated both costs and benefits of recreation on a per hectare basis, using assumptions about the average area within which the bulk of a recreation centre's activity takes place – we assume this is approximately 500ha.

Costs do not fluctuate greatly across species, and therefore can be presented in terms of a representative species for each vegetation category within the typology: for example, Bateman et al. (2003) use the Sitka Spruce to represent conifers and the Beech to represent broadleaves. We propose a similar approach, but also aim to consider the variation in costs:

- Within different forest types: i.e. because of differences not picked up in the typology, for example associated with differences in species. These are addressed by presenting ranges for costs rather than single point estimates.

- Across different forest types: i.e. because of differences that are reflected in the typology. These are addressed by presenting different cost ranges for different types.

Based on data provided by the FC (PFE Landuse Financial Models), we use the following broad cost categories:

- Land management: a composite of all the costs related to planning, planting, maintaining and harvesting a woodland. In FC data, timber revenues are added back in to give a net cost or benefit figure, however here we keep the timber revenues separate on the 'ecosystem services' side of the assessment, and account for the full costs of land management. It would be possible to be more specific about cost categories under the land management umbrella, but there is little to gain in this because the costs form a natural 'package' and separating them out does not give a better fit to the typology.

- Provision of access: here, separating the costs from general management does give a better fit to the typology, since we know that in the 'no access' types there can be no costs for providing access. The average costs here are assumed to apply to multiple-objective, low facilities access. Additional costs of recreation not based on area are also available and these can be divided up across the 'high' facilities areas to tune the costs assumed in the model to the actual costs faced by the estate.

- Conservation and heritage: these costs also fit into the typology under the multiple objectives heading, and because they vary in the data between high and low biodiversity priority woodlands.

- Community engagement: these costs are particularly relevant for community forests, although they also arise elsewhere to a minor extent

Under our assumption explained in Section 4 below – approximately 50 high facility centres of 500 ha each - there are approximately 25,000ha of PFE woodlands in the category "high facilities". Splitting an annual spend of almost £5 million on providing recreation facilities across this area gives a cost of approximately £200/ha/yr for these areas.

The base data are presented in Table 13 below, rounded off from the original FC data. These are the figures that form the basis for the assessment of costs for each forest type. The figures are based on an assessment of the total costs for different categories within the PFE, divided by the number of hectares present to give an average cost per hectare per year. Therefore the figures used here reflect averages, and are appropriate for use at a national scale, but may not reflect well the details of specific case studies

Table 13: Average costs for different types of woodlands/open habitats on the PFE (£ per hectare per year)

Type in FC Data	Land management	Access provision	Conservation and heritage	Community engagement
Community woodland	160	160	50	160
Coniferous / commercial (inc. PAWS)	120	6	10	10
Broadleaved	120	6	10	10
ASNW/restored PAWS	80	6	30	10
Open lowland heath and other priority	40	6	120	10
Open 'other' (interpret as lower priority)	40	6	20	10
Cost of high facilities access		160		

7. Values of Ecosystem Services of Woods and Forests

Defra (2007) defines ecosystem services as "the wide range of valuable benefits that a healthy natural environment provides for people, either directly or indirectly". The most widespread categorisation of ecosystem services derives from the Millennium Ecosystem Assessment (2005), which divides services as follows:

- Provisioning services – products obtained from ecosystems, such as timber, fresh water and food;
- Regulating services – benefits from the regulation of natural processes, such as air quality regulation, climate regulation and water/flood regulation;
- Cultural services – benefits people obtain from ecosystems through recreation, aesthetic enjoyment, appreciation of heritage and tradition, learning and similar non-material benefits; and
- Supporting services – services that underpin production of all other ecosystem services, for example primary production, soil formation, nutrient cycling and water cycling.

There are several variations on this theme (see e.g. Balmford et al. 2008;Boyd and Banzhaf 2007; Fisher et al. 2009; Martin-Lopez et al. 2009) and in particular there is a common distinction between 'final' services that are directly consumable end-points of ecosystem functioning and 'intermediate' services that support these services. Thus the supporting services and some of the regulating services are 'intermediate', and their value to humans derives from their role in supporting the value of 'final' services. This is important from the perspective of valuation, since there is a risk of double-counting if we attempt to value both the final and the intermediate services. The correct approach to dealing with this depends on the boundaries of the assessment in relation to the system under study. For this study focusing on woodlands and forests at a national scale, we do not attempt to value supporting / intermediate services. This does not imply that these services are not valuable (on the contrary, they are of great value) but simply that the major part of this value is already reflected via the values applied to final services in the provisioning, regulating or cultural categories. The National Ecosystem Assessment currently being undertaken for the UK and funded by all of the national assemblies, Defra, and others, takes this approach

The ecosystem service impacts of forestry depend heavily on the species, spacing and mix of trees grown, the types of habitat they replace, and their context/ location in the landscape. The main services, and options for their valuation, are listed in Table 14.

Table 14: Ecosystem services of woods and forests and their economic value

Ecosystem Service	Main types in woods and forests	Methods of Valuation
Provisioning Services	Timber (fibre, construction, furniture) Renewable energy (fuel woods) Food (wild foods) Ornamental goods (Xmas trees, foliages, moss)	Provisioning services have direct use value and are relatively easy to monetise. Many have market values, and others (such as wild foods) will have market equivalents even if they are not directly sold. Recreational/cultural aspects of wild food collection / hunting will not be covered by market equivalents, but can be treated under 'Cultural services'
Regulating Services	Climate change regulation (carbon sequestration, soil impacts) Air quality regulation Water/flood regulation Water purification Pollination and pest control services	Indirect use values. Some services can be monetised relatively easily, in particular carbon sequestration can be valued at official UK shadow prices. Others require production function methods or other techniques, and service definition/measurement can be difficult.
Cultural services	Walking Picnics Biking Riding Camping Field sports Views/aesthetic enjoyment Historic/cultural values Education Biodiversity (part) Other non-material benefits	Mix of value types: direct use values for many services, but also non-use values. Direct use values measured in some cases via markets, more generally via travel cost and sometimes hedonic methods. Non-use values require stated preference techniques. Valuation issues relating to scale and alternative resources/activities. Care required to avoid double counting.
Supporting services	Photosynthesis/ primary production Soil formation Nutrient cycling Water cycling	Correspond to all components of economic value through their support for the other ecosystem services. Valuation likely to be difficult, but also for most appraisal purposes unnecessary, since generally these are intermediate services and their values are already (largely) contained in the values of the other service categories.

In 2003, the FC released a report titled The Social and Environmental Benefits of Forests in Great Britain (Willis et al. 2003) that explored seven primary non-commercial benefits arising from woodlands in Great Britain: recreation; landscape; biodiversity; carbon sequestration; archaeological preservation; pollution absorption; and water supply and quality. An estimation of the total annual and capitalised value from that study is presented in Table 15.

Table 15: Social and Environmental Benefits of woods and forests in Great Britain (£ millions, 2002 prices)

Environmental Benefit*	Annual Value	Capitalised Value
Recreation	393	11,218
Biodiversity	386	11,029
Landscape	150	4,292
Carbon sequestration	94	2,676
Air pollution absorption	<1	11
Total	1,023	29,226

*Only lists the benefits identified as most important in Phase 1 of the study. Source: Willis et al, 2003. Note that carbon value based on £6.67 per tonne of carbon sequestrated, much lower than current official values; with current guidance on values (DECC 2009) the carbon values would dominate other values in this analysis.

This gives an impression of the overall values at stake. However for appraisal of specific forestry options, using the forest typology, we need to consider the marginal impacts of changes in forest services.

In Section 2, we set out the arguments for using average costs smoothed over time and the forest estate, rather than attempting to build bottom-up estimates of management costs. Similar arguments hold for some services on the benefits side, most notably timber production, for which average revenue figures are available from the same source as the cost figures. For consistency, and because the typology does not include time, it is sensible to adopt this approach across the board, and to consider the value of a given ecosystem service for a given woodland type as the average level of that service across a forestry cycle.

The timing of costs and benefits is also analysed because they may arise on different timescales (e.g. benefits of PAWs restoration may lag costs). This will be handled by specifying the timing of when actions take place and therefore allocating costs and benefits over appropriate timescales (with smoothed profiles, as above, where necessary), using discount rates as per the HM Treasury Green Book[3] (this includes a declining discount rate for long-term costs and benefits).

With each of the services, this study requires both data suitable for aggregation across the whole forest estate in England, and marginal values for changes to the estate at a national or site level. This creates a clear marginal-aggregation conflict for data. Where the data set is strong enough this may be allowed for in the choice of values, but in other cases assumptions are necessary and potential pitfalls need to be borne in mind.

[3] http://www.hm-treasury.gov.uk/data_greenbook_index.htm

7.1 Provisioning Services

Timber/fibre

The most 'obvious' marketed service provided by forestry is timber production, though for the PFE revenues from other sources such as recreation spend are also significant. In the UK, gross value added in forestry and primary wood processing was slightly over £2bn in 2007 (Forestry Commission 2009). Timber is a marketed product and can be valued using market prices. However in terms of annual flows to a forest, timber sales from a specific forest are a very lumpy or variable index, since timber harvesting occurs at lengthy intervals for any specific area. Hence for any specific forest, the change in value of standing stock is a better indicator of the annual flow of benefit, even though these flows may be converted to 'hard cash' only infrequently. However this argument does not apply to larger forests, and even less to the entire Public Forest Estate, or all English woodlands, because they include a wide distribution of age and yield classes and therefore 'smooth out' revenue fluctuations over time.

Another key factor in determining harvesting prices is whether the cost of working the timber is included (giving a much higher sale price). The standing sales index does not include working costs so equates to the 'real' value of the timber. It demonstrates the variation dependant on tree size.

Prices can be volatile – for example, the coniferous standing sales price index for Great Britain fell 30% in real terms in the year to March 2009, having risen 52% in the year to March 2008 – and it can be difficult to predict the future values of timber, which depend on demand and, most importantly, on world supply. Since year on year variation is so large, it is important to consider smoothed averages for valuation purposes – available for example in Bateman et al. (2003) who examine price series back to 1870.

See Figure 5 for timber price indices for the period March 1984 to March 2009.

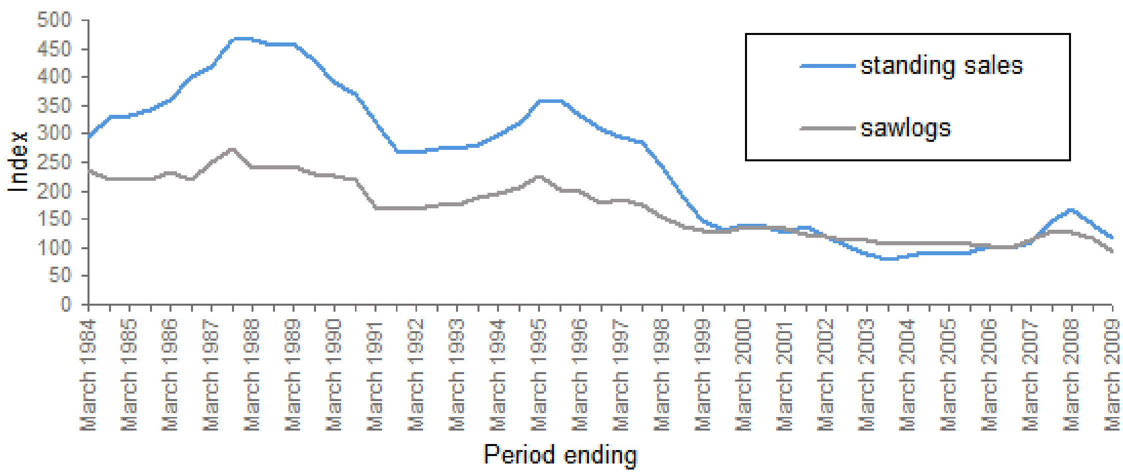


Figure 18: Source: Timber Price Indices in real terms 1984-2009, from FC 2009

Estimates of values per hectare by age of forest, and of annual returns to selected private forestry, are available for private coniferous forests in the UK via the IPD UK Forestry Index. For example average total return since 1992 is estimated at 4.1% for North England (IDP 2008). However these estimates reflect the returns to investors, which is not the same as the underlying value of the ecosystem service (timber production) due to subsidies/grants and tax incentives that distort the link between price and value, includes other incomes (e.g. from shooting), but does not reflect any non-market benefits.

The best approach for our current purposes is to derive annualised average flows of costs and timber benefits for each forest type. This in effect ignores the specific timings and age characteristics of specific woodlands and forests, instead considering them simply as representative of their type. As with many of the assumptions we make, this is acceptable for a broad-brush assessment of forests at the national scale, but would have to be reconsidered for any specific case study.

The average values for timber production available from the FC data (PFE Landuse Financial Models) are as follows:

- Conifers and PAWS: £120 per ha year
- ASNW and restored PAWS: £15 per ha year
- Other broadleaved: £30 per ha year
- Open habitats: £0.

We do not separately consider employment in forestry or associated industries such as forest tourism or timber processing. Overall, timber production plays a small but significant role in supporting jobs in rural areas. However, there is a general trend towards mechanisation in forestry, and employment in timber production has fallen. Although important from a social policy perspective, insofar as an economic analysis is concerned, employment is not directly a benefit but rather a cost (the cost of labour), although where unemployment is significant the economic cost of labour may much lower than the financial cost (because the "alternative use" of the labour is unemployment). Nevertheless, it is likely that any change in cost estimates resulting from a full analysis of this issue would be very small in comparison to overall costs and benefits, so we do not attempt this here.

Conclusion: we value timber production according to the averages in the FC data, both for FC land and for private land. However, we need to make some adjustments to account for the different management objectives. For simplicity, we assume that the FC figures apply to land managed under 'multiple objectives'. The FC extracts 90% of the annual increment of softwoods, and 44% of the increment of hardwoods (see Figure 19) – this contrasts with 37% and 11% respectively for non-FC land, reflecting in particular that a large proportion of non-FC woodlands are not under active management.

Based on a total broadleaved areas of ≈63,000ha, of which ANSW/restored PAWS accounts for ≈18,000ha, we estimate that 26% of the increment from ANSW/restored PAWS is extracted, and 51% of the 'other' broadleaves' increment.

Based on these assumptions, we can value timber output from 'multiple objective' land as shown in Table 16 (in the conclusions to Section 7.1, below). We assume that urban community woodlands have zero timber revenues, reflecting that the focus here is not at all on harvesting, and that if ever timber were to be harvested from these areas it would probably cost more than its value to extract.

These values assume that there is no systematic difference in the annual increment between FC and non-FC land, within each of the categories above, and ignores any premium value for certified timber or any other systematic difference in timber values.

Renewable energy

Woodfuel is expected to be an important factor in meeting the 2008 EU target, which stipulates that 15% of all energy produced in the UK should come from renewable sources. In fact, the Renewable Energy Strategy has anticipated that

30% of these renewable sources will be bioenergy. According to 2009 Forestry Commission data, in 2008 the UK supplied an estimated:

- 0.8 million oven dry tonnes of wood chips;
- 0.1 million oven dry tonnes of wood pellets (excluding imported pellets);
- 0.1 million oven dry tonnes of logs for stoves and open fires; and
- 0.1 million oven dry tonnes of woodfuel in other forms.

In principle the greenhouse gas regulation impacts, and other pollution impacts, arising through displaced conventional power generation, should be considered. The carbon intensity of the 'average grid mix' is 0.49 $kgCO_2$/kWh (Carbon Trust, 2006[4]), whereas for woodfuel it can range from 0.354 to 0.349 $kgCO_2$/kWh for wood chips and pellets respectively (FC 2009). However new official guidelines (DECC 2009) are that new renewable investments should be considered as displacing not conventional but rather renewable sources: "Changes in the level of renewable energy delivered should be valued using the marginal cost of delivering it from other sources: £118/MWh." This is a target-based approach: the UK has a commitment to meet certain levels of renewables, and the impact of producing renewable energy from woodland sources, under this approach, is to reduce the need for renewables investments elsewhere. If valuing in this way, we should not take account of the external costs of conventional energy, because it is not conventional energy that is displaced.

This approach applies only to renewable investments that count towards the UK renewables target; logs for domestic use do not come into this category and it is appropriate to account for the impacts of displaced conventional energy here, although some of the possible impact will be absorbed by increase in service demand (i.e. heating a house/room more than would be the case without the log fire) so a simple energy-content calculation is not strictly accurate.

Costs associated with renewables production should in principle be taken into account. These include the construction and running costs for producing the energy. These can be quite site specific, in particular for woodfuel, for which the efficiency depends on transport costs, though "unless transport distances are very high, the embodied energy of the fuel is generally a small percentage of the energy output from the fuel" (Ayling 2005). Local impacts of transport could be significant and for larger renewable power plants these costs would need to be taken into account.

[4] Differs from 0.43 kg CO_2 per delivered kWh often quoted: "figure quoted here uses different data sources and covers a more recent time-period" (Carbon Trust, 2006)

Conclusion: there are some potentially complex considerations that should in principle be taken into account in a detailed study. However for the purposes of a broad-scale approach, we can use the following line of argument:

- Trees absorb carbon, and this will be accounted for under 'regulation of greenhouse gases' below;
- When harvested and burned for energy, carbon is released, but this displaces energy and carbon emissions from other sources. If it is displacing other renewables, then the result is likely to be a net increase in emissions, so we should in principle value that increase, but also value the energy produced at the marginal cost of renewable investments (DECC 2009);
- The market value of fuel woods is an ecosystem service that should be valued in the assessment BUT the value identified for 'timber/fibre' above includes all timber sales from the PFE and therefore already accounts for fuel woods

Forest foods

Although in principle the value of forest foods such as mushrooms could be calculated via market proxies, in practice this is likely to be low for most cases, and will be reflected in recreational values. An exception to this is any case in which the forest product is actually marketed, in which case that value can be used. Foods arising from field sports are also valuable, but again, this may be better accounted for via the payments made for participation in field sports, with the exception of game traded via game dealers, in which case market values could be considered. Research for Scotland (Edwards et al 2009) showed that value of non-timber forest products like mushrooms was tiny.

Conclusion: we do not attempt to value forest foods directly.

Summary for provisioning services

For provisioning services, we assume that the average timber revenue figures from the PFE are representative of the revenues arising for timber and fuel wood sales per hectare in the PFE. But we also need to account for differences in the rate of extraction, in particular between the PFE and non-FC forests (see Figure 19), as explained above. The overall estimates of provisioning services are detailed in Table 16.

Table 16: Provisioning service values for different forest types (£/ha/yr)

Management:	**Multiple objectives**	**For Timber**	**Low intensity**
Conifer/PAWS	120	120	0
Broadleaf high value	15	45	0
Other broadleaf	30	45	0
Open habitat	0	0	0
Urban community woodlands	0	na	na

7.2 Regulating Services

Regulation of greenhouse gas emissions

Carbon sequestration associated with woodlands can be broken down into four main areas (Brainard et al 2006):

- Live wood, including all biomass in plantation trees;
- Wood products (including harvest, storage, displacement factors, fossil fuels used in manufacturing and end-of-life impacts);
- Leaf litter and debris; and
- Soils: generally increase carbon storage when first afforested, eventually reaching new equilibrium, but peat soils are an exception and can release large volumes of carbon when afforested.

The total carbon in UK woods and forests has increased from 1990 to 2005 and the total stock is projected to continue to increase to 893 mtC by 2010. The carbon in forest soils accounts for most (around 80%) of total forest carbon, and most of the increase in the total figures for UK woods and forests is due to change in land-use: existing soil carbon stocks being counted as wood/forest carbon when the land is converted to wood/forest.

In climate change reporting, removals to forestland, also called the forest sink, measures the net annual accumulation of carbon in woods and forests by woody biomass, soils and litter. The annual rate is reported to have peaked in 2004 at 16 million tonnes CO_2 in total, of which 12 million tonnes CO_2 was in living biomass, and is expected to fall steadily to 2020. Under the Kyoto protocol, additional woodland planted since 1990 contributes to the UK's carbon dioxide emissions target; this will increase as woodland continues to be planted (FC 2009).

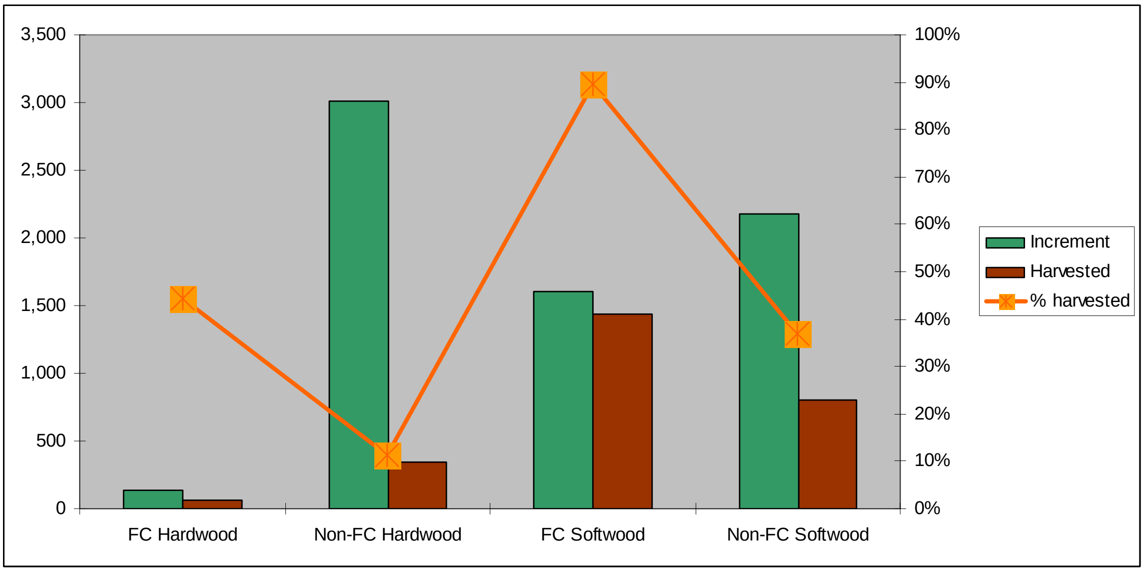


Figure 19: Annual increment ('000 m3) and proportion harvested (%) by type

Forest carbon accounting confronts some issues with the certainty of both current and future scenarios. Relationships between carbon sequestration and tree species, growth rate, thinning, and rotation length are known reasonably well, but there is uncertainty about changes in the carbon content of soils between agriculture and forestry, and about the fate over time of carbon locked-up in timber products.

Carbon storage in vegetation or soils is reversible, although it can be argued that this does not detract from the value at present (future emissions from the land would need to be accounted for separately). Taylor (2005) notes that new forested land in Britain can accumulate carbon at 2 teC/ha for over 100 years, and, over the time horizons of appraisal, it is valid to consider sequestered carbon as a quasi-permanent solution. Other greenhouse gas fluxes may offset the carbon benefits, and should in principle be considered, however these may be site specific (depending for example on underlying soils).

When accounting for carbon in forestry, the appropriate treatment will depend on the counterfactual and/or baseline conditions. Average productivity of broadleaf and conifer woodland respectively over the course of a conventional rotation is [5]12 and [6]4 cubic metres of timber per hectare per year. This represents an average rate of carbon uptake, including into non-harvestable fractions (roots and branches) of [7]10.6 and [8]5.7 tCO2/ha/yr. However, on the PFE timber harvest is [9]86% of annual increment (the comparative estimate for the private sector is 22%). As a result, the net uptake of CO2 into the growing biomass of the PFE in England only makes a contribution of [10]253,000 tCO_2/yr to the total forest carbon sink of the UK of [11]14.2 million tCO_2 in 2007, of which 2.9 million tCO_2 is attributed to English woodlands. However, the wood and timber products harvested from PFE woodlands also make a contribution to climate change mitigation through substituting for fossil fuels both directly (in the form of woodfuel) and indirectly by replacing energy intensive materials such as concrete and steel. Based on the analysis presented in Read (2009) and averaged over the course of conventional rotations, wood and timber products from broadleaf woodland could potentially deliver abatement of [12]3.4 tCO2/ha/yr through sustainable production, while for conifer woodland, this would amount to [13]8.1 tCO2/ha/yr. Native woodlands managed for biodiversity and other objectives generally will not deliver abatement through substitution of fossil fuels, but will typically support larger stores of carbon

[5] Actual figure 12.58 [source John Tewson].

[6] Actual figure 4.12 [source John Tewson]. Note: this may be an underestimate as it includes 9,000 ha nominally YC0 broadleaves.

[7] Assumes GYC12 Douglas fir, specific density 0.35, with expansion coefficients of 1.2 for and 1.18 for non-merchantable above-ground and below-ground components, respectively.

[8] Assumes GYC4 oak, specific density 0.56, with expansion coefficients of 1.2 for and 1.18 for non-merchantable above-ground and below-ground components, respectively.

[9] 90% for softwoods and 44% for hardwoods [source John Tewson].

[10] Based on increment and harvest figures for the PFE, assuming specific densities of 0.55 and 0.35 for hardwoods and softwoods, respectively, and a combined expansion coefficient for non-harvestable fractions of 1.38.

[11] UK GHG inventory report for the Land Use, Land Use Change and Forestry Sector.

[12] Substitution (including traded sector) through product displacement and direct fossil fuel assumption based on the analysis presented in Read *et al*. (2009). Substitution scaled to GYC4 from GYC6 mixed broadleaf woodland (SAB) managed on an 80 year rotation (Case C1 in Read *et al*., 2009).

[13] Substitution (including traded sector) through product displacement and direct fossil fuel assumption based on the analysis presented in Read *et al*. (2009) thinned Sitka spruce/Douglas-fir managed on a 60 year rotation (Case G in Read *et al*., 2009).

up when averaged over the long term - potentially [14]400 tCO2e/ha more. Open habitats clearly support much lower carbon stocks in vegetation (typically less than [15]50 tCO_2e/ha)and except in rare circumstances, do not deliver abatement through fossil fuel substitution.

The valuation of carbon storage requires a value per tonne of carbon: this can be derived in various ways, but in the UK, for public sector appraisals, there are official values that must be used. The most recent guidance, set out in DECC (2009), is based on estimates of abatement costs: this reflects that the UK policy on carbon emissions is target-driven, with cost-effective attainment of a target requiring equal marginal abatement costs across sources. The guidance distinguishes between 'traded' and 'non-traded' carbon ('traded' means 'covered directly or indirectly by the EU Emissions Trading Scheme), because there are different targets. The 'traded' and 'non-traded' prices differ until 2030, from when it is assumed that a global carbon market is in place with a single price. The relevant prices for the forestry sector are 'non-traded' and rise from £50/tCO_2e (range £25-£70) in 2008 to £70/tCO_2e (range £35-£105) in 2030, then to £200/tCO_2e (range £100-£300) by 2050. Although official values need not be directly related to WTP estimates, they are clearly the most suitable choice for appraisal purposes, for reasons including consistency in appraisal across the public sector and ease of application.

Conclusion: although there are many nuances to accounting for carbon in woodlands, including lifecycles of forest products, thinnings, and so on, on average overall it is acceptable to use a constant sequestration per year. See for example Figure 1 in Brainard et al (2008): a linear trend gives a perfectly acceptable fit to the "Net C flux" curve, certainly within the bounds of measurement and valuation errors. If we assume that the scenarios considered here represent approximately steady-state conditions for the PFE as a whole, then we can also assume approximately constant harvesting and carbon substitution benefits.

Based on the discussion presented above, including data from Read et al (2009; see also ADAS, 2009)) and on assistance with data and interpretation from the Forestry Commission (Mark Broadmeadow, pers comm) we make a simple assumption that the total of sequestration and substitution impacts for broadleaves, on average through cycles of planting and harvesting, is approximately 3.4tCO_2e/ha/yr, while for conifers the comparable figures is 8.1tCO_2e/ha/yr. These figures represent broad averages across the whole estate and over long periods.

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[14] See Chapter 6 of Read *et al*. (2009). Average (mid-rotation) carbon stocks for FMA 1 unmanaged forest nature reserve 800 tCO_2e/ha; for FMA 4 intensively managed even-aged forestry, 400 tCO_2e/ha.

[15] FCE step 2 open habitat policy development evidence paper. A conservative value of 18 tCO_2e given as an average for all open habitats.

As noted above, unharvested woodlands will not provide any substitution benefits, but on the other hand they support higher average stocks of carbon. Where there is no harvesting (under “low intensity” management) there will be sequestration but no substitution: on the other hand, these woodlands will build up biomass (up to a point). There also remains the option of harvesting in future. Therefore the specific details of the carbon impacts for woodlands under low-intensity management will depend on case-specific factors and on the time-horizons of analysis. For the purposes of the present broad-scale assessment, looking towards a long-term steady state for the PFE, we make a rough assumption that, on average across woodlands and over the time scales of interest in this study, non-harvested woodlands corresponds with a 50% reduction in the net greenhouse gas impact over several rotations. However this is a very crude assumption: more detailed work taking account of different ages and yield classes could involve more accurate measurements here.

Community woodlands are a special case because the planting density is much lower than in other woodlands. In addition, we assume that there is little prospect of commercial harvesting from these woodlands, and therefore limited potential for substitution effects: although at some point in the future some fuel wood extraction is possible, this would generally be expensive work, given constraints associated with urban location and low planting densities. We make a very crude assumption that urban community woodlands sequester 1tCO_2e/ha/yr.

Carbon sequestration/emissions from open habitat within woodland areas are difficult to determine, since they will depend on a wide range of site-specific factors. Generally, the process of converting woodland to open habitat will involve substantial losses of carbon, but the open habitat itself may or may not be a source or a sink. Total carbon stocks in open habitats will be significantly lower than in woodlands. Methane emissions from peat habitats is a particular issue. For the purposes of the broad assessment here, we assume zero net emissions from open habitats, and also consider that the emissions involved in converting from forest to open can be ignored because generally this will happen at the time of harvest, the timber and fuelwood removed will displace emissions from elsewhere as normal, and there will be no net difference at that time. There will however be an ongoing loss reflected in the cost-benefit framework via the ongoing annual reduction in sequestration.

Air pollution regulation

Woodlands play a role in regulating air pollution, both via direct absorption of pollutants and through their role in producing oxygen. Various methods can be used to estimate the value of avoided illness or death from air pollution. In many cases estimating a dose-response relationship is a preliminary step: this expresses a relationship between pollution levels and statistical health outcomes in a population, including estimation of the impact of woodlands on pollution levels. This is then followed by valuation of the health impacts thereby estimated – for example Willis et al. (2003) used a value of £124,998 for each death delayed by 1 year due to PM10 and SO_2 absorbed by trees, and £602 for an 11 day hospital stay avoided due to reduced respiratory illness.

The total value of air pollution regulation by woods and forests reported in Willis et al (2003) is very low compared to other services (see Table 15) but this may be largely because the research focused on the effects of tree absorption within 1km^2 areas; a lack of information on trees' absorption of pollution on a wider scale meant that assessment of the impacts of pollution absorption beyond this very local scale was not possible.

Conclusion: A key problem here is the availability of data suitable for estimating a dose-response function. In the absence of clear information, we do not attempt to value the role of forests in reducing air pollution. We note, however, that this role could be important, particularly in urban areas, and further research here may be justified.

Water purification and supply

Although water supply is a provisioning service, the role of woods and forests is more indirect – purification, retention – and so woods and forests contribute to regulating services that support water supply downstream in catchments.

There are three major properties of forest watersheds generally responsible for the quantity and quality of water flow; interception, evapotranspiration, and infiltration (Ferguson 1999). Removal of forest cover from a forested watershed can result in important hydrological changes, resulting in decreased interception of rainfall by the forest canopy, decreased evapotranspiration, decreased rainfall interception by surface litter, and increased runoff volumes (Stednick 1996).

Woods and forests play a key role in many watersheds, influencing particle load and timing of runoff, impacting on downstream catchments in terms of water quality and quantity, which can in turn impact on drinking water and on water for irrigation and industry as well as recreational use of water courses. During periods of low precipitation, forestry can reduce runoff to the point where a negative value due to low flow has been suggested for some areas of South West England (Willis 2002) and Ireland Brander et al. 2009), but Willis (2002) also notes that British water companies perceive little impact of existing forestry on water supply costs.

Willis et al. (2003) use a cost of up to £1.24 per m^3 where water is lost to abstraction for potable uses, depending on the region, but for most areas the marginal cost is zero. The externality cost of woodland on water quality has been 'internalised' within forestry through the application of guidelines on woodland planting and conditions attached to forest certification. However there may be scenarios under which these costs could be significant. Willis (2002) argues that forestry and land-management decisions are long-term and that the value/cost of the water supply service impact can be estimated via the long run marginal costs (LRMC) of water supply in the area. These are estimates for the total cost of abstracting the next cubic metre (m^3) of water, including any capital investment costs. Estimates of LRMC are available from water companies via OFWAT (Willis 2002).

If the area under assessment drains into a hydro-electric dam, then there may be a need to assess the opportunity cost of reduced flows (renewable electricity generation foregone, and associated increase in conventional energy and emissions) and any impacts on the running costs or expected lifetime of the power station (for example, associated with reduced sediment loads). In principle this can apply also to hydro-power potential: some management options may facilitate hydro-power and others preclude it. This would need to be taken into account in the definition of the environmental baseline and the options.

In principle, reduced water availability could also reduce agricultural values due to reduced irrigation. However, Willis (2002) notes that, because of subsidies, the marginal social cost of agricultural production exceeds its marginal value to society, so the cost of reduced water for agriculture is likely to be low at the margin.

Where recreational downstream benefits are also of importance, the techniques available for valuation or benefits transfer are identical to those for outdoor recreational values (see forest recreation section). University of Brighton (2008) provides a review and assessment of valuation of water-based recreation in the UK context, and makes a list of recommendations for research in this area. However for present purposes it is highly unlikely that the importance of forestry impacts on downstream water-based recreation would be significant enough to justify the effort of their estimation.

Conclusion: forestry impacts on water supply and quality are very uncertain, and site-specific. Willis et al (2003) do not identify these issues as being among the significant ones (see Table 15). We do not have strong data and valuation estimates for assessing these impacts. Also, the scenarios under consideration do not envisage wide-scale deforestation, but rather focus primarily on alterations in management practices, and changes in types of woodland cover, so the impacts on water supply and quality may be expected to be minor. Therefore we do not attempt to value these impacts here, but note that such valuation could be necessary if examining scenarios involving large scale changes in extent of woodland cover.

Flood mitigation

In addition to possible impacts on water quality and quantity, forestry can influence the frequency, severity and/or control costs for flooding downstream, by influencing water storage capacity and risks of excessive runoff. Valuation can be carried out through estimating the expected damage costs avoided plus any change in flood defence expenditures. Values could also be estimated through willingness to pay to reduce flood risks. Care is needed to avoid double counting if mixing these methods.

To assess values of changes in this service, we would need a clear determination of the link between forestry / land management and flood risks downstream. Data availability is a significant problem here. If a link could be made, the costs of flood risk could be broken into two main components:

- The impact on flood protection expenditures arising from changes in flow and gross risks; and
- The *residual* risk of flooding and the damage costs associated.

Both are highly location specific, though it may be possible to derive ballpark figures for rough assessments.

Conclusion: Full valuation of the benefits of flood risk management is a complex exercise, but achievable, for example following guidelines set out in the Multicoloured Manual (Penning-Rowsell et al 2005). For specific cases, it may be possible to determine the impacts of particular forest options on flood risks in associate flood plains. Assessment of average impacts at the national level would however be a major exercise, beyond the scope of this study. Where scenarios include radical changes in forest cover at the catchment scale, then detailed analysis may be warranted. However for present purposes, and in particular examining changes in management practices rather than widescale changes in extent of forest cover, the impacts are likely to be limited.

7.3 Cultural Services

Woodland areas have important cultural services, both in terms of use and non-use values. Key uses include recreation and aesthetic appeal, while important non-use values include heritage and biodiversity conservation (there are also use elements to these values). Figure 20 summarises questionnaire results supporting the strong cultural and non-use element to how the English public views forests.

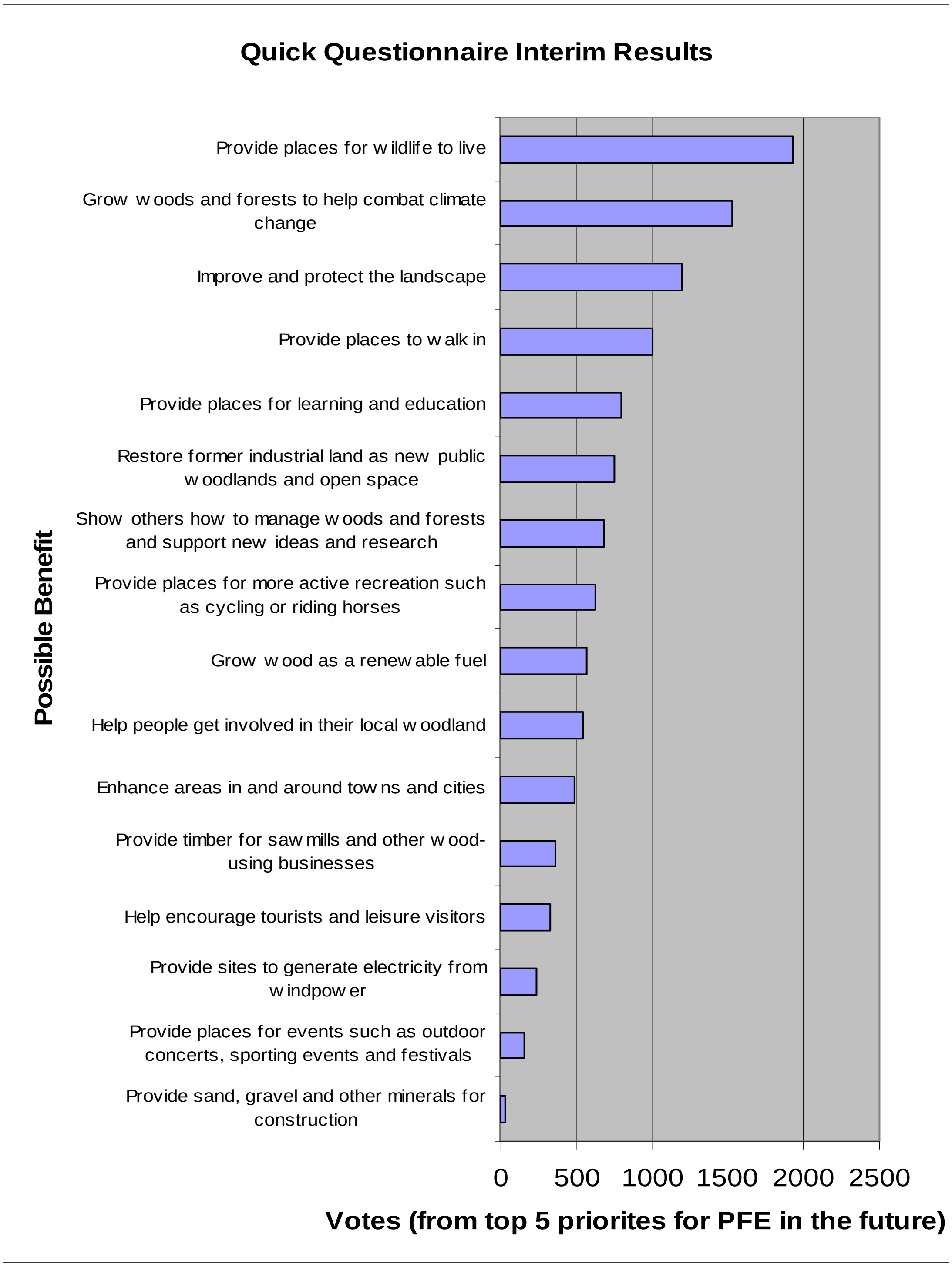

Figure 20: Public attitudes to the PFE: strong evidence for cultural importance

Source: FC data.

It is noteworthy that, despite the high value of recreation in forests (see below), the top three responses in the public survey of priorities for the PFE (Figure 20) relate to other values: "provide places for wildlife to live", "grow woods and forests to help combat climate change" and "improve and protect the landscape". Of these, we assume that the climate change values are adequately reflected in the official values applied to greenhouse gas sequestration (see Section 7.2). The landscape issue is considered in this section under "aesthetic values" (the use value element) and under "biodiversity and non-use" (the non-use element). The issue of providing habitat for wildlife is considered under "biodiversity and non-use" (for the non-use element) although wildlife also has use values (such as birdwatching) that are considered to be included under the recreation category.

Forest Recreation

Woods and forests are widely used for recreation purposes in England, and 77% of people have visited woodland in the last few years for walks, picnics or other recreation (Public Opinion of Forestry Survey, England, 2009). There were 170 million visits to woodland in the England Leisure Visits Survey 2005 (respondents living in England) – 5% of all leisure visits. Roughly 1/3 trips under 1 hour, 1/3 between 1 and 3 hours, 1/3 over 3 hours (including travel time). Round trips roughly 1/3 under 5 miles, 1/3 up to 20 miles, 1/3 over 20 miles. However Woodland Trust (2004) estimates 59% of visits to woodland sites involve a total round-trip distance of under 5 miles (The Woodland Trust, 2004). The total number of visits is rather uncertain, with Jones et al (2002) citing 350m annual visits for the UK, and the GB Day Visits Survey giving for England 308 million (1996) and 321 million (1998).

The Woods for People project has created a UK-wide provisional inventory of accessible woodland. Over half the population has access to over 20ha of woodland within 4km. In 2008, 48% of UK woodland was assessed as being accessible to the public, but only 34% of English woodland. So although woodlands are heavily used, 2/3 of English woodlands are not accessible to the public. This is likely to be a major source of difference in total economic value of different types of forest.

It is worth noting that provision of recreation facilities, and tourism expenditure, can be important direct and indirect sources of employment and income in forest areas. This is not reflected directly in the economic value framework used here, beyond the consideration of the value of recreation, and the costs of providing access. In general, at the national level of analysis, the net impacts would be small, because the expenditures are diverted from other areas, and because employing scarce labour is a cost rather than a benefit, as discussed above. Again, the impact of using a shadow value for labour would be small relative to other costs and benefits, and we have not attempted to estimate this explicitly.

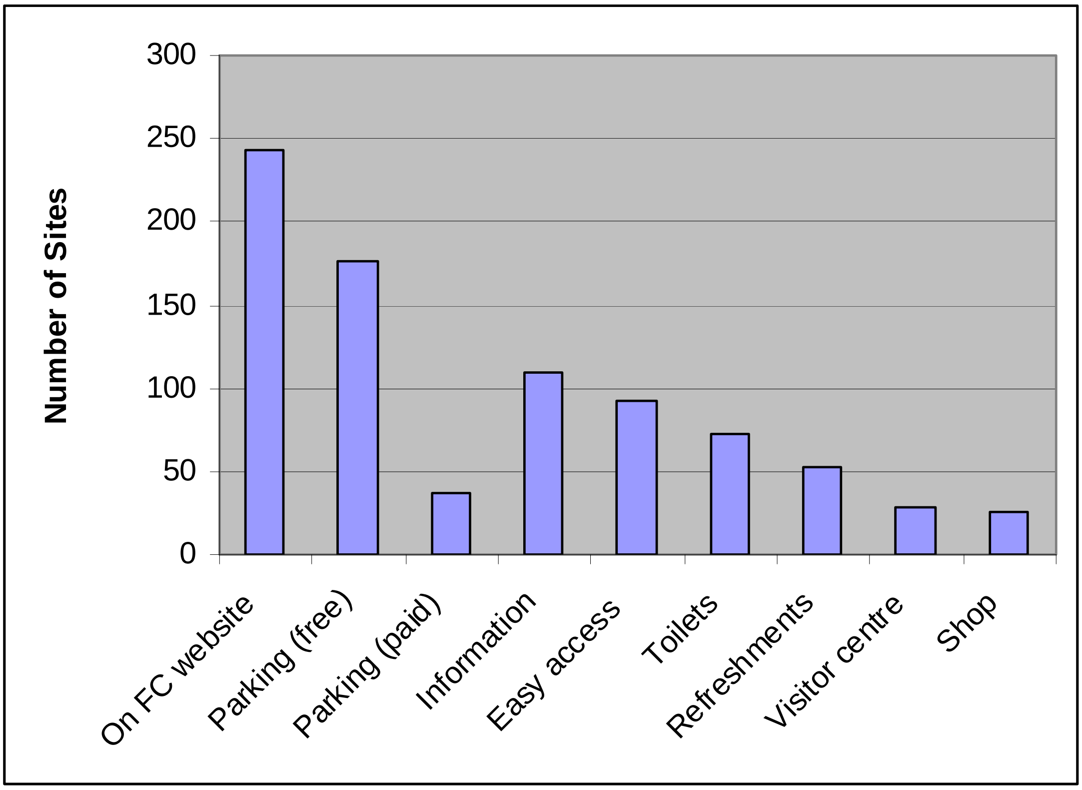

Figure 21: FC sites in England with specific facilities (Forestry Facts and Figures 2007)

Table 9 summarises economic valuation methods that can be used to estimate the value of forest recreation.

Table 17: Economic Valuation Techniques for Forest Recreation

Technique	Applicability	Pros	Cons	Overall
Market price	Entrance fees; local expenditures	Easily observable and based on real payments	Relate to prices not values; free access does not mean zero value	Important data that must be processed carefully. Key input for travel cost. Suitable for certain paying activities such as field sports, 'Go Ape'
Hedonic pricing	In principle, via housing and hotel/holiday let markets	Based on actual behaviour/ expenditures	Data may be hard to get. Problems defining market boundaries and participants.	Potentially useful if data are available but not recommended for primary study.
Travel cost	Any site or activity which involves travel to the uplands.	Based on actual behaviour, relatively straightforward	Hard to value prospective changes	Useful if available. Primary studies possible.
Stated Preference	Yes	Can be used to value all recreational activities. Additionality can be internalized.	Can be complicated to implement and analyse.	Very useful if available. Difficult to separate use and non-use - bear in mind for avoiding double counting (easier to separate user and non-user). Primary study possible.

Forest recreation has long been recognised as important and valuable, and the Forestry Commission established in 1992 an estimated value for recreational visitors of £1 per visit (since indexed) (Willis et al 2000). Willis et al (2003) used values of £1.84 to £3.06 (at 2008 prices) for each recreational visit. Bateman and Jones (2003) provide a meta-analysis of forest recreation values for the FC. They include 13 different studies published before 1997, covering 21 different woods and forests that provide a total of 77 different estimates of the per-person per-visit recreational benefits from both travel cost and contingent valuation methods. The majority of these estimates relate to use value, although 16 are classified as relating to use plus option values. Of the 61 value observations related to current use values, estimates range from £0.11 to £4.78 (2008 prices). Christie et al (2005) estimate the value of recreational improvements to forest sites for different user types (walkers, cyclists, horse riders, nature watchers) ranging between £8.53 - £16.18 per visit (2008 prices) via travel cost studies. Contingent behaviour and choice experiment analyses are used to estimate changes in visitor welfare associated with improvements[16] to specific recreational facilities (e.g. value of paved cycle track to cyclists). Scarpa (2003) similarly reports values of £1.88 – £3.16 per visit based on contingent valuation data for woodland sites (2008 prices). Murphy 2006 found for an on-site survey in Ireland in a commercial forest per visit that the typical value placed by a user on a visit to a trail or forest site was £4.88 (2008 prices).

Jones et al (2002) found a weak but statistically significant difference in the value of recreational forest visits based on facilities at a particular site, although the effects of site location, proximity to populations and substitute sites provided a stronger predictor of demand than facilities available. But it is clear that visitors do respond to facilities, publicity and 'welcome', and this is supported by research such as Carter et al (2009). Forest recreation values are summarised in Table 19 below.

Conclusion: The value estimates available suggest that values for trips to woodlands could be rather higher than previous estimates used in forestry appraisal. The Christie et al (2006) study in particular would support values around £15 per visit for forests offering specific amenities for walkers, cyclists or horse riders. Zanderson and Tol (2008) find a similar value of £15 in a European meta-analysis. Higher values arise in the Kaval (2006) study: this is for the US, and straight transfer is not advisable, but nevertheless this very wide review gives support to the use of Christie et al's values. The values reported by Bateman and

[16] Note however that what one user considers an improvement may be viewed as excessive development by another: in principle, valuation studies should detect averages across all, including those who have negative values for a change. In practice, those who prefer low-facility areas are likely to focus activities on such areas. For detailed specific assessments these factors may be important considerations, but for the current broad assessment, with scenarios involving limited changes in facility provision, such nuances can be ignored.

Jones (2003), Scarpa (2003) and Fitzpatrick and Associates / Coillte (2005) are lower, something around £2.50 per visit. The average expenditure (ELVS) for woodland leisure visits from home is ≈£12, and ≈£26 for tourism visits (over 3 hours, to sites not visited regularly); though expenditure figures do not give any direct indication of surplus values.

For the purposes of completing this study, we assume that:

- 'High facilities' woods and forests have a value per trip of £12.50, and
- 'Low facilities' woods and forests have a value per trip of £2.50.

We also need to estimate how many trips are to 'high' facility woodlands and how many to 'low', but have little to go on. As a working assumption, we estimate that the PFE attracts approximately 40 million visits per year (based on the consultation document) and that of these:

- 12 million are to urban community woodlands
- 8 million are to 'high' facilities forests, with 5 million in peri-urban and 3 million in rural areas
- the remaining 20 million visits are to low facilities woodlands, 12 million in peri-urban areas and 8 million in rural areas.

These assumptions can be compared with the 170m visits to woodlands per year from the ELVS. If 34% of 1,128,000ha of woodland is accessible, i.e. 385,000 ha, then average visit rates for 170m visits per year equal 445 visits per ha per year, though of course the actual visit rates will vary greatly depending on population and site characteristics. Our estimates range from 74 visits/ha/yr for rural with low facilities, to 400 visits/ha/yr for peri-urban with high facilities, and 1145/ha.yr for urban community woodlands.

Table 18 presents the results of these working assumptions.

Table 18: Working assumptions for visit numbers in typology

Type	Area (ha)	Visits/year	Value (£/yr)	≈£/ha.yr
Urban	10,493	12,000,000	30,000,000	2,850
Peri-urban (low)	74,137	12,000,000	30,000,000	400
Peri-urban (high)	12,500	5,000,000	50,000,000	4,000
Rural (low)	108,792	8,000,000	20,000,000	180
Rural (high)	12,500	3,000,000	30,000,000	2,400

Combining the per visit estimates for high and low facility forests above with the number of visits in Table 18 results in the following value per hectare estimates:

- Urban community woodland: £2,850 per ha per year
- Peri-urban, high facilities: £4,000 per ha per year

- Peri-urban, low facilities: £400 per ha per year
- Rural, high facilities: £2,400 per ha per year
- Rural, low facilities: £180 per ha per year

These figures result in a total estimate of around £160m/yr for recreation in the PFE, or about £740/ha/yr on average over the accessible PFE. This is higher on a per hectare basis than implied by previous estimates (e.g. Willis et al 2003 – value of about £400m for all woodlands in Great Britain) as is to be expected since we use higher values per visit.

There are major reservations about using values per hectare for recreation values. Neither visit numbers nor per visit values are linearly related to forest size, but rather both diminish rapidly once a forest reaches a certain size. The number of visitors also diminishes rapidly as distance from population increases (the 'distance decay' effect – see the Jones et al (2002), Bateman et al (2006)). In an attempt to overcome this problem, at least partly, the figures used here have been tuned so that the total number of visits is approximately the same as measured in the ELVS, and with explicit assumptions regarding the distribution of visits across urban, peri-urban and rural sites, and between high and low facilities sites. This make the approach reasonable for assessment of the status quo. The scenarios under assessment can involve substantial changes in the locations and types of facilities available; this is especially true of the 'people-focused' scenario, which involves increased investments in recreation facilities, and the methods used here will result in such scenarios (a) showing substantial increases in average recreation values per visit and (b) showing substantial increases in number of visits. We assume that it is possible to allocate new investments and forests under such scenarios in such a way that they occur in places currently less well served by woodlands, thereby minimising any substitution effects.

Nevertheless the use of values per hectare remains a weakness of the methodology, in particular where total visit numbers and values are estimated to vary considerably from current levels. Although there is scope for greater recreation in woodlands, in particular if siting new woodlands (or new access rights) near populations that currently lack access to nearby woodlands, there are limits to what can reasonably be expected. This must be kept in mind and it may be necessary to adjust recreation values in scenarios departing significantly from the base case. A spatial analysis in a GIS framework, taking explicit account of location and substitute sites, would help to reduce these concerns.

Aesthetic values

Woods and forests are often considered attractive features of landscapes, though some forms of forest can also be thought to detract from natural beauty. Some part of aesthetic value is captured within forest recreational values, but the value of viewing forest from the outside is additional. Values accruing to residents with views over forest can be detected via hedonic methods. Values for others could be assessed using stated preference or potentially other methods, but there is generally a problem in identifying beneficiary groups – for example those engaging in recreation on foot or in vehicles in non-forest areas with a view of forest. Some researchers have attempted to value household willingness to pay for particular forms of forest, or for views of woodlands from home or when travelling. Entec and Hanley (1997) use choice experiments to estimate values for selective felling of (£12.89 per household per year), organic shape (£13.90/hh/yr), and diverse mix of evergreen, broadleaf, and larch species (£11.36/hh/yr). The WTP for an 'ideal' forest landscape inferred by summing these variables was £38.15/hh/yr. In a separate CV study, they estimate £29.16/hh/yr for changes to 'ideal' forest form.

Garrod (2002) found values for woodland views from home of £268/hh/yr for urban fringe broadleaves, and a further £226/hh/yr for forest views whilst travelling. Based on this, Willis et al 2003 use an estimate of £269 per household per year, for those households with a woodland landscape view on the urban fringe. Note however that these estimates relate to implicit prices (first-stage hedonic analysis) not full value estimates (second-stage).

At 2008 prices, Garrod's estimates are around £180m per year for the aesthetic appeal of UK forests. This is approximately £60/ha/yr, though of course the actual value per hectare will be highly location specific. Urban woodlands will be particularly valuable, while remote rural woodlands will be less seen. At these levels, aesthetic values would clearly be very important. However they are also highly uncertain.

The Bold Colliery valuation carried out for the FC provides strong evidence for a positive impact on house values associated with woodland development on brownfield sites, however it is not possible to extrapolate from this study to values for England overall or per hectare .

Conclusion: For a working assumption, we use the following values:

- Urban woodlands: £4,000/ha/yr, reflecting the high population density and impact on the urban landscape
- Peri-urban woodlands: £400/ha/yr, and £100 for woodlands managed primarily for timber
- Rural woodlands: £40/ha/yr, and £10 for woodlands managed primarily for timber

These are very broad-brush assumptions intended only to give an indicative value for the visual/landscape impact of woodlands. A particular problem is again that we apply values per hectare, while in practice it may be only the woodland edges that are particularly visible from homes and transport routes, and therefore valued. This problem is partly dealt with by tuning the values so that the England total is a little under £100m. Nevertheless these values are very approximate and could be improved, both by more detailed studies of aesthetic values, and by incorporation in a GIS model taking account of location specific effects, notably population density, and applying values along visible edges rather than woodland areas.

Table 19: Forest recreation values: Bateman and Jones (2003) meta-analysis and subsequent studies

Ref	Study good context and methodology	Definition of the Good	Study good site	Substitutes	Mean WTP (per visitor per trip, as reported in study)	Population considered (sample)
Bateman, I. and Jones, A. (2003)	Meta-analysis of informal recreational value of woodlands (CV, BT)	Generally rural forest, with generic recreation benefit	Mix of commercial forest and nature reserve sites, FC and other	In many	Estimates range from £0.07 to £3.14	n/a
Scarpa, R. (2003)	Compensating variation for recreational visit to woodland (CV, BT)	Rural forest with generic recreation benefit	CV over 7 FC sites: Brenin (Wales), Dartmoor, Delamere, Epping, New Forest, Thetford	Not considered	CV: £1.66 - £2.78 BT: £1.10 - £3.00	n=428 (for CV)
Fitzpatrick and Associates / Coillte (2005)	Recreation in Irish Forests				£4.44 average per visit	

Table 19: Forest recreation values: Bateman and Jones (2003) meta-analysis and subsequent studies

Ref	Study good context and methodology	Definition of the Good	Study good site	Substitutes	Mean WTP (per visitor per trip, as reported in study)		Population considered (sample)
Kaval (2006)	Meta-analysis of outdoors recreation		Recreation sites in US	Not considered	All activities (values per person day)	£41 (sd £65)	1229
					Backpacking Birdwatching Camping X-country skiing Downhill skiing Fishing General Hiking Horse Riding Hunting Mountain biking Picnicking Rock-climbing Sightseeing Viewing wildlife	£89 (sd £39) £81 (sd £86) £26 (sd £28) £22 (sd £8) £23 (sd £13) £36 (sd £67) £57 (sd £121) £21 (sd £25) £13 (sd 0) £32 (sd £25) £118 (sd £203) £48 (sd £74) £75 (sd £52) £36 (sd £53) £31 (sd £31)	
					National parks National forests State parks and forests	£86.77 (sd £105) £37.28 (sd £49) £35.93 (sd=£39)	49 186 114
Zanderson and Tol 2008	Meta-analysis of forest recreation in Europe (TC studies only)	All types of forest with generic recreation benefit	Sites covered in 25 studies in 9 countries	Considered	£0.57 /trip to £97.52/trip; Mean £15.06, median £3.94		n=251

Table 19: Forest recreation values: Bateman and Jones (2003) meta-analysis and subsequent studies						
Ref	**Study good context and methodology**	**Definition of the Good**	**Study good site**	**Substitutes**	**Mean WTP (per visitor per trip, as reported in study)**	**Population considered (sample)**
Christie et al. 2006	Value of recreational improvements of forest to specific user types (TC, CB, CE)	Rural forest and rural forest with specific recreational amenities	Cwm Carn, Dyfnant, Glentress, New Forest, Rothiemurchus, Thetford, Whinlatter	Considered	Average values by TC method over 7 sites: Cyclists – £14.97 Walkers - £14.51 Other Visitors - £14.99 Nature Watchers - £7.90 Horse Riders - £14.20 (CE, CB provided various values for specific site attributes)	n=1,568 For TC: Cyclists – 322 Walkers – 416 Other Visitors - 416 Nature Watchers - 104Horse Riders - 81

Notes:

1. CE = choice experiment; CV = contingent valuation; TC = travel cost; BT = benefits transfer, CB = contingent behaviour;
2. Some studies not included because they were urban or urban fringe;
3. Some studies not included because they estimated household values (e.g. Bateman, et al., 1996) or once-and-for-all willingness-to-pay values (Hanley and Spash, 1993), here focus is on per visitor per trip values.

Cultural values

For some people, woods and forests have important cultural, historical/traditional and/or quasi-spiritual importance. Some part of this may be reflected in their use values for recreation, but there may be additional use and non-use values that cannot be captured using travel cost or other methods focusing on recreational use values. "Group visits to woodlands for educational purposes have few substitutes and are actively pursued by schools, scout groups, bird-watchers and other educational organisations." (Willis et al 2002) – again, some part of this value will be reflected in recreation, but there may be additional values to education, including for values held by third parties for the education of current and future generations.

Cultural values are highly context specific and can be contentious – different people can have different views of the desirable state of a landscape, for example. There can be also be cultural values against forestry or tree encroachment – for example preferences for traditional land management or open landscapes, or risks posed by woods and forests to archaeological values. There is some evidence that people place a value on the current intensity of management over either more intensive or less intensive management. For example Willis and Garrod (1993) found strong preferences for the status quo landscape in the Yorkshire Dales, with more conserved landscape also favoured, and strong preferences against intensive and semi-intensive options. There is a basic choice between valuing whole landscapes/areas, and valuing specific features. Examples of the 'features' approach include Hanley and others (1998), who found strong preferences for increases in broad-leaved woodland, heather moors and wet grasslands, and lower values for dry stone walls and archaeology, for an ESA in Scotland. The Environmental Landscape Features (ELF) model (IERM/SAC 1999, Oglethorpe 2005; see Table 20) is a form of meta-analysis / benefits transfer for valuing landscape features in England. Values, based on contingent valuation studies, were included for rough grassland, heather moorland, salt marsh, woodland, wetland and hay meadow (1999) and hedgerows and field margins (2001). The estimates are intended only to account for values of residents, and to allow for diminishing marginal values of additional units of a feature, but aim to value the entirety of a given resource within an area. Eftec (2006; see Table 21) reports results of choice experiments examining the value of environmental changes in Severely Disadvantaged Areas across England, and for comparison present these alongside values processed from the ELF to represent 1% changes in the feature within a government region. The results are generally broadly consistent.

Swanwick et al. 2007 conclude that "there are strong arguments for a whole landscape approach as representing more realistically the way that people view and value landscapes", but temper this with the observation that the choice between whole landscape and component based valuation can depend on the proposed use or policy application of the results. They further suggest that contingent valuation is more suited to whole landscape approaches, whilst choice experiments are more suited to landscape component (or feature) valuation.

A general issue with all these valuations is that they are very likely to contain elements of both use and non-use values. People, and survey instruments, may not be able to distinguish clearly between values for viewing and experiencing a landscape in a particular configuration or quality, and non-use values associated with the same features. This is not a problem for assessing the total (use and non-use) value of a given area, but it does give concern regarding possible double counting if values for cultural heritage and values for recreation are estimated separately and both included in an assessment. Similar problems may arise with separate accounting for cultural values and for biodiversity conservation.

Table 20: Household values for 1% increase in woodland from Environmental Landscape Features model

English Region		NE	NW	Y&H	EM	WM	E	SE	SW
Woodland	Lower	5.79	7.74	5.02	4.99	5.07	4.63	2.98	2.28
	Upper	8.72	11.65	7.55	7.52	7.62	6.98	4.50	3.42
	Average	7.26	9.69	6.28	6.26	6.35	5.81	3.75	2.85

Source: Oglethorpe 2005. Values are normalised using relative regional consumer price levels.

Table 21: Household values for 1% increase in broadleaf and mixed woodland in Severely Disadvantaged Areas

English Region	North West	Yorkshire and Humberside	West Midlands	East Midlands	South West	South East
Broadleaf and mixed woodland	0.61 (0.30-0.91)	0.15 (-0.16-0.48)	0.43 (0.07-0.81)	0.97 (0.03-2.46)	0.39 (-0.01-0.78)	1.21 (0.81-1.66)

Figures in brackets are the 95% confidence interval. Note that if the confidence interval spans zero then the WTP is not significantly different from zero. Note that value for South East is for improvement in all other regions (no SDA in south east)
Source: eftec, 2006.

Conclusion: we use separate values for recreation and aesthetic values, and consider any additional non-use values under the heading biodiversity and non-use values, rather than attempting to include a separate value for cultural values. This is in order to avoid double-counting. There would be particular concern about overlap with values expressed for aesthetic aspects of woodlands, and also with recreational values, both of which may be reasons for people to express high cultural values for woodlands. This is not to say that all aspects of cultural values will be captured in one or other of the other categories, but a significant part is likely to be accounted for, and on balance the risks of double-counting outweigh the risks of under-counting.

Biodiversity, wildlife and non-use values

One of the services provided by woodland areas in the UK is the conservation of biodiversity. Particularly important biodiversity categorisations are highlighted in the typology (UKBAP priority habitats, ASNW, PAWS and OSNW). Ancient semi-natural woodland (ASNW) tends to be richer in plants and animals than other woodland areas (FC 2009).

The value of biodiversity conservation can in principle be split into separate components: the non-use value of biodiversity, and the use value in terms of the support function that biodiversity plays in underpinning other ecosystem goods and services. Table 14 summarises how different economic valuation methods can be applied to valuing forest biodiversity and wildlife.

Table 22: Economic Valuation Techniques for Biodiversity and Wildlife

Technique	Applicability	Pros	Cons	Overall	Examples
Market price	Very limited - possible premium on labelled products; donations to conservation NGOs	Based on real transactions	Very limited coverage and applicability. Donations usually too general, and/or may include use values	Not a likely option	Premium on FSC timber
Proxy value	possible to calculate cost of creating habitat; some use of stewardship payments as proxy, lowest cost methods of delivering targets	relatively easy to calculate	Creation cost: measures cost, not value; stewardship payments: not necessarily related to value at all	Useful information, but not value estimates. Can be used if costs actually incurred.	Costs of creating compensatory habitats under EC directives; cost-effective ways of delivering safe minimum standards
Stated preference	Yes	Possible to address non-use values fully	May be difficult to separate from use values. Requires very careful study design.	The only real option for valuation (as opposed to cost-based proxies)	

We consider that the use values of biodiversity and wildlife are (in principle) captured under other categories – recreation and aesthetic values for uses involving watching wildlife, and provisioning or regulating services for other direct or indirect uses of biodiversity. As a supporting / intermediate service, it can be argued that accounting for use values of biodiversity separately would entail a significant risk of double-counting, since we are already accounting for the final services supported by biodiversity. This argument is correct so far as it goes, however it must be recognised that our value estimates for the supported goods and services will only be accurate if in fact the biodiversity necessary to their provision remains present in the future. In other words, if we expect biodiversity to decline, we should reduce our estimates of the value of final services supported by biodiversity, although in practice we may lack the scientific knowledge to do this.

What remains is the non-use component of existence, altruistic and bequest values associated with conservation. This part is difficult to measure in physical or monetary terms. Non-use values need to be estimated via stated preference techniques. Willis et al (2003) present estimates of 35p per household per year for enhanced biodiversity in each 12,000 ha (1%) of commercial Sitka spruce forest; 84p per household/year for a 12,000 ha increase in Lowland New Broadleaved Native forest, and £1.13 per household/year for a similar increase in Ancient Semi Natural Woodland, for example.

Juutinen 2008 presents meta-analysis of contingent valuation studies for biodiversity value of old-growth boreal forests in Finland, arriving at £200/ha/yr – which puts forest in the range between thresholds for delaying harvesting (£84/ha/yr) and permanent conservation (£398/ha/yr) – but this value may not be suitable for direct transfer to the UK. Lindhjem 2007 presents a meta-analysis of mean WTP for forest protection in multiple use forestry, £120/hh/y (standard deviation £138/hh/y). However the value is scale insensitive, and so it is difficult to derive per ha measures. The issue of scale insensitivity is a crucial one for stated preference valuations, and is discussed further below.

Yousefpour (2008) (see Yousefpour and Hanewinkel 2009) presents a different approach to valuing biodiversity, calculating a Shannon index from simulation runs for forests, and transforming this into a parametric function for the utility of the Shannon index, based on calculating the imposed opportunity costs of the forest owner. However this does not result in a willingness-to-pay based value but rather reflects costs, and so is not suitable for use in a cost-benefit study.

Nunes et al. (2009) present a meta-analysis of studies looking at forest biodiversity values, covering 65 separate studies with 248 value estimates. However by 'biodiversity' values they intend a general conception of biodiversity as the supporting service underpinning all other values, and their data points are for the total values of forest ecosystem services. Not all studies cover all values, so they include dummy variables for cultural services and for provisioning/regulating services, against the omitted category 'all' services. This can allow us to separate out the cultural aspects. However there are problems arising through the log-linear form of the value equation. Applying the meta-analysis model to English forests gives approximately the following results per hectare per year:

- €640/ha year for all services;
- €45/ha year for cultural only, and
- €20/ha year for provisioning/regulating.

Considering the balance of €575/ha year to relate to non-use values would be naïve. The problem is that the meta-analysis function is a good statistical fit for explaining the variability in the results of valuation studies, but does not give additive results for the different services. The values per hectare are also highly sensitive to the area under consideration – the values in the list above have been calculated for all English woodlands, but if instead we consider a 100,000 ha forest, the function predicts over €2,000 per ha year for the service value.

This finding of declining marginal values results from a negative estimated coefficient on the log of forest area, and shows significant marginal decreasing utility with the provision of additional hectares. This is in keeping with previous meta-analyses of forest values (Lindhjem 2007) and ecosystem values (Ghermandi et al. (2007), Woodward and Wui (2003)). This is a difficult issue because on the one hand it is a real reflection of values (the more we have of something the less a bit more of it is worth) but on the other hand it can be an artefact of the scale of assessment – as the example presented here shows, since it would arguably be equally valid to consider woods and forests in England as a single entity of over 1,100,000, or as 11 regional entities of approximately 100,000 hectares each, but the total values given by the function would be radically different. It is also difficult to account for in the additive cost-benefit framework as it requires values to be functions of provision rather than constant values per hectare. Of course this is essential if we are examining scenarios involving large changes in total forest areas, but for minor alterations in area or for changes in forest type it might be a complication better avoided, not least because we lack the basic data on which to make a robust determination of the relationship between area and value per hectare.

The values noted in Table 20 and Table 21 above are also relevant to the non-use category. If we take even a low value of 10 pence per household for a 1% increase in woodland area, and apply that over the full area in England (1,124,000ha, so a 1% increase is 11,240ha), this suggests a value of a little over £190/ha. More realistically, this value should apply primarily to "high" biodiversity areas that will be culturally preferred. The Willis (2003) estimates above of 35p-£1.13 per household per year for a 12,000ha increase in different types of forest could justify higher values, as could the figures from other studies cited, but on the other hand we need to avoid double-counting with recreational and aesthetic values.

Conclusion: with rather limited hard evidence, we value non-use values of biodiversity and cultural aspects of woodlands using the following very simple assumption. 'High' priority sites are assumed to be worth £300/ha/yr, and 'low' priority sites £30/ha/yr. Of course this is a major simplification and again is intended only to ensure that a value for biodiversity conservation is included in the study. The uncertainty in the value estimates is only half of the problem; we also have very limited knowledge of how exactly the different types in the woodland typology relate to biodiversity conservation outcomes. Overall it is important to include a value in this key category, but it is not a value that can be considered precise, and the true benefit in terms of biodiversity and cultural non-use values could be significantly greater: in the base case, the total value estimated here works out at only around £2 per household per year for the entire PFE in England.

7.4 Supporting Services

Supporting services, though very important, should not in general be accounted for separately in an economic analysis, since they are intermediate services that support other, final services. Where the objective is to highlight the importance of specific ecosystem services, individually, it can be entirely appropriate to value intermediate services, however where – as here – the objective is appraisal of net ecosystem service values in total, this must be avoided. We aim to value the final services, and if we also valued the intermediate services this would result in double-counting of benefits.

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ANNEX 1: Economic appraisal of forestry options

Ecosystem services, and economic valuation, are explicitly anthropocentric perspectives, and only apply where humans are affected. Ecological *functions* exist and can be described independently of human use and values, but ecosystem *services* only exist in the context of human use. Hence in a valuation framework we consider ecological functions only through their impacts on ecosystem services used (or potentially used in future) by humans.

Economic appraisal attempts to assess the social welfare impacts of the changes in resource allocations arising from a policy, plan, or project. The most common approaches to economic appraisal, cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA), add up net costs and benefits across individuals and across time, measured using economic valuation techniques, based on the 'Total Economic Value' framework. These aspects are discussed further below.

There are some key principles that should guide economic appraisal and the use of economic valuation techniques:

- Appropriate effort for appraisal: the decision-making context, legal requirements, option characteristics, location, habitats affected, uses of the environment, scale of environmental effects and so on will determine the 'accuracy' that is needed from economic value evidence. This, in turn, determines the effort that is appropriate both for economic valuation and appraisal.
- Sensitivity analysis: limitations of data and uncertainty over environmental effects and monetary values can be partly addressed by sensitivity analysis. Analysis should be proportionate to the decision in-hand.
- Transparency of analysis and ensuring an 'audit trail': key assumptions, limitations, omissions and uncertainties should be explicitly reported.
- CBA and similar methods are approximations based on imperfect indices of social welfare. Other information will also often be relevant. Economic appraisal methods should always be considered as decision support tools: an aid to structuring certain types of information for decision making, not a replacement for deliberation or consideration of other evidence.

These points need to be kept in mind both through the development of the appraisal methodology and in its application. In particular, in reaching decisions about appropriate levels of effort, and including where to target scarce resources in resolving uncertainties or improving valuation data.

Economic Valuation

Economic valuation of forestry services needs to be considered in terms of change in service provision, since economic appraisal involves the comparison of different 'states of the world':

- The counterfactual scenario: the state of the world under 'baseline' or 'counterfactual' conditions, i.e. *without* the change(s) appraised.

- The policy scenario(s): one or more states of the world *with* the change(s) or intervention(s) that lead(s) to different outcomes.

The 'policy scenario' under consideration could be just about anything: from small changes to specific management practices, through larger changes such as planting a large new forest, or removing tree cover from an area, to extreme scenarios such as complete removal of English woodlands. The basic principles and methodology remain the same, but the larger / more extreme the change under consideration, the less accurate economic valuation is likely to be.

Whatever the policy under consideration, establishing a consistent and appropriate counterfactual is crucial to providing an accurate appraisal. But the choice of counterfactual is not always clear-cut, both because the choice of counterfactual may depend on the specific question to be answered, and because changing conditions (climate change, social and economic changes) mean that the counterfactual is not a static 'status quo' scenario.

For analysing the impact of the FC, several hypothetical counterfactuals are possible. The 'obvious' counterfactual of 'No FC' is in fact incomplete, since it is necessary to specify more precisely what is meant:

- 'FC land vanishes': this scenario aims to consider the 'total' value of FC land, by setting the counterfactual as the hypothetical state of the world where the FC land simply stops existing. This is of course an unrealistic scenario but could help answer the question "what is the value of having FC woods and forests at all?".

- 'FC never established': this scenario sets the counterfactual as what would have happened if the FC had never been set up. However this is highly speculative and delves rather too much into history – interesting, but of limited relevance to decision making in the present. It would help answer the question "what is the value of the FC having been set up to look after woods and forests?".

- 'FC sells land': this imagines that the FC stops operating and sells land (to private foresters, to developers, to NGOs, or to whoever else would buy it); this is a possible counterfactual/baseline if the objective is to assess the benefits to society of the continuing existence of FC land ownership and management, but requires estimation of what the private sector would do with the land. It will help answer the question "what is the value of the FC carrying on looking after woods and forests rather than selling them to next best use?". Note that this scenario is presented purely for the purpose of research within this study and is **out of scope of the Public Forest Estate Study.**

- ‘No active FC Management’: this imagines that the FC continues nominally to hold land, but invests no resources in running the estate; it is neutral on the issues of ownership of the land. This is an alternative counterfactual for assessing the benefits to society of ongoing FC operations. Variants here include (a) public access continues and (b) public access banned. It could help answer the question “what is the value of FC carrying on looking after the public forest estate rather than passing management with little restriction to third parties?”. Note that this scenario is presented purely for the purpose of research within this study and is **out of scope of the Public Forest Estate Study.**

In addition there are different baselines that would be more appropriate for the different policy question of assessing the value of certain changes in FC management practices or budgets. Here the issue is no longer the ‘total value’ of FC activities, but rather the marginal changes in values when management changes. The two main options are:

- ‘Status quo’: a recent snapshot of management and service values, this has the advantage that it can be directly measured, but the disadvantage that it is static, ignoring climate and other exogenous changes, and ongoing trends.

- ‘Business as usual’: similar to ‘status quo’, but a dynamic counterfactual, that takes account of our best estimates of the likely evolution of activities and key parameters (such as world timber prices and input costs) in response to key drivers such as climate change and population growth.

Different counterfactuals might be used for different policy and appraisal purposes. The information needs of the counterfactual will differ, but the basic approach and framework for ecosystem service valuation stays the same.

Linking value and cost estimates to the typology

Using standard values, varying across the different woodland and forest types in the typology, is the most appropriate and consistent approach to broad-brush estimation of benefits and costs at the national and regional scale. It must be recognised, however, that this method does ignore local variability not reflected in both the typology and the value estimates.

In certain circumstances, it may be appropriate to ‘tune’ values to the typology, when determining unit values, or when developing scenarios. This is not the case when values are near-perfectly scale independent and linear (for example, carbon sequestration), but where values vary with forest area, and/or have unit values that are non-constant across relevant ranges of physical provision, some tuning may be required. The different timing of costs and benefits also needs to be considered. Since short-term spending will be ‘smoothed’ over relevant timescales, the starting point for flows of costs and benefits is the key consideration, particularly where investments only realise benefits with a lag.

The most important case is probably recreation, and it is necessary to tune the value used in the typology such that the application of the typology to English forests overall approximately reproduces the actual total visitor numbers (from day visits surveys). This gives the most appropriate means of estimating total recreation values for the estate. When assessing changes in forest types, in particular through future scenarios for English woodlands, it is necessary to consider how the total numbers of visits might vary. Where there are strong substitute effects, for example where increasing the provision of out-of-town forests near a given population that already has access to such forests, we might expect relatively low increase in visits; where providing new urban community woodlands we might expect significant increase in visits, even where there are already woodlands nearby.

The need for tuning is dependent on the scale of the assessment in relation to the scale of the value under consideration. For example, timber is traded globally and the market value is little influenced by changes in English production, so for assessment of changes in English timber supply prices can be considered independent. At a global level, however, this is clearly not the case, implying either that a demand function should be used for valuation purposes, or that some constant supply constraint should be used, as in Yousefpour and Hanewinkel (2009).

Total Economic Value

The values used are based on the Total Economic Value (TEV) conceptual framework (Pearce 1989) that classifies the different sources of value to individual humans from goods and services. It splits value into 'use' and 'non-use' components.

- Use value
    - Direct use
        - Consumptive: personal use of resource in which the resource is used up (e.g. timber products).
        - Non-consumptive: personal use of resource in which resource is conserved (e.g. recreation, but this may become consumptive if there is congestion or damage to the resource).
    - Indirect use: where the service leads to benefit by its impact on another production or consumption process (e.g. role of woods and forests in purifying water supplies).
- Option value
    - Option value: value of keeping open option to use resource in future over and above any current and planned future use. It only exists because of uncertainty about future preferences and/or availability of the good, and risk-averse preferences.

  - o Quasi-option value: value of avoiding/delaying irreversible decisions where changed technology or knowledge could alter optimal management. Particularly relevant to conservation, where possible future uses or roles in ecosystem stability and service provision are not known perfectly, and where events such as extinction, invasive species introduction or habitat transformation can be irreversible

- Non-use value
  - o Altruistic and bequest values: from knowing that others can use the forest now and/or in the future, respectively.
  - o Existence: value of knowing the forest exists, not associated with any current or future human use; but this is still a value held by humans, and is different from 'intrinsic value[17]'.

These are all parts of economic value because they are all reflections of different ways in which individual humans value environments and their goods and services. Changing the level of provision of an environmental good or service results in changes in the levels of these values, or components of welfare, and the sum of these changes gives a measure of the total economic value to the individual.

We can derive a measure of economic value for any given change by looking at trade-offs that an individual is prepared to make. Considering some proposed improvement in environmental quality that would result in changes to the above components of TEV for an individual, we ask, what is the most of some other good or service the individual is prepared to give up in order to secure the improvement in environmental quality? The answer expresses, for that individual, the value of the environmental change in terms of the value of the other good or service.

The other good or service (the 'numeraire') could be anything, but to be useful as an index it should be an easily understood quantity. For reasons of convenience and comparability, money is generally used. This has several clear advantages, in particular that people in modern societies are well accustomed to using money in a wide range of trade-offs (buying most of their daily necessities and luxuries, selling their labour, trading-off through time via borrowing and saving, donating to charitable causes). It must be recognised, however, that people may not be used to making such trade-offs in all cases, and their preferences or values may be vague or poorly-formed in unfamiliar areas – for example, preferences regarding non-use values of biodiversity. Economic valuation, from both markets and non-market

[17] The natural environment, in whole and in parts, is often considered to have 'intrinsic value' (value in and of itself), over and above any human values for appreciation, use and enjoyment of environmental resources. Although this may be true, humans can have no way of assessing or measuring such values, and can take them into account only very imperfectly through moral arguments for restricting our interference with nature.

studies, therefore rests on the assumptions that individuals allocate their resources so as to maximise their personal welfare, and are capable of considering the trade-offs involved in a cogent and coherent fashion. To the extent that this is correct, monetary values, expressed as willingness to pay (WTP) for different goods and services, are a useful index of personal welfare[18].

Economic valuation

Economic valuation techniques must be used to furnish the set of values needed to carry out cost benefit analysis. The methods seek to answer the question "what would the price be if there were a market for this?" – or more accurately, "what would the demand curve be?", because price changes with quantity of a good or service, and often we are interested in the value of sizeable changes in quantity and/or quality. There are three main types of valuation techniques:

- Market-based techniques: using evidence from markets in which environmental goods and services are traded, markets in which they enter into the production function for traded goods and services, or markets for substitutes or alternative resources. These can be applied for example to timber (direct markets), flood risk (for example, a production function relating the expected damage of flood risk to tree cover, rainfall, protection expenditures, and value of property exposed), and water quality (market for alternative, e.g. bottled water and/or the costs of purifying water for consumption).

- Revealed preference (RP) techniques: based on interpreting actual behaviour with both environmental and market elements. Recreational values are often assessed using RP techniques, and aesthetic elements may also be valued this way.

- Stated preference (SP) techniques: based on stated behavioural intentions in hypothetical markets created through surveys. Very widely applicable, used for example for biodiversity, and the only techniques capable of capturing non-use values.

In principle, non-market valuation can be applied to changes in final or intermediate services, to changes in entire habitats or ecosystems, or even directly to changes in management practices. But the potential for valuation, and its accuracy, are crucially dependent on individuals' awareness of the ways in which

[18] Personal welfare here refers to the individual's perception of his or her wellbeing. The TEV framework is individualistic, in the sense of not being paternalistic (it is the individual's own perceptions/values that are counted), though not in the sense of being selfish (because 'personal welfare' can include altruistic and non-use motives).

the object of valuation influences their personal welfare. The closer we can get to final services, the better the valuation is likely to be. Where there is uncertainty about how a management change will influence services, deciding to apply non-market valuation techniques to the management change does not remove that uncertainty, but merely shifts it to the valuation exercise, and its respondents.

So the first important step in appraisal is to use the best scientific information available to assess the likely physical and ecological impacts of the option under consideration. That is why, in the framework and methodology presented in this study, we first develop a typology of forest systems, and then consider the typical ecosystem services supported/provided by each type, and then how these can be valued. For any specific application of the methodology (for example the case studies), we need to select a counterfactual, assess how the ecosystem services differ between the counterfactual and the scenario under consideration, then apply valuation to these changes.

Market techniques

- **Market values**: can be calculated for traded ecosystem goods and services. Where markets exist, this method is relatively straightforward. The values do not account for any externalities associated with the production and use of marketed ecosystem goods and services. It may be necessary to adjust for taxation or for subsidies to forestry.

- Proxy values can also be calculated via a production function, avoided costs or replacement costs:

    - **Production function**: uses statistical analysis to determine how changes in some ecosystem function affect production of some other good(s) or service(s) traded in (a) market(s). The primary difficulty in this method is the availability of scientific knowledge and/or data for estimating the production function(s).

    - **Avoided cost**: estimates a value based on the costs that would have been incurred in the absence of the ecosystem service. In a forestry context, this is particularly relevant for downstream flood control, where reduced flood risk leads to avoided flood damages.

    - **Replacement cost**: estimates a value based on the cost to replace an ecosystem function or service. In some cases, the method is applied to entire ecosystems – for example, the cost of providing new habitat to compensate for habitat losses. More generally the method refers to replacing ecological functions with human-engineered alternatives. For example, flood control could be valued at the cost of providing flood defences instead.

Revealed preference

- **Travel Cost**: assesses the demand for recreation in an area through econometric estimation of a demand function based on survey data relating to individual costs of travel and other expenditures to participate in recreation. This method is widely used and is a relatively inexpensive extension to simple collection of visitor data. It only accounts for the benefits of direct use for recreation.

- **Hedonic Pricing:** determines a value for aesthetic or environmental quality aspects of an ecosystem by statistical analysis of property markets. This approach assumes that the sale or rental values of properties can be explained as a function of a wide range of property 'attributes', including variables relating to environmental quality. The technique is often employed to assess nuisance from noise, traffic, or proximity to waste or quarry facilities, and to assess benefits of location near water bodies (rivers, lake shores, beaches). The technique only accounts for use values associated with occupation of the property. It may be difficult to separate out precise sources of value – for example, appreciation of landscape/view, proximity to recreation facilities, peace and quiet. For forestry in the UK, hedonic methods will be most useful for urban woods, which may have a significant impact on adjacent and nearby housing prices, reflecting their benefits to residents. In any event, hedonic methods will only detect certain aspects of use values associated with living near a site; use values of non-resident visitors will not be covered.

Stated preference

- **Contingent valuation**: surveys establish hypothetical markets in order to determine WTP for some specified change in a whole ecosystem or some subset of its components, goods and services. The technique is applicable to any type of good, service or value, and in particular can be used for valuing non-use benefits which are otherwise not possible to assess using market or RP techniques.

- **Choice experiments:** or related techniques such as conjoint analysis and contingent ranking. CE methods are similar to CV : rather than directly posing a WTP question, CE derives WTP values from statistical analysis of observed choices from multiple hypothetical scenarios. Each scenario includes a small number of features, one of which is some measure of monetary payment (entrance fee, tax etc.), and at least one other representing the ecosystem good(s) or service(s) under consideration.

Some common measures are not true economic value estimates, because they are not based on consumer demand but on costs of supply: for example, estimates based on costs of recreating a damaged resource, or replacing it with a substitute resource. Although these estimates can be useful in certain circumstances, in particular putting ceilings or floors on value estimates, great care is needed if using them for appraisal purposes. Assuming the value of a resource is equal to the costs of replacing it makes costs equal to benefits by definition, making the CBA a meaningless exercise.

Other measures are sometimes used that are not directly based on either demand or supply but rather on policy instruments – for example values based on subsidies available for specific management interventions. Under certain circumstances, using these values can be justified through arguments about the assumed optimality of policy, or consistency across related areas of policy. However they are clearly not direct estimates of value, and again are of no use in evaluating the policies from which they are derived.

Cost benefit analysis

Cost benefit analysis proceeds by drawing up a comprehensive list of the differences between the (estimated) state of the world with the policy or project under consideration, and the (estimated) state of the world without that policy or project. To the full extent possible, all the different impacts are valued using economic valuation techniques, and added together to give a net appreciation of the impact of the policy or project.

Deriving the net impact involves adding together the impacts from different years, and discounting is used to allow for the comparison of costs and benefits that occur in different time periods. This is based on the principles of time preference (people prefer to receive goods and services now rather than later) and the opportunity cost of capital (resources invested now can give a profitable rate of return in the future)[19]. The exact choice of discount rate is a source of perpetual debate, but we can avoid the details and defer to official UK policy on discounting (HM Treasury, 2003). The policy states that the recommended discount rate is 3.5% for the short to medium term and then declines beyond 30 years, which is primarily a way to account for uncertainty about the future. The rates are shown in Table 3.

Table 23: UK public sector discount rates

Period (years)	0–30	31–75	76–125	126–200	201–300	301+
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

Source: HM Treasury, 2003

[19] Note that discounting is nothing to do with inflation. All costs or benefits in economic appraisal should be expressed in 'real terms' (or 'constant prices'), rather than 'nominal terms' (current prices). Generally the most convenient and intuitive base year is the year of the study. Published GDP deflators should be used to update values from earlier years (correcting for the impact of inflation), and any future price estimates that include inflation should have this removed.

The use of CBA, with estimates of economic value based on individual WTP for changes in goods and services, is supported by UK Government policy. The official guidelines for CBA are set out in the 'Green Book' (HM Treasury, 2003) on appraisal. These guidelines state that "Calculating the present value of the differences between the streams of costs and benefits provides the net present value (NPV) of an option. The NPV is the primary criterion for deciding whether government action can be justified."

Of course it is recognised that CBA is an approximate method, and that social welfare is not necessarily a simple additive function of individual welfares. In particular, social welfare can depend on distribution (equity) or on other aspects of wellbeing that may not be captured by individualistic economic valuation methods. In our society we do rely on markets, and hence individual WTP, to allocate a large proportion of resources, adjusting allocations through tax and benefit policies, and public spending on services. This suggests that using individual values to assess the social welfare impact of small changes to overall allocations can be an acceptable approximation. Nonetheless it is preferable to take account of the distributional impacts. The Green Book covers this in Annex 5, calling for a "rigorous analysis of how the costs and benefits of a proposal are spread across different socio-economic groups". However, the guidelines recognise that the information necessary for calculating distributional weights may be costly to acquire, and therefore allow that studies may instead present a fully justified decision not to use explicit weighting.

An alternative approach is to assess and report separately the distribution of costs and benefits, flagging up 'winners' and 'losers' for decision makers. A formal approach to this, the 'Sugden approach', is under consideration in the UK (Defra 2007)[20] but is not currently official policy.

Economic Valuation Issues

Opportunity Cost of Land

In certain applications it is necessary to consider the opportunity cost of forest land – that is, the value of the land in its next best alternative use. This will depend on the site: the main alternative to a forest site on lowland rural land is likely to be arable or grassland use for agriculture, the main alternative to an upland rural forest may be extensive sheep grazing on moorland/grassland, and the alternative to an urban woodland might be either open space or conversion to residential or commercial development. The details will vary from case to case and there can be some complex questions relating to the treatment of planning restrictions and so on.

[20] Defra. 2007 R&D Technical Report FD2018/TR1 and 2 – The 'Sugden' Approach – Testing a Disaggregated Approach to Appraisal.

In many cases, however, it is not necessary to consider this opportunity cost: where we are considering the value of changes in woodland management, for example the value of investing in recreation facilities, the issue of opportunity cost can be ignored because it is the same for both scenarios (‘with’ and ‘without’ facilities). It is only when we use one of the counterfactuals/baselines that involve considering the land without trees that we need to estimate opportunity cost – that is, if we are attempting to value the total contribution of woods and forests, or are considering options for afforesting or deforesting land.

When it is necessary to consider the opportunity cost of land, a useful source is the ‘Multi-coloured Manual’ (Penning-Rowsell et al. 2005) which gives standard methods for valuing agricultural land. It was developed for applications to flood damage assessments, and the valuation methods for ‘land permanently lost to agriculture’ can be used to estimate the opportunity cost of converting agricultural land to woodland or forest.

Double counting

There is a serious risk of double counting when valuing different services separately, in particular where values from stated preference surveys are used, because it can be difficult to determine precisely what survey good respondents are considering – is it just the biodiversity value of woods and forests, for example, or are they also thinking about cultural values and perhaps some recreational values? State-of-the-art survey design can help avoid this problem, but for most practical applications of valuation we are dealing with benefits transfer rather than primary studies. (to expand)

Issue of scale

There is a common problem in stated preference valuation research in forestry that responses are not sensitive to scale – this makes it very difficult to derive or use ‘per hectare’ values. Several potential scale-related errors may need to be kept in mind. These include:

- Failure to take account of diminishing marginal WTP for goods and services: substitution effects and part-whole bias. This can be a particular issue for recreation values, where the existence of substitute sites may limit the losses or gains at a site under consideration. It can also arise for conservation, where for example the value of the 1000th hectare conserved may be much less than the value of the 2nd, and the value of increasing populations of a species is similarly unlikely to be linear.

- Failure to take account of complementarity and embedding effects. In contrast with substitution effects, where goods are consumed jointly, this will tend to bias WTP estimates downwards.

- Failure to take account of distance decay in WTP, or otherwise mis-specifying the population affected by a change. Use values should generally decrease with distance, because of the higher costs of travelling further and likely increasing availability of substitutes. Estimating the distance-decay effect is important in determining the populations affected by a change, for calculating aggregate WTP. When values are expressed per household, the size of the affected population, and the way in which WTP declines with distance from the affected area, are key issues. This applies in particular to use values; distance decay for non-use is much less pronounced, because there is no direct link from distance to non-use. Hanley and others (2003) report more rapid distance decay for use values than for non-use values (as expected) and no significant effect for a general class of environmental good, where a significant effect exists for a specific local example of the same class. They also report a substantial part–whole effect in aggregating non-use values.