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Woodland Management for Timber and Wood Products: The Impact on Public Good Outputs

A report to the Forestry Commission and Defra

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Executive Summary

This report presents the results of a literature-based investigation into the impacts of woodland management for timber and wood products on public good outputs. The stimulus for the research arose from the observation that there is widespread under-management of woodlands in Britain (particularly broadleaved woodland in England), in relation to what might be regarded as good practice with respect to timber production. Recent analysis also indicates that public good values, particularly biodiversity, may be reduced due to a lack of management.

The emphasis of forest policy is on supporting the delivery of multifunctional benefits of woodlands and forests. There is firm evidence that, in addition to the effects of timber production on income and employment in the forest sector, woodlands generate substantial public good benefits, including recreation, biodiversity, landscape and carbon sequestration.

The aim of this study was to examine the provision of public goods associated with the management of woodland for timber and wood products in England. Specific objectives were to:

- review the evidence of the impact that woodland management for timber and wood products has on the generation of public good outputs;
- provide an assessment of the public good outputs of different types of woodland management, including minimal intervention approaches;
- provide an assessment of the types of woodland (ASNW, PAWS, conifer, coppice broadleaf, high forest etc.) and the situations (rural, urban etc.) in which woodland management is likely to be particularly important;
- explore the options for stimulating management of woodlands for timber and wood products.

The principal method was a desk-based review of academic, policy and grey literature to compile the evidence base for the impacts of woodland management for timber on biodiversity, recreation, landscape and carbon sequestration. The constraints of the study only allowed for a consideration of these four principal evidenced public good benefits. However, it is acknowledged that these are not the only benefits provided by woodlands. An expert workshop was also held to enable a range of interested stakeholders to assess the gathered evidence and explore various options for stimulating woodland management for timber, if indeed, such management was deemed desirable for enhancing public good outputs.

The overall conclusions were that, in general, low to moderate levels of woodland management have beneficial effects on public good outputs in most types of woodland. Such management improves the structural heterogeneity of woodlands and, thus, the diversity of ecosystems and species. However, the increased shading that is occurring in many woodlands may simply be a phase in their even-aged development. Natural processes will eventually take over in the long-term, in which case non-intervention may then be sufficient at the site level, but there are risks with this approach if most woods at the landscape scale are at a similar (shaded) stage. Some species may require more intensive management regimes (such as clearfell for the woodlark) or, conversely, low rates of turnover and disturbance (for some bryophytes, lichen and bats) or high amounts of deadwood (e.g. fungi and invertebrates).

In general, lowland broadleaved woodland near to urban areas and where other recreational space is limited is likely to present the best opportunity for enhancing recreational values. Moderate levels of management, such as ride maintenance, some thinning or single tree selection can enhance recreational public good values. However, recreation can also be enhanced by non-timber management such as the provision of facilities (car parks, toilets) and interpretation.

External landscape values are generally unaffected by woodland management. The exception to this is when clearfell occurs and values may be negatively affected for a relatively short period of time after harvesting. However, internal landscapes can be considerably improved by thinning and management.

Carbon sequestration offers potentially the largest public good value, depending on the value used (ranging from £2.66 to £140 per tonne of carbon sequestered (tC)). It is also the least understood of all public values. Non-intervention old-growth forests appear to have the highest value in terms of stored carbon, with a reduction in carbon storage as management intensifies and timber is removed and soil disturbed. However, managed woodland in which high yield timber is harvested and re-grown, may offer greater overall carbon benefits by providing fossil fuel substitution and material substitution (for concrete and steel).

In order to stimulate woodland management, a variety of approaches will be required, including market stimulation, regulation and advisory roles. Appropriate management regimes will be determined by a number of factors including location, type of woodland, substitutability, size, condition and ownership motivations. The conclusion of this study is that stimulating the market for low-grade timber and wood fuel alongside other markets could provide a win-win situation. Making woodlands financially profitable will provide an economic benefit to the woodland owner and, thus, encourage management. As long as best practice is followed, such management will jointly produce enhanced public good benefits. In this way the external costs of public good provision can be internalized through profitable woodland management for wood products.

In order to assess the likely opportunities for enhancing public good benefits through woodland management for timber and wood products, further research is required regarding the dynamics of carbon sequestration in un(der)managed temperate English woodlands and the balance between non-intervention carbon storage and felling and restocking management regimes. Also, further research is required into the motivations of private woodland owners in order to understand further their reasons for ownership and, in particular, the production of timber and other wood products.

Introduction

Forests and woodlands are a multi-functional resource. There is firm evidence that, in addition to the effects of timber production on income and employment in the forest sector, woodlands generate public good outputs – including recreation, biodiversity, landscape and carbon sequestration (Willis *et al.*, 2003). Recent economic analyses (e.g. CJC Consulting 2005) have focused on the effects of woodland planting. However, there is also a need to understand better the economic effects of woodland management on the existing woodland resource, which is not only much more extensive, but also likely to be associated with higher levels of non-market values. In particular, better evidence is required on how woodland management for timber contributes to wider policy objectives including the provision of public goods. There is also concern that harvesting is occurring well below the sustainable increment. Thus, there appears to be an under-utilisation of a renewable, carbon-lean resource. Only about 30% of non-FC woodlands in England have a felling licence, are in a Woodland Grant Scheme or are estates under the Dedication of Woodlands Scheme.

Circumstantial evidence indicates that some types of woodland management (not necessarily for timber) may positively affect levels of public good output. For example, recent UK studies about wildlife of semi-natural woodland suggests a decline in diversity of woodland plants may be associated with lower levels of management (Kirby *et al.*, 2005), although this evidence is presented in biological rather than economic terms. Equally, improved woodland management may increase the carbon storage capacity of woodland. However, increased management may also adversely affect levels of public good output. For example, large scale clear-fell impacts on landscape values (albeit only for a period of time) and even more modest woodland management can damage soils, impacting adversely on wildlife and impeding recreational access if good practice guidelines are not followed.

Two major policy questions arise from this. First, in terms of the provision of public goods, should we be concerned at the extent of under-management in woodlands? Second, if positive non-market values are associated with woodland management, how can more active management of woodland for timber and wood products be stimulated, with the effect of increasing the flow of public goods?

1.1 Aims and Objectives

The aim of this study was to examine the provision of public goods associated with the management of woodland for timber and wood products in England. Specific objectives were to:

- review the evidence of the impact that woodland management for timber and wood products has on the generation of public good outputs;
- provide an assessment of the public good outputs of different types of woodland management, including minimal intervention approaches;
- provide an assessment of the types of woodland (ASNW, PAWS, conifer, coppice broadleaf, high forest etc.) and the situations (rural, urban etc.) in which woodland management is likely to be particularly important;
- explore the options for stimulating management of woodlands for timber and wood products.

This report outlines the findings from a literature review on the public good benefits of forestry and the impacts of woodland management for timber on those public goods. The first section gives an overview of the theoretical concepts behind the study: total economic value (TEV) of forestry, joint production and the potential trade offs between timber production and public good outputs. The second section outlines the evidence base relating to woodland management for timber and public good outputs, followed by the findings from an expert workshop held at Swindon on 22nd March 2006. Finally, a summary of the findings and conclusions are given, along with a review of possible policy mechanisms, outlining possible management regimes to promote the enhanced delivery of public good benefits.

1.1 Definition of Woodland Management

Throughout this report, when we use the term 'woodland management' we mean 'the management of woodland for timber or woody fibre production'. We have abbreviated this to woodland management for timber (or WMFT) for convenience and brevity throughout. Although we recognise a number of other motivations to manage woodland, such as sporting shooting, conservation or recreation, in this study we focused on woodland management for wood products (although there are undoubtedly some overlapping benefits). We are also only examining WMFT in existing woodlands, not the value of creating new woodlands.

1.2 Methods

Our approach for this project was to trawl academic, policy and grey literature relating to the UK and more widely, with particular reference to that considering 'under-managed' private woodland in Europe. We did not consider enhanced management of woodland for game in this study, although we recognise it as a possible driver of greater levels of woodland management. Our emphasis was on the relationship between public good outputs and those woodlands normally associated with high levels of non-market (public/quasi-public) goods.

For the purposes of this study, only four public goods were considered: biodiversity, recreation, landscape and carbon sequestration. We acknowledge that there are many other public goods resulting from woodland and forestry. However, the scope of this study did not allow for a full consideration of these, although these are outlined in chapter 3. The four public goods associated with biodiversity, recreation, landscape and carbon sequestration were identified by Willis *et al.* (2003) as having the highest value in terms of public good benefit (see Table 1 on page 18).

In many instances, it was not possible to establish quantitatively the total economic impact of silvicultural activity on public good outputs. In many situations, especially those associated with use values, it is impossible to develop robust benefit transfer[1] models that enable attribution of value, not least because of the potential substitutability of non-woodland for woodland provision. However, we have endeavoured to indicate the magnitude of change ordinally (on a scale from negligible-significant-very significant).

An expert workshop was also held on Wednesday 22nd March 2006 in order to obtain feedback to a circulated draft of the literature review. Workshop participants represented a range of forestry interests, such as timber production, biodiversity,

[1] Benefit transfer is a technique by which a benefit is estimated for a particular site for which data is available, and then transferred to a comparative site for which data is not available.

landscape, informal recreation and carbon. This expert panel was invited to assess what the value shifts are likely to be on the varying parameters. Participants were also asked to consider how well the English Woodland Grant Scheme (EWGS) currently delivers opportunities to enhance public good outputs. The workshop participants also considered alternative policy options and priorities.

Theoretical Context

This section explores the concept of total economic value (TEV) as it applies to forestry, together with a definition of public goods. It explores the issues of joint production and the spatial and temporal variability of public goods and management. These issues define the theoretical context within which this study is situated and provides a foundation for exploring the issue of woodland management for timber and the enhancement of public good outputs.

2.1 Total Economic Value

Pigou (1932) distinguished between the private costs of production and consumption and the full social costs, and stated that these needed to be included in the cost-benefit analysis (CBA). Much of the early work on market failure related to the negative effects of production on welfare, either of consumers or other producers. It was argued that uncompensated losses to human welfare due, for example, to the negative effects of the emission of waste substances should be factored into the economic framework. These so-called spill-over effects or externalities do not necessarily relate to the environment, although environment-related externalities have become more and more the focus of attention in cost benefit analysis and the study of market failure.

Environmental economics aims to recognise the value of natural capital by integrating environmental services into cost benefit analyses (Turner *et al.*, 1994). For example, a cost-benefit analysis for a coal-fired power station should include an evaluation of the external costs of atmospheric pollution as well as the profit from the electricity produced. The pollutants from the power station will have economic consequences that can be quantified – such as crop losses due to sulphur dioxide emissions, visual impacts and medical costs for resulting health problems. Thus, the total economic value (TEV) includes a valuation of both use and non-use values of financial and social costs and benefits. However, it is important to remember that TEV is related to the valuation of people's preferences (anthropocentric and instrumental value) and not to the intrinsic value of natural capital, which it is impossible to measure using these techniques (Turner et al., 1994).

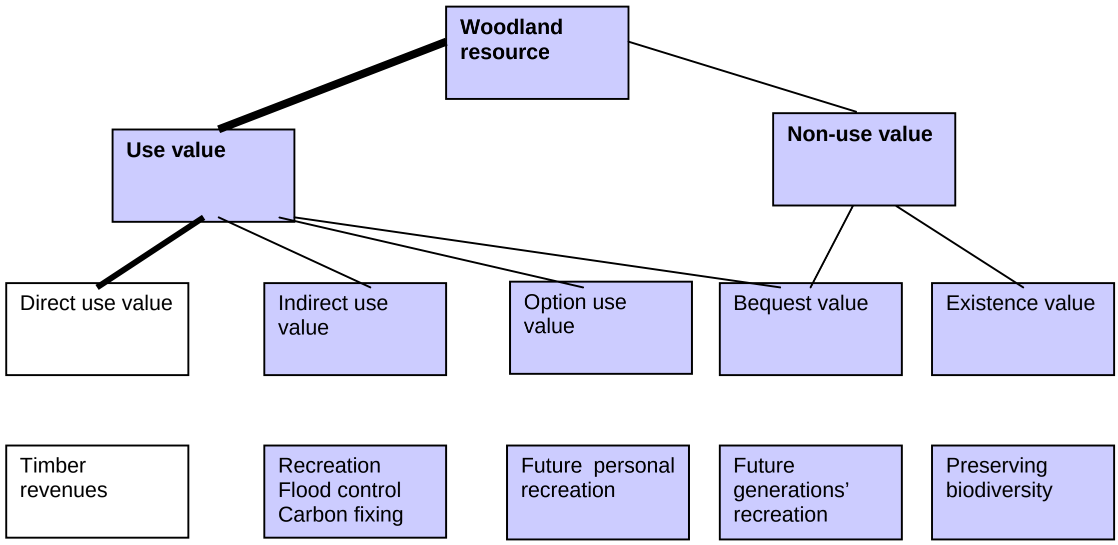

Figure 1: The total economic value of woodland (Turner et al., 1994)

As can be seen in Figure 1, the TEV of any woodland consists of a combination of use values and non-use values (bequest and existence values). Use value can be 'direct' (i.e. timber production) or 'indirect' (i.e. functional values in terms of recreation, carbon sequestration etc.). Option values relate to the option of protecting the resource for future use, and can either be direct or indirect. Non-use values include existence values, the value of preserving the resource as part of the wider ecosystem, and bequest values, the value associated with passing on the resource to future generations.

Much of the advance of environmental economics has been contingent on the development of scientific understanding relating to processes and responses. The biophysical impact must be understood before the economic impact can be estimated. In the simplistic Pigovian pollution problem, a factory pollutes a watercourse and destroys, for example, fish stocks with a value. With non-point pollution and more generally with much more complex process-response models, the accurate estimation of the biophysical response curve must precede the estimation of the damage function from an economic perspective.

The issue of property rights is also of fundamental importance in understanding both the nature of and solutions to environmental economic problems. In the case of some environmental products, such as clean water or clean air, the possession of this right by the state puts it in a position to make the polluter pay. If the private owner of land has the rights to the water, including the right to pollute it, the strict neoclassical solution is to reward the provider for the good he provides to wider society. This latter course of action is termed the 'provider paid principle', in contrast to the 'polluter pays principle', and applies where a negative impact is being inflicted on the owner of a property right.

Environmental economics, therefore, aims to put a price on environmental assets and services and to identify the opportunity costs of resource use, management or degradation. Various methods are used to ascertain environmental valuation, but there are two main groups of approaches: stated preference methods and revealed preference methods. One of the main stated preference methods is contingent valuation (CV), where people are asked how much they are willing to pay for a part of the environment to be conserved, or how much they would accept as compensation for its loss (Turner et al., 1994; Hanley *et al.*, 2001).

Alternatively, revealed preference approaches, such as hedonic pricing and travel cost methods, attempt to infer the value people place on environmental goods by their actual behaviour (Hanley *et al.*, 2001). Hedonic pricing (HP) asserts that environmental services are reflected in a marketed good, most commonly the housing market (Hanley and Spash, 1993), with people choosing to live in (and paying a premium for) areas where the environment will improve quality of life.

Travel cost methods (TCM) were the first form of environmental valuation, used in the United States to manage recreation in national parks and are now widely used for valuing the non-market benefits of outdoor recreational resources (Hanley & Spash 1993). TCMs are based on the assumption that time and expenditure is incurred in travelling to recreational areas and, from this, values for environmental services can be inferred (Perman *et al.*, 2003). A statistical relationship can be determined from the observed visits and the cost of visits from which a consumer's surplus per visit can be measured. This approach has been used widely in the UK for valuing the non-market benefits of national parks and forests (for example Willis & Benson (1989) used TCM to examine the recreational value of forests).

2.2 Public Goods

In economics, a public good is something that is impossible to produce for private profit because private sector providers are unable to acquire profit from their provision. The defining characteristic is that the good can be consumed by more than one individual. Thus, public goods are non-rivalrous - once produced, everyone can benefit from them without others' enjoyment being diminished. In the context of woodland, one person's enjoyment of visiting the woodland does not necessarily diminish another's enjoyment. Public goods are also non-excludable, meaning that it is difficult to prevent access to them. Thus, in the case of open access woodland, where *allemensretten* (Everyman's right) prevails, all are free to visit the woodland if they choose.

However, the above definition of public goods essentially relates to 'pure' public goods, which are fully non-rivalrous and non-excludable. At the other end of the spectrum, pure private goods are fully rival and fully excludable. Such polarization of the provision of public goods is rare, although almost all market goods have a high degree of excludability. Goods can also be excludable but non-rival, or they can be rival but non-excludable. Often, however, goods are partially excludable and/or rival and can be located variously along a spectrum as illustrated in Figure 2 (Mantau *et al.*, 2001). Thus, there is a continuum between pure public goods at one extreme and pure private goods at the other (McGuire, 1987).

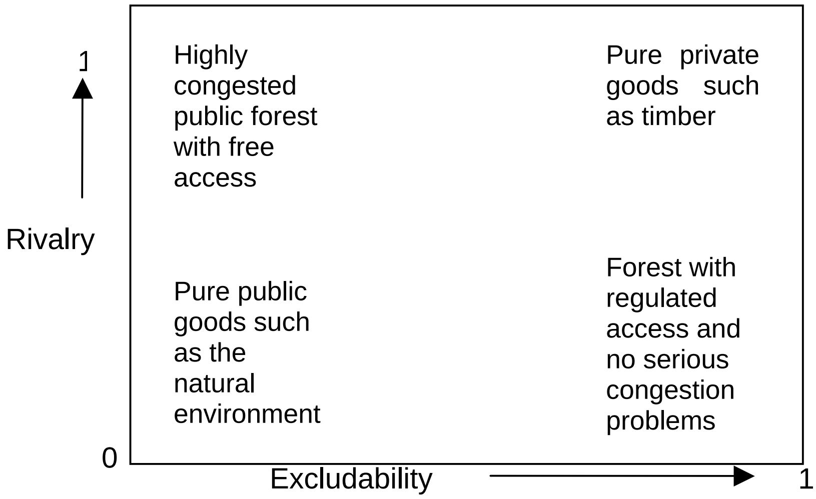

Figure 2: Example of impure public goods within forestry (adapted from Mantau* et al. *2001).

The extent to which a public good remains a public good depends on the distribution of property rights (Slee, 2006). For example, legislation granting public right of access to woodlands in Scotland under the Land Reform Act 2003 turned a notionally private good unambiguously into a public good. Access to woodlands in England is more limited, based on the 1949 National Parks and Access to the Countryside Act (woodlands and forest remain outside the legislation of the Countryside and Rights of Way (CROW) Act 2000), except for the special case of dedication.

2.3 Joint Production

Different outputs of forests and woodlands – timber, other products and public goods – may be jointly produced. Joint production occurs when the production of one good inadvertently results in the production of another. However, resources are not limitless and often using them in one way prevents them for being used in another way, especially when used intensively for one output. In other words, a trade off occurs whereby the increased production of one good causes a reduction in the production of another. Figure 3 illustrates a possible production possibility curve for timber production, with a reduction in public goods (e.g. biodiversity) with an increase in timber production. Conversely, an increase in biodiversity results in a decrease in timber production.

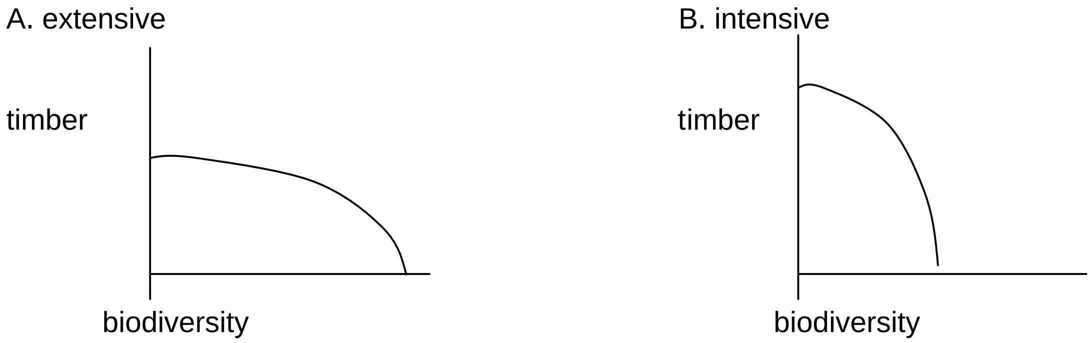

Figure 3: Joint production under extensive and intensive land management regimes (Slee, 2006).

In practice, there is likely to be a part of the joint production curve where there is complementarity (Figure 4). An increase in woodland management for timber may well (up to a certain point), be associated with increased value for recreation. For example, the maintenance of rides within a forest for accessibility of harvesting machinery can also be utilized as cycle tracks (see Figure 4). In this instance, an increase in the production of one good (forestry tracks for timber harvesting) results in the production of another good (access for recreational use). Indeed, it is the assertion of this relationship which underpins this project.

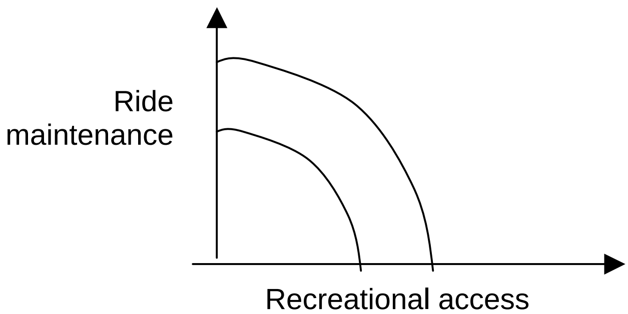

Figure 4: Joint production example of timber and recreation

Figure 5 outlines hypothetical possible production intensity curves for public good outputs under different management regimes, recognising the scope for complementarity. It is likely that some form of modest management will have a positive effect on public good outputs, although increasing intensity of the management regime is likely to reduce public good outputs as a trade off occurs. The key is to determine the optimal range for the provision of management for timber and public good outputs together. Once this range is identified the appropriate form of management and ways to achieve this can be explored.

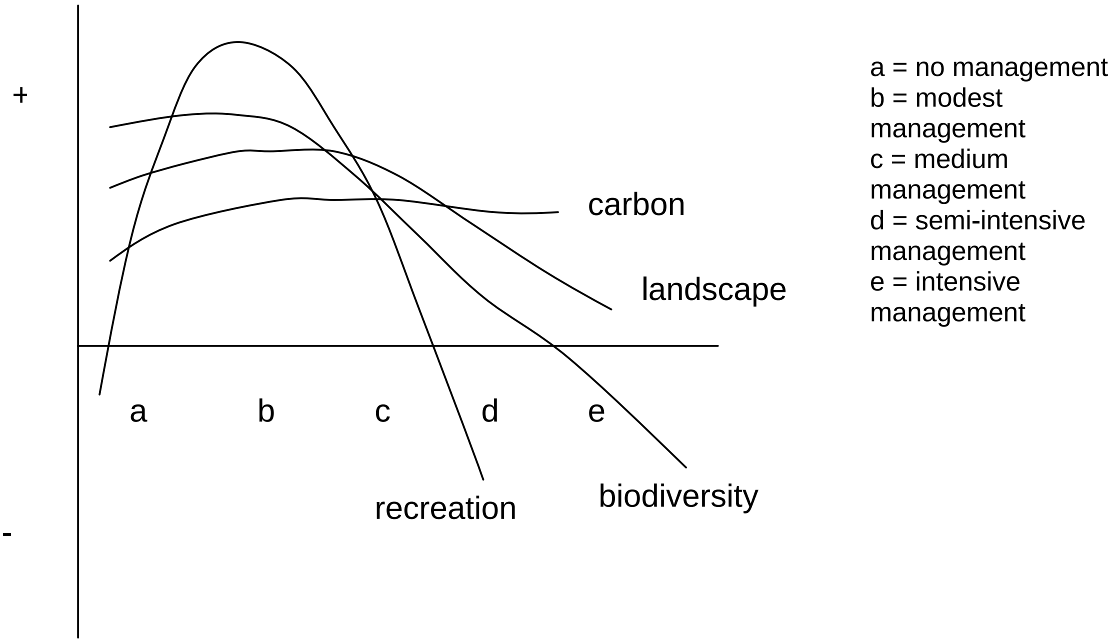

Figure 5: Hypothetical generalised public good value curves.

2.4 Policy choices

Once the TEV of a resource is determined, ways of achieving an optimal and sustainable economic regime are required. Within environmental policy there are two main methods for implementing desired outcomes. Firstly, market-based approaches that use economic incentives to encourage best practice, and secondly, the regulatory approach or 'command and control' regulations (CAC), based on government intervention (Turner et al., 1994).

The market approach, now widely preferred by most politicians and endorsed by such bodies as the Royal Commission on Environmental Pollution, involves a range of means through which the provider of a public benefit is rewarded or through which a producer of a disbenefit is penalised. The most common mechanisms to deal with benefits are grants (although a range of other approaches can also be used) and a range of mechanisms from taxes to marketable pollution permits have been proposed to deal with public disbenefits.

The regulatory approach involves government regulation through methods such as Best Practicable Means (BPM) and Best Available Technology Not Entailing Excessive Cost (BATNEEC). This approach requires action on the part of producers who must conform to a set of governmental orders. In contrast to the regulatory approach which seeks to obtain base level regulatory compliance, well-designed economic incentives can encourage improved environmental behaviour by producers and consumers.

The Evidence Base for Public Good Values

This section outlines the evidence base on the public good values of woodland in the UK. With the overall policy emphasis strongly on multipurpose or multifunctional forestry, it is important to understand the value of public goods in order to determine the TEV of woodlands. The public good values from woodlands and forests range from informal recreation, landscape, biodiversity to carbon sequestration and air pollution absorption. Benefits from these public goods accrue to a range of non-forest agents, e.g. visitors, home owners and society more widely. We will also consider timber values in this section, as the direct use values of timber production and timber processing must obviously also be taken into account when ascertaining TEV. For the purposes of this study, it was not the intention to ascribe specific economic values to public goods. This section outlines the various studies which have done this and illustrates the range of findings found. The purpose of this study was to evaluate the degree of impact that WMFT has on these public goods whilst bearing in mind the relative economic value of each public good output.

3.1 Timber values

Total softwood output in Britain was 9.6 million cu m in 2001 (CJC Consulting, 2004), with England harvesting 2.3 million cu m of conifers and 0.6 million cu m of broadleaves (although this figure is probably over 1 million as small scale harvest for firewood and small local sales are not recorded). The British supply of timber contributes around 15% to total use of timber, paper, boards and other wood products used in Britain (FC, 2002).

The price of this timber has, over the past 15 years, fallen dramatically. Average prices of softwood timber have fallen as low as less than 35% of their 1994 values in real terms, although there has been some recovery in the past two years. The peak value represented exceptional market conditions caused by competition for supply from new processing capacity coming on line, but the decline in stumpage values is real enough in spite of this. A strong pound, and changes in the pattern of world supplies all favoured the UK as a market destination for softwood, especially from Sweden and the Baltic States. Higher fuel costs, Health and Safety legislation and higher resultant haulage rates all compounded the problem of low timber prices for all UK woodland owners. The hardwood market is insignificant in comparison, but has held up quite well until recently, when oak, in particular that derived from French storm damage, became readily and cheaply available in the market and the St Regis paper mill at Sudbrook closed.

Without attempting to factor in the results of climate change, world supplies of wood fibre are tending to increase as highly productive plantation forestry increasingly supplants indigenous forest as a source of wood raw material. Some commentators predict that as much as 80% of the world's timber supplies will come from man-made plantations by 2050. The obvious conclusion is that prices for home grown UK timber will not rise as world timber prices adjust to this availability of supply. Clearly, there will be fluctuations, but the general trend does not support optimism for future price rises for traditional timber products, sawn wood and fibre in one form or another.

The Forestry Commission’s Forest Employment Survey (FC, 2002) calculates that there are 6,166 FTE jobs in forestry and primary wood processing in England, together with 8,573 in haulage, processing and related non-forest jobs. The number of people directly employed in forestry has declined over the past 15 years, with timber producers increasingly employing less labour-intensive new technologies and also using capital intensive contractors to counteract declining timber prices. Furthermore, the first cost-benefit analysis of forestry in 1972 (H.M. Treasury), although now highly dated, indicated that the cost of creating jobs through forestry in areas where commercial returns are poor is extremely high. The study also found that secondary benefits (e.g. environmental) were very limited and unimportant, but there are significant recreational benefits, but these are specific to more accessible areas of forest. The National Audit Office (NAO, 1986) in a subsequent CBA broadly validated these findings.

There is universal agreement that timber production in isolation from other public benefits gives a very low social return (Price, 1997). But the case for forestry has been improved by the acceptance by Treasury of low discount rates for some long-term projects (H.M. Treasury, 2003) and the recognition of a wide range of non-market benefits has increased the calculated returns, where these are calculated in social rather than financial terms.

3.2 Government intervention

Government intervention in forestry occurs for three main reasons: international and EU obligations; market failure and intervention in relation to other policy agendas (CJC Consulting, 2005). There is a further economic argument for intervention to displace other negative externality-creating activities such as imported timber that is harvested unsustainably or where there are external social costs involved (such as pollution from soil, water or air) (CJC Consulting, 2005).

Among the plethora of grant schemes of the post WW2 years, the Dedication scheme is widely regarded as a model approach. This did not offer major rewards; grants, for the most part were token and relied on the woodland owner paying, at the very least, 60% of the costs. Rates of grant were rarely revised, in spite of sometimes rampant inflation in the economy. However, Dedication was designed for the long haul, and needed a set of legally binding covenants, binding on, and passing with the land, before any grants could be claimed. It also needed a plan of operations on a set simple template, to be in force. This created a valuable relationship between the Forestry Commission, authorising grant aid on behalf of the Ministry of Agriculture, and the woodland owner, who looked to the private woodland officer for technical and practical advice and help.

This ran in parallel with an ingenious interpretation of the taxation of woodlands. Income from timber sales was free from income or capital gains tax, and largely free from Estate Duty (now IHT), on Tax Schedule B, a fixed peppercorn assessment of the notional rental value of the woodlands as woods. Once during his or her ownership of land or woodlands, the owner could opt for all, or part of the landholding to be taxed on Schedule D, whereby his "losses" on replanting and maintaining young plantations, were allowed against his other income for tax purposes. This arrangement allowed replanting after felling, and then widespread new planting especially in the uplands, to come about. With marginal tax rates as high, in the 1960s, as 98% of higher income earners, this scheme had clear attractions both to the resident estate with taxable income from the farms which could alleviated by offsetting forestry losses, and to a new breed of investor who bought forest land and planted it up. In the 1980s, lower rates of tax, and unwise proliferation of planting in unsuitable contexts, combined to end the Schedule B / Schedule D arrangement, but there is no doubt that the combination of tax relief and Dedication drove the management and creation of woods in a way not experienced since. The Woodland Grant Schemes that replaced them in the 1980s and 1990s paid higher rates of grant and were based on a contract between the applicant with an interest in land and the Forestry Commission. This approach certainly succeeded in stimulating new planting in lowland contexts, but really achieved not much else apart from positive management outcomes from some of the Woodland Improvement Schemes (WIGs). The decline now observed in woodland management dates from this change, and is partially influenced by it. One success story has been the National Forest Tender Scheme, which invited landowners to tender, in competition, for a fixed pot of money. Basically, they were asked to say how much per hectare it would take to encourage them to create new woodlands of a type and form that satisfied the National Forest's objectives. Provision for management could be rolled up into the initial tender, but there is no provision for continuing management costs outside of the English Woodlands Grant Scheme (EWGS).

In 2004/05 the FC grant aided 171,000 ha of forests and woodlands with management grants (FC, 2004). 156,000 ha were subject to annual management grants (AMGs), 12,000 ha of woodland improvement grants (WIGs) and 3,000 ha in Livestock Exclusion Annual Premiums (LEAPs). The Forestry Commission (FC, 2002) state that 26% of the woodland area in England is certified to UKFS standard. Much of this comprises the public estate. 70% of the private estate is outside any formal FC management scheme (FC, 2002).

The net cost of intervention by the government (excluding fiscal measures) in English forestry is around £60 million per year (CJC Consulting, 2005). 40% of this is spent on supporting the delivery of benefits from the public estate. Evidence supports the case for directing a higher proportion of public investment to the existing forest estate, as opposed to new planting (CJC Consulting, 2005). New planting is only justified where it delivers cost-effective public benefits or where it is required to deliver wider policy agendas such as urban regeneration. Intervention has the potential to deliver net benefits for urban amenity, local woodland access, recreation provision and biodiversity (CJC Consulting, 2005). However, the benefits from such intervention are generally highly dependent on location and accessibility as this will inevitably determine the level of public use.

The Woodland Trust advocates the restoration of under-managed woodlands into useful sustainable production in order to enhance biodiversity (WT, 2005). The Woodland Trust asserts that managing woodlands sustainably not only provides useful products for humans, but also benefits the woodland health and diversity (WT, 2005).

Whether or not WMFT can have a positive impact on public good benefits, one reason for encouraging WMFT is to provide options for future timber production alongside environment and social benefits. This would provide the option value (under the TEV framework) and also allow for some manoeuvrability in terms of the potential for timber production should this be required in the future. However, whether government intervention can be justified purely on the basis of securing a future supply of timber is questionable.

3.3 The Forest Estate in England

England has 1,119,000 ha of woodland and forest (FC, 2005) 67% of which is broadleaved and the majority is in non-FC ownership (82%). Only 25% of the FC estate is broadleaved, whereas 76% of the non-FC estate is broadleaved. There are also more non-FC coniferous forests in England (217,000 ha) than in Wales (64,000 ha). England's private sector is made up of a few large landowners (100-500+ ha) and a much larger number of medium (<100 ha) ownerships, many of which have a long tradition of management. In addition, there are very many small owners, up to say 10 ha, whose woods may not be managed in any continuous way, or which are neglected.

3.4 Public good values

According to a major study by Willis *et al.* (2003) the total value of the social and environmental benefits of forestry in Britain is about £1 billion per year. The aggregate capitalised value is £29.2 billion. This total aggregate value of woodland is largely dominated by recreational and biodiversity values (Table 1), accounting for over 75% of the social and environmental values.

Table 1: Annual and capitalised social and environmental benefits of forests in Britain (£ millions, 2002 prices) (Willis et al., 2003).

Environmental benefit	*Annual value*	*Capitalised value*
Recreation	392.65	11,218
Landscape	150.22	4,292
Biodiversity	386.00	11,029
Carbon sequestration[1]	93.66	2,676
Air pollution absorption	0.39	11
Total	1,022.92	29,226

[1] These figures are approximations since carbon sequestration and future climate change impacts vary and are difficult to predict. They are calculated using the value of £6.67 per tC, which is very low when compared with Government's recommended central value for the social cost of carbon of £70 per tonne (2000 prices), increasing by £1 per year to 2030.

In a survey on public opinion of forestry in 2001, 92% of the respondents supported the use of public money for forestry in order to provide public benefits (Heggie, 2001). The greatest support was for providing good wildlife habitats (70%) and over half agreed with public support for forestry to ameliorate global warming, provide good places to visit, improve the landscape, make the air healthier and bring jobs to rural areas. Less than a third supported providing public money to support forestry for timber for sawmills and bioenergy fuels, although there has been a significant increase in support for this since earlier studies in 1995, 1997 and 1999 (Heggie, 2001).

3.5 The public good value of biodiversity

The broadleaved forest area expanded in Britain by 5% between 1990-2000 (Haines-Young *et al.*, 2000). However, there has been a significant turnover of forest and some ancient woodlands may have been lost as this new woodland estate has been created.

According to Willis *et al.* (2003) the annual biodiversity value of woodlands in Britain is £386 million. This accounts for 38% of the total estimated public good values. The study also estimated the marginal benefits of biodiversity as 35p per household per year for enhanced biodiversity in each 12,000 ha (1%) of commercial Sitka spruce forest, 84p per household per year for a 12,000 ha increase in lowland new broadleaved native forest, and £1.13 per household per year for a 12,000 ha increase in ancient semi-natural woodland.

Table 2: Relative biodiversity values for different types of forest (Willis et al., 2003)

Biodiversity forest type	Relative preference for existing area	Relative preference for an increase+ of 12,000 ha	Relative WTP values per household for an increase of 12,000 ha	Absolute WTP values per household for an increase of 12,000 ha
Upland Conifer Forest (control)	1.00	1.00	1.00	0.35
Lowland Conifer Forest	1.21	1.15	0.94	0.33
Lowland Ancient Semi-Natural Broadleaved Forest	2.11	2.31	3.23	1.13
Lowland New Broadleaved Native Forest	1.95	4.23	2.40	0.84
Upland Native Broadleaved Woods	2.32	3.31	2.57	0.90
Upland New Native Broadleaved Woods	1.95	3.15	1.74	0.61

+ Or in the case of ancient lowland and upland native broadleaved woodland to protect and regenerate these woodland types.

Table 3: Total aggregate annual biodiversity values for woodland types (aggregated at a regional rather than GB level)

	Area (thousand ha)				Value (£ millions)				
Region	ASNW	NPB	RP	NPB+ RP	ASNW	NPB	RP	NPB+ RP	Total annual biodiversity value
Eastern	18			13	28			9	37
East Midlands	11			9	17			7	24
North East	6			15	9			10	19
North West	14			9	22			6	28
South East (incl. London)	82			19	128			12	140
South West	35			14	54			9	63
West Midlands	19			6	30			4	34
Yorkshire & Humberside	9			7	14			5	19
England	193	43	49	92	302	34	27	61	363

RP = replanting; NPB = new planting broadleaves

Hanley *et al* (2002) (who adopted Garrod & Willis 1997 as the basis for his estimates) published the most comprehensive and inclusive assessment of non-use value of biodiversity in UK. The study showed a preference for improving biodiversity values in lowland new broadleaved native forest and upland native broadleaved woods (see Table 4).

Table 4: Relative biodiversity preferences for different types of forest, and actual mean WTP (£ per household per year) (Hanley et al., 2002).

Biodiversity forest type	Relative preference for existing area	Relative preference for an increase* of 12,000 ha	Absolute WTP values (£ per household per year) for an increase of 12,000 ha
Upland Conifer Forest (control)	1.00	1.00	0.35
Lowland Conifer Forest	1.21	1.15	0.33
Lowland Ancient Semi-Natural Broadleaved Forest	2.11	2.31	1.13
Lowland New Broadleaved Native Forest	1.95	4.23	0.84
Upland Native Broadleaved Forest	2.32	3.31	0.90
Upland New Native Broadleaved Forest	1.95	3.15	0.61

** Ancient lowland and upland native broadleaved woodland – to protect and regenerate these woodland types.*
In columns 2 and 3 the base value is the individual mean for upland conifer, with other types of forest scaled to that token unit, for existing area and increase in area, respectively.

The Crabtree *et al.* (CJC Consulting, 2005) study indicated a biodiversity preference for restoring PAWS and creating new areas of semi-natural broadleaved forest adjacent to existing woodlands. In addition to the use of such economic arguments, there are other policy drivers with respect to biodiversity objectives, including the SSSI SPA targets, the woodland bird indicators, UKBAPs and the England Biodiversity Strategy. In the biodiversity arena, command and control measures mix freely with economic instruments and rationales.

3.6 The public good value of recreation

There has been long term recreational value in the overall woodland resource and there is growing interest in recreation on near-natural forest or wildwoods (Worrell *et al.*, 2002; Garforth and Dudley, 2003). The TNS Travel and Tourism (2004) omnibus survey estimated that there were 222 million visitors to woodlands in England in 2004, 21% of which were to FC woods, 33% to local authority woods, 23% to private woods and 7% to woods owned by voluntary or NGO organisations. This estimate is much higher than that of Benson and Willis (1992), who estimated that there were 28 million visits to FC woods in Britain in 1992, 21.5 million of which were in England. Benson and Willis (1992) also stated that the location of woodlands is a major determinant of the value of recreation in those areas (see Table 5). For example, the marginal benefits of woodland recreation are higher where substitute recreational experiences are limited. The TNS survey indicated that walking (62%) is the most popular activity in woodlands, followed by cycling (8%) and horse riding (2%). A Forestry Commission survey indicated that 30-40% of all visitors to woodlands and forests are dog walkers (Christie *et al.*, 2005).

Table 5: Estimates in the variations of value on recreation across the UK (**Willis **and** Garrod**, 1991).

	Value per ha per year
Cheshire	£445
New Forest	£425
Forest of Dean	£245
Brecon	£42
Thetford	£14
Newton Stewart	£4
Lorne (Argyll)	£2

The total annual value of recreation in woodlands and forests is estimated at £393m (Willis *et al.*, 2003). The marginal values for woodland recreation are also estimated at £1.66 for each recreational visit (90p for local visits, £1.80 for visits from a greater distance) (Willis *et al.*, 2003). A travel cost survey by the Forestry Commission in the 1980s found a consumer surplus of £2 per person per visit. In 1992 the Treasury reduced this to £1. The current figure used is £1.60 per visit, with the increase on the 1992 figure due to inflation. Similarly, a survey by Scarpa (2003) found the mean maximum willingness to pay for a woodland visit ranged from £1.66 to £2.75. Dog walkers' have a low consumers' surplus on marginal walks (4p to 30p), most likely due to their frequency of visits (Willis and Garrod, 1991). The marginal benefits of woodland recreation are understandably higher when substitute recreational experiences are limited (CJC Consulting, 2003).

There is an increasing policy emphasis on the expansion of recreation within woodland sites, especially sites that are more accessible to where people live. Conversion of existing sites is preferred to the creation of new sites, as this presents a more cost-effective approach (CJC Consulting, 2005).

In a recent study, the Woodland Trust (2004) estimated that 10% of England's population has access to 2ha+ accessible woods within 500m of their homes and 55% have access to 20ha+ accessible woods within 4km. The study calculated that if all existing woods were opened (most of which are in private ownership) an extra 26% of the population would have 2ha+ wood within 500m and an extra 28% would have access to a 20ha+ wood within 4km. However, there is a need to consider the marginal costs and benefits of making different woodlands accessible.

Forest-related tourism expenditure associated with tourism day visits is estimated to be around £2.3 billion, over 3% of total tourism expenditure in the UK. For England the figure is £2,054 million, which is 3.4% of tourism expenditure (Hill *et al.*, 2003). On average, around 13% of total tourism expenditure incurred by visitors to six countryside areas surveyed could be considered to be "forest-associated expenditure" (see Table 6). Slee *et al* (2004) have argued that such values, termed the halo effect, can be enormously significant in local economies.

Table 6: Proportion of tourism expenditure in the countryside that is "forest-associated" (%) (Hill et al., 2003).

	%
New Forest	15
Lake District	12
Borders	11
Wye Valley	17
Snowdonia	12
Total	**13**

3.7 The public good value of landscape

Woodlands are a highly visible and valued component of many landscapes (FC, 2004). However, the valuation of landscapes is complex and there is only limited economic evidence of the benefits or disbenefits of changes in woodland concentration or design on the landscape. Garrod (2003) estimated that an average household was willing to pay £227 per year for views of urban fringe broadleaved woodland on journeys. Views of woodland in other landscape settings were either small or statistically insignificant. The study showed that typical respondents preferred small woodlands of randomly spaced broadleaves of varying heights with areas of open space. Garrod also estimated the capitalised value of forest landscape at £7,980 per house. Anderson & Cordell (1988) estimated that local trees added 4% to house prices and Morales (1980) estimated this at 6%. A hedonic pricing model in Gloucestershire estimated that 20% general tree cover added 7.1% to house values, although higher percentages of tree cover could detract from house prices (Garrod and Willis, 1992).

Willis *et al.* (2003) estimate a value of £269 per annum per household for those households with a woodland landscape view on the urban fringe. CJC Consulting (2005) conclude that the landscape value (in terms of public good) of woodlands is higher in urbanised areas. This is because more people in these areas are able to enjoy the woodland landscape than in remote areas. Garrod (2003) also showed that a preference for forested over non-forested landscapes was only found for broadleaved woodland in a peri-urban setting. However, it is also recognised that a small amount of additional trees and woods can help to conserve highly valued rural upland landscapes.

Table 7: Aggregate capitalised value of woodland landscape in England (Willis et al., 2003)

Number of households with woodland view	183,324
Value of woodland view for houses (£, millions)	1,408
Number of households seeing woodland on journey	329,444
Value of woodland view on journeys per household (£, millions)	2,133
Total value of views of urban fringe woodland (£, millions)	3,540

3.8 The public good value of carbon

Two main approaches have been used in existing studies to estimate the value of carbon, namely the cost-benefit analysis (CBA) approach and the marginal cost (MC) approach. Each has a number of uncertainties associated with it, which can be grouped into two main categories: scientific uncertainties and uncertainties associated with economic valuation (Clarkson and Deyes, 2002). Scientific uncertainties include uncertainties in present measurement and prediction of future emissions, estimating the climate impact associated with increased levels of atmospheric carbon and identifying the physical impacts resulting from climate change (Clarkson and Deyes, 2002). The economic valuation uncertainties include how to estimate values for non-market impacts, predicting how the impacts will change in the future and determining the rate at which future impacts should be discounted to today's prices (Clarkson and Deyes, 2002). Thus, we see a range of carbon values estimated in the literature from £2.66 to £140 per tonne of carbon sequestered (tC).

A sophisticated model by Fankhauser (1994; 1995) in the early 1990s provided well-documented estimates for the value of carbon sequestration. Fankhauser estimated a value of $20.3 per tC in 1991, increasing to $22.8, $25.3 and $27.8 over the next 3 decades to 2021. The IPCC estimated a range of $6 to $160 per tC (in 2000 prices) based on existing studies (IPCC, 1996). Pearce (2003) argues that the base case of social marginal cost of carbon is £2.66 to £6 tC, while Willis *et al.* (2003) use the value £6.67 per tC.

The government has estimated the social cost of carbon in forests as £70 per tC with an upper value of £140 per tC and a lower value of £35 per tC (in 2000 prices, and increasing by £1 per tC per annum) (Clarkson and Deyes, 2002). This estimate includes a damage function to provide a sensitivity analysis to reflect the risk associated with climate change damages. However, it does not include a consideration of climatic catastrophes (such as the melting of the West Antarctic ice sheet), hence the upper and lower estimates (Clarkson and Deyes, 2002).

Brainard *et al.* (2003) estimated the net present value (NPV) for carbon sequestered by woodland in England as over £772 million, with most of this value occurring in private broadleaved woodland (see Table 8).

Table 8: NPV estimates (£millions) for carbon sequestered by woodland in England (price per tC = £6.67, with annual increments of 6.67p to year 2002-2031) Brainard* et al *(2003).

	NPV (£ million), **discount rate = 3.5%**
Forestry Commission	
Beech	9.50
Oak	11.57
Sitka Spruce	21.07
Other Broadleaf	15.30
Other Conifer	54.72
FC Totals	115.21
Private woodland	
Broadleaf	523.94
Conifer	133.17
Private woodland Totals	657.11
All England Woodland	772.32

The total annual value of carbon sequestration in Britain includes estimates of £94 million per year at £6.67 per tC, to £983 million per year at £70 per tC (Willis *et al.,* 2003). At the higher level the value for carbon sequestration is clearly much higher than that of either biodiversity (£386 million) and recreation (£393 million) in Willis *et al.*'s (2003) study. However, it is important to note that these limited analyses are restricted to the value of carbon associated with sequestration in living biomass, soils and wood products and are most appropriate to studies of the benefits of woodland creation. They do not consider the carbon benefits that accrue from wood replacing fossil fuels directly in the form of woodfuel or, indirectly, by replacing materials such as concrete and steel that have high CO_2 emissions associated with their production. It is these substitution benefits that are likely to contribute most to arguments in favour of woodland management for carbon objectives.

3.9 Other public good values

As well as biodiversity, recreation, landscape and carbon sequestration, a range of other public goods are provided by forests and woodlands, such as pollution absorption, water supply and quality and protection of archaeological artefacts (Willis *et al.*, 2003). There is also increasing evidence to support the view that woodlands and forests can improve quality of life and health (DETR, 2000; CABE, 2003). In England, it has been estimated that the net pollution (particulates (PM_{10}) and SO_2) absorbed by trees reduces deaths by 5 per year, and reduces hospital admissions by 4 per year. This amounts to a benefit of £583,570 per year (Powe and Willis, 2004). According to Willis *et al*. (2003), £124,998 is saved each year for each death avoided by 1 year due to PM_{10} and SO_2 absorbed by trees, and £602 for an 11 day hospital stay avoided due to reduced respiratory illness. Recent arguments about woodlands as providers of opportunities for enhanced health through the provision of 'green gyms' are recognised, but calculation of economic values of such benefits are highly locationally specific and are much influenced by substitution effects. It is, therefore, likely that the health improvement value from pollution absorption estimated by Powe and Willis (2004) grossly underestimates the total contribution of woodland to the health agenda.

England's semi-natural ancient woodlands also have much cultural heritage. Many ancient woodland sites contain features related to past woodland management, such as wood banks and saw pits, as well as archaeological features such as Bronze age burial sites or Roman houses. Any management of these woodlands needs to be sensitive to the historic features present.

Woodlands can also improve soil, water and flood control as well as reducing pollution from agriculture (CJC Consulting, 2005). However, there is a cost of 13p to £1.24 per m^3 where water is lost to abstraction for potable uses, although for most areas where no abstraction occurs the marginal cost is zero. The externality cost of woodland on water quality has largely been 'internalised' within forestry through the application of guidelines on woodland planting and conditions attached to forest certification.

There is a strong case for intervention in forestry when it aids regeneration and urban development. There are potential positive benefits to quality of life and impacts on attractiveness to businesses and their retention in an area (CJC Consulting, 2005). Community forests provide a good example of the role of woodland in regeneration. Other forest and woodland initiatives have also been shown to stimulate local economic activity (Slee *et al.*, 2005). However, the use of forestry in rural development is not always ideal because of the long time-scale, uneven labour profile and the effects of long-term dependence on subsidy (CJC Consulting, 2005). However, CJC Consulting (2005) suggest that there is a much stronger case for forestry when it stimulates innovation.

The 1998 England Forest Strategy includes a commitment to increase renewable sources of energy and use of short-rotation coppice. The Defra Energy Crops Scheme has offered an establishment grant of £1000 per hectare for short-rotation coppice (SRC) (£920 for Miscanthus) since 2000. A further €45 per ha subsidy for energy crops on non-set-aside land may also be available under the Single Payment Scheme. The Energy Crops Scheme will finish in 2006 when a new Rural Development Plan is introduced. To date, up-take of the scheme has been very low.

3.10 Intrinsic Value

Whilst this study is explaining public good outputs within a predominantly economic paradigm, there are values ascribed to woodlands and forests that cannot be accounted for in this way. The most obvious of these is biodiversity. It can be argued that woodlands have an intrinsic value[2] for biodiversity regardless of their instrumental value to humans. In other words, the public good value for biodiversity determined by people's preferences (which gives an anthropocentric and instrumental value) does not encompass any value which may be intrinsically inherent within the woodland. It is, therefore, not possible to show empirically, using economic methods, what intrinsic value in a woodland is. Thus, for public goods such as biodiversity where there may be considerable intrinsic value, any economic valuation of that public good will be an underestimate of total value (Turner et al., 1994).

[2] Intrinsic value is the value of an environmental asset which exists independent of its utility to humans.

The Evidence Base on Woodland Management and Public Good Outputs

This section outlines the evidence for the impact of woodland management for timber and wood products (WMFT) on public good outputs. Such evidence can then be used to determine whether WMFT is indeed desirable for enhancing public good outputs, and if so, what policy mechanisms can be used to achieve the desired outcomes. However, it should be noted that much of the evidence presented is not framed within an economic context and requires 'translation' to an economic framework.

4.1 Biodiversity and WMFT

Disturbance is fundamental to the development and function of forest ecosystems (Oliver, 1981; Attiwill, 1994) and ranges from the frequent, small-scale, gap-forming disturbances (at single tree level) to the infrequent stand- or landscape-scale events that can significantly alter large areas of forest. Silvicultural practices can be said to partially mimic the natural forest processes of gap dynamics, whether it be large-scale disturbance by clearcutting or partial cutting systems as in small-scale disturbance regimes. Coates and Burton (1997) conclude that treefall gaps, whether natural or man-made, are an essential component of stand and landscape heterogeneity.

Until the late 19th century (and much later in some areas) English woodlands were managed by coppicing, thinning, felling, pollarding and grazing, in order to provide fuel, small wood and timber (Rackham, 1976). This diversity of demands created the structural heterogeneity and rich mix of species that are today associated with ancient woodlands. A survey of the long-term ecological change in British woodlands carried out between 1971 and 2001 revealed not much difference in broadleaf composition but some differences in structure during this time (Kirby *et al.*, 2005). In addition, there was a decline in woodland specialist richness and ground flora richness which many consider represents a deterioration in the quality of biodiversity of woods over that time. The authors state that an increase in the total basal area of tree stems is most closely correlated with this decline. The study indicated a decline in the openness of woods, with most decline occurring in large and small glades and paths of less than 5m wide. WMFT may well help to 'open up' woodlands and, thus, increase ground flora diversity. However, the observed declining biodiversity might simply be a phase in the even-aged development of woodlands. If left unmanaged natural processes will eventually take over and may well balance out the shade/light conditions within the woodlands without the need for human interference. Such processes may well occur over very long time periods, with a change from species typical of managed woodlands to those associated with mature old-growth forests (Peterken and Backmeroff, 1988). However, there are risks with this approach if most woods at the landscape scale are at a similar (shaded) stage.
Habitat changes arising from reduced management may benefit some species (such as those inhabiting fallen dead wood or shade loving species), while having a significantly negative effect on much ground flora. The Kirby *et al.* (2005) study suggests that a management regime that creates varying open and closed phases within woodland is likely to increase ground flora richness, particularly the ruderal elements of woodland flora, together with some woodland specialists (Barkham and Hance, 1982) as well as many butterflies and woodland birds (Amar *et al.*, 2006). However, such management may occur without timber production.

English Nature (2003) suggests that the reduction of biodiversity values of British woodlands is a function of forestry and woodland management (mostly lack of), overgrazing by deer and browsing (Table 2). Overgrazing causes long-term damage to woodland structure, limits natural regeneration and leads to biodiversity loss (Rackham, 2001). Deer browsing also affects ground flora diversity (Fuller, 2001; Fuller and Gill, 2001; Fuller *et al.*, 2005) and can have impacts on other species. For example, deer browse the White Admiral butterfly's food plant, honeysuckle (Liley *et al.*, 2004). Grazing by deer and lack of management may be related in that the extra costs of preventing damage to regrowth/regeneration can be a reason why owners are unwilling, for example, to carry out coppice work.

Table 9: Reasons for adverse condition in broadleaved and yew woodland SSSIs in England in 2003 (% of area in adverse condition)

Adverse reason	Upland	Lowland
Agriculture overgrazing	52.1	1.2
Forestry and woodland management*	33.2	65.7
Forestry deer grazing/browsing	19.1	15.5
Lack of corrective works weed control	5.9	4.1
Agriculture inappropriate CS/ESA prescription	4.8	0.2
Lack of corrective works scrub control	3.5	13.0
Game management pheasant rearing	1.0	1.9
Agriculture undergrazing	0.3	6.9
Freshwater quality direct pollution	0.3	1.2
Freshwater drainage	0.0	14.8
Air pollution (no/so)	0.0	2.0
Public access/disturbance	0.0	1.9

Note: Reasons listed on less than 1% of SSSIs are excluded. * Mainly lack of woodland management.
Source: English Nature ENSIS data September 2003.

Recent analysis indicates that butterfly species are declining more rapidly than either birds or plants (Thomas *et al.*, 2004). Mature broadleaved woodlands, clearings, coppice areas, rides and glades all hold different butterfly species (Liley *et al.*, 2004). For example, Purple Emperors (*Apatura iris*) require large blocks of broadleaved woodland with goat willow (*Salix caprea*), whereas Duke of Burgundy (*Hamearis lucina*) requires clearings within ancient woodland sites with *Primula* species as its main food plant. The decline of the Dingy Skipper (*Erynnis tages*) has been linked to changes in woodland management which lead to shadier woods and a lack of open areas. Conversely, shade tolerant species, such as the Silver-washed Fritillary (*Argynnis paphia*), the Speckled Wood (*Pararge aegeria*) and the Purple Hairstreak (*Neozephyrus quercus*) have increased their range (Liley *et al.*, 2004), most likely due to the increase in shady woodland habitats resulting from a lack of management. The most threatened butterfly species are those that require early successional habitats such as newly cleared or felled areas (Asher *et al.*, 2001; Warren *et al.*, 2001).

WMFT can also positively or negatively affect bat species. Bats require holes in mature trees for roosting, dead wood and hollow trees, and a dense understorey (Boye and Dietz, 2005), as well as connectivity in the landscape in order to move between their roosting sites and foraging areas. Clearfelling can impede this connectivity, although this can be mitigated through good harvest design, such as the retention of treeline, woodland edges, ride edges and historic features such as woodbanks. Positive management can, however, be beneficial for bats. Bechstein's bats, for example, prefer uneven aged, deciduous semi-natural or ancient woodlands with a dense mixed species understorey. They do not favour large areas of continuous high forest, but prefer slightly fragmented, structurally diverse forests (Greenaway and Hill, 2004).

Thus, managing a woodland with biodiversity objectives in mind will involve providing a range of habitats and structures that benefit most species (for example, see the Forestry Commission study (2005) on bats; Fuller *et al.* (2001) and Amar *et al.* (2006) on birds; Tudor *et al*. (2004) and Grundel *et al.* (1998) on butterflies). Often woodland management for particular species may simply involve improving awareness and the provision of suitable habitats. This may require designating an area within a woodland as a natural reserve, for example, for bats. Ancient trees provide the best habitats for bats and should be retained where possible. Such management does not prevent harvesting operations elsewhere within the woodland block, although timing harvesting to occur outside of the period when bats are raising their young (May to September) in tree roosts is advised (FC, 2005). The recognition of the need for woodland management to be conditioned by the demands of different species raises important questions about the value of different species. There are necessarily trade-offs between different components of biodiversity. Active woodland management can be a way of ensuring that across a suite of woods there are suitable areas for each of these components.

Woodlands and forests also have biodiversity impacts on non-forest habitats. These can be beneficial, such as the provision of cover for breeding or roosting for species that predominantly inhabit open habitats. They also provide a source of shelter for prey. Further indirect biodiversity benefits occur from improved water quality following conversion of agricultural land to broadleaved forest. Woodland shelterbelts and scrub can act as a buffer or barrier to pollution and noise disturbance and can limit soil erosion. Opening up existing woodlands may benefit non-forest biodiversity (for example, along rides and glades).

Kirby *et al.* (2005) also indicate that the changing climate is likely to play an important role in determining woodland structure and diversity over the next 50 years. They suggest that large populations or meta-populations (rather than small populations) and connectivity of habitats are likely to provide the best opportunities for species to adapt to changing environmental conditions. They also caution that a warming climate may have an impact on appropriate management techniques, with warmer summers exposing ground flora in open woods to the effects of drought and rising nitrogen levels may favour competitive species rather than more stress-tolerant ground flora. Evidence for the impact of nitrogen pollution is provided by Haines-Young *et al.* (2000) and Kennedy (2003).

Greatorex-Davies *et al.* (1994) showed that the presence of canopy gaps in forests can significantly enhance invertebrate faunal abundance and species richness, especially of butterflies. Canopy gaps can also affect the structure of vertebrate communities, with different species colonizing open areas as opposed to closed canopy areas. Coates and Burton (1997) state that varying gap sizes have an impact on vegetation responses. Varying light regimes, water balance and nutrient availability associated with different gap sizes and gap positions affect seed germination, seedling mortality, tree growth, vegetation development and animal activity.

Bryophytes (liverworts and mosses) are sensitive to management (Fenton and Frego, 2005). Fenton and Frego (2005) found species were more abundant under remnant canopy than in open and clear-cut areas. They concluded that the most effective way to promote bryophyte survival across a managed landscape may be to conserve populations within harvested stands, which would require patches of undisturbed canopy. Similarly, Nelson and Halpern (2005) showed that over short time frames 1 ha size plots not subject to disturbance are sufficient to maintain most common mosses through harvesting disturbances, but are not large enough to prevent the decline or loss of liverworts.

Humphrey (2005) states that if timber production is also an objective in upland old-growth stands, these sites should be managed by single tree selection or small group-fell silviculture, control of over-prolific regeneration of shade-tolerant conifers and maintaining some deadwood and veteran trees. Where normal patch clearfelling takes places, small areas of old-growth forest (0.25 to 2 ha) should be maintained to provide a temporary habitat for species (such as bryophytes, lichens, fungi, invertebrates, small mammals, birds) and to encourage dispersal.

Thus, if management complies with best practice, activities such as thinning, coppicing and restoring PAWS can have a positive effect on biodiversity.

A summary of the positive and negative impacts of WMFT on biodiversity is given in Table 10. Any management regime needs to attempt to maximise the positive impacts of WMFT and minimize the negative. The key is to understand what is most important on a particular site in relation to its history and place in the landscape.

Table 10: The positive and negative impacts of WMFT on biodiversity

Positive Impacts	**Negative Impacts**
Reduces shading for light-loving species (e.g. ground flora, birds, many butterflies)	Density of replanting often too high.*
Maintains canopy gaps in glades and rides.*	Non-selective-weeding in open habitats for replanted stock can impacts species that use these habitats as food source, for nesting or shelter.
Provides temporary open habitats.*	Damage to other rodents from squirrel control.
Can mimic natural disturbance.	Soil and ground cover damage.
Controls invasive or non-native species.	Reduction in standing and felled deadwood.
Beneficial for non-forest species in open areas.	Can impede habitat connectivity.*
Creates structural heterogeneity.	Bryophytes and mosses require undisturbed canopy.

*Applies to clear-felling only.

4.2 Recreation and WMFT

In order to determine the impacts of WMFT on recreational values, it is first necessary to outline what enhances recreational provision in woodlands. A study undertaken by Ward Thompson *et al.* (2005) investigated how and why people use local woodlands. Their findings revealed that freedom from litter and proximity to woodlands is important for regular woodland users. Access to open green space, such as woodlands, can contribute to the quality of life and well-being of individuals

(Kaplan and Kaplan, 1989; Berger, 1996; Hickman *et al.*, 1999). However, there are also issues of feelings of insecurity in open spaces, relating to fears of personal attack or injury (Burgess *et al.*, 1988; Fisher and Nasar, 1992). These fears are associated with ideas of teenage delinquency, vandalism, litter, drug abuse, male sexual violence against unaccompanied women, abduction and abuse of unsupervised children and racially motivated attacks (Ward Thompson *et al.*, 2005).

A study by Coles and Bussey (2000) found that most people stated that proximity of woodlands are a key factor in determining where they chose to go. Most visits were within 5 minutes walk of home, although over 25% were prepared to walk up to 10 to 30 minutes from home (Coles and Bussey, 2000). Similarly, Harrison *et al.* (1995) found that ideally green spaces should be within 230 m of the user's home. In the Coles & Bussey study, 75% of the user population live within 275 m of a woodland. The same study also recommended that woodlands should be a minimum of 2 ha to maximise social value and have an open structure, and while tree species was not seen as an important factor, most users preferred mixed woods. Open woodlands give a positive image, whereas dense, gloomy woodlands can create negative images with many places that might hide an attacker, or limit the view ahead and induce fear of crime (Burgess, 1995). In a study in Sweden, woods managed using a shelterwood system yielded the highest recreational value in a study (Holgén *et al.*, 2000), whereas clearfelling had the lowest recreational value. However, the temperate woods and forests of England are different to the boreal forests of Scandinavia and are likely to require different management techniques to promote public good benefits.

The respondents in Ward Thompson *et al.*'s (2005) study stressed that they felt that the woodlands near to where they lived needed to be tidied up, the signage maintained and good footpaths provided. People want a mix between a very wild woodland and a woodland park; partly managed but also with a natural feel. The two issues that prevented more frequent woodland use were safety and forest abuse and the presence of rangers or wardens was believed to be a solution to deter vandalism and encourage a feeling of safety. Woodlands with very mature, mixed-species trees and a fairly open layout were the most popular for visitors.

These studies show that the recent demands for 'natural' woodland need to be tempered by recognition that many woodland visitors prefer a degree of management. However, that management may not necessarily be for timber production, but in order to enhance the recreational experience. A study for the Forestry Commission in 2001 showed that over three-quarters of the respondents would like to see toilet facilities at woodland sites (Heggie, 2001). The majority also wished to see sign-posted walks suitable for all abilities, a car park, nature trails and a picnic area. Nonetheless, some types of management for recreation may well contribute beneficially to woodland production.

Much of the above analysis of woodland recreation refers mainly to informal recreation, such as walking or dog-walking. Other forms of recreation, such as horse riding and mountain biking may have different responses to woodland management for timber. Such recreationists may have different preferences on the type or location of woodland used. For instance, mountain bikers may prefer upland woodland sites. Access for horse riders is important, with well-kept bridleways necessary for access. There are issues of path erosion, especially rutting of tracks in wet weather, associated with both biking and horse riding.

A summary of the positive and negative impacts of WMFT on recreation is given in Table 11.

Table 11: The positive and negative impacts of WMFT on recreation

Positive Impacts	**Negative Impacts**
Creates open areas for recreational use.*	Can detract from naturalness of woodland experience (especially clearfell).
Reduces gloominess and shading in woodlands – reduces fear of crime.	Adverse public reaction to tree removal or felling.
Improves access (ride maintenance).	

*Applies to clear-felling only.

4.3 Landscape and WMFT

Woodlands and forests can have a significant impact on the landscape. They are important elements in greening urban environments, screening (noise and visual), improving well-being and contributing to sense of place and quality of life. However, woodlands can also reduce landscape diversity by hiding other features, such as streams, rocks and other vegetation (Lucas, 1991). Appropriately designed WMFT regimes can improve landscapes, whilst bad design can damage landscape. Issues such as shape, scale, sense of place (cultural and traditional heritage), diversity, colour and landform will affect the impact of WMFT on the wider landscape (Lucas, 1991; Bell, 2004).

Small-scale landscape issues or visual amenity within woods are also important. Creating a more open structure, clearings, rides, riparian/water features and vistas can all improve the internal landscape of woodlands. These elements can also enhance biodiversity and provide recreational benefits.

But what sort of natural environments and landscapes do people prefer? The way that individuals view and value a particular landscape is relative (Lothian, 1999) and influenced by culture, society, history and personal experience. Furthermore, the way individuals react to and interpret the natural environment is multi-faceted and the way they attach meaning to those landscapes is equally complex (Fredrickson and Anderson, 1999). Individuals may view the same landscape but see it differently dependent upon their perception or use of that landscape.

Studies in the USA show that clear-cutting has a major negative influence on the aesthetic appeal of landscapes (Ribe *et al.*, 2002; Ribe and Matteson, 2002) with an 'aesthetic dip' just after timber harvests (Ribe, 1989; Sheppard *et al.*, 2001). This is most likely due to people's preferences for naturalistic landscape scenes (McCool *et al.*, 1986; Magill, 1992) and an aversion to the perceived destruction of life (Chokor and Mene, 1992). In Karjalainen and Komulainen's (1999) study in Finland, landscapes without any traces of logging were preferred to those with evident felling areas. The Forest Landscape Design Guidelines (FC, 1994) set out the principles and practical application of forest design for applicants for the Woodland Grant Scheme and felling licences, in order to mitigate any potential negative impacts of harvesting and re-planting.

Without timber harvesting natural processes would eventually take over. These processes would be unpredictable and catastrophic. The effects of the storm in 1987 illustrate the vulnerability of a regionally uniform stock of ageing woodlands to such climatic catastrophes. With the likelihood of an increase in such events associated with climate change, the un(der)managed state of many of England's woodlands may make them more vulnerable in such circumstances and be a threat to public benefit.

A summary of the positive and negative impacts of WMFT on landscape is given in Table 12.

Table 12: The positive and negative impacts of WMFT on landscape.

Positive Impacts	Negative Impacts
Can reduce the impact of unpredictable climatic catastrophes.	Landscape change (e.g. clearfell).
Improves internal woodland landscape (vistas, rides, glades, light).	

4.4 Carbon and WMFT

The carbon balance is affected by WMFT in three main ways:

- locking up carbon in standing timber
- the substitution of fossil fuel with wood fuel
- material substitution or locking up carbon in wood products

Since about 50% of standing timber is carbon, any WMFT regime that affects the volume of standing timber will affect the volume of carbon stored. Many factors determine the rate of sequestration by trees, including those pertaining to silviculture, site conditions and the age and vigour of the trees (Bateman and Lovett, 2000; FTA, 2004). Further, actions to increase carbon sequestration can affect other outputs from forestry, such as harvest level and the availability of forest biofuel (Backéus *et al.*, 2005). Models have been developed to simulate carbon uptake rates and the complex biological processes, nutrient balance and socio-economic factors that affect the potential of a forest to sequester carbon, e.g. CO2FIX (Nabuurs *et al.*, 2002; Masera *et al.*, 2003), FORECAST (Seely *et al.*, 2002), FORSKA (Lasch *et al.*, 2002) and CENTURY (Song and Woodcock, 2003). Some models also incorporate carbon emissions from decay, burning of forest products, harvesting operations and timber transportation (Liski *et al.*, 2001; ECCM, 2002). However, there are uncertainties about the relationships of the variables used in the model, uncertainties about the potential damage caused by rising carbon dioxide levels and variations in how income elasticity affects people's willingness to pay to avoid damage.

The Edinburgh Centre for Carbon Management (ECCM, 2002) estimates 1 ha of mature oak (YC4, planted at an initial spacing of 1.2m, stocking density of 4,200 plants per hectare, intermediate thinning and excluding soil) will offset 75 tC over a 100 year period. A mixed woodland with 50% oak or other broadleaf (YC4) will offset 30-60 tC per hectare.

Several studies indicate that regulating the rotation length of tree stands is an effective way to manage the standing carbon stocks of forests (Liski et al., 2001; Backéus et al., 2005). Longer rotation length favours carbon sequestration. However, the costs are decreased timber harvests and, thus, decreased revenues to landowners (Liski et al., 2001) and a lowering of the NPV of the harvest (see Figure 6). Further studies also concur that carbon sequestration is increased with longer rotation of harvesting (van Kooten *et al.*, 1995).

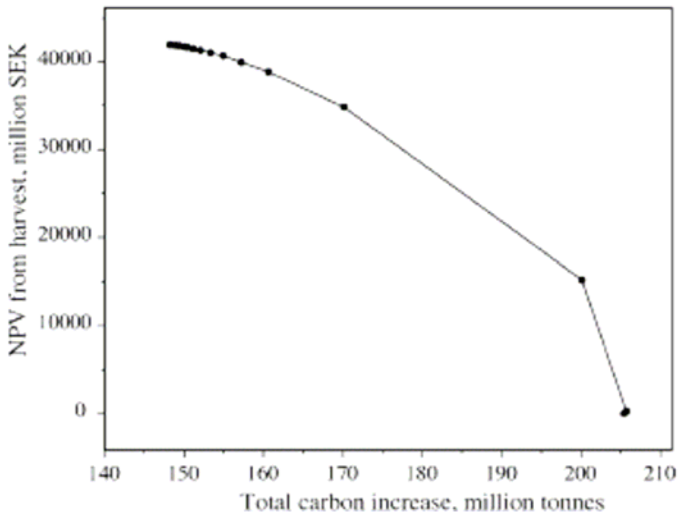

Figure 6: Trade off between NPVof harvest and total increase in forest carbon storage for a 100-year period for carbon prices between zero (upper-left point) and 2308 (lower-right point) SEK tonne-1 (Backéus et al., 2005).

Thus, a trade-off exists between timber production and carbon sequestration. While a move from unmanaged woodlands to managed plantations results in an increase in yield (Bateman, 1996), such profit maximisation results in smaller stems being periodically removed (thinned) so as to promote the growth of a reduced number of larger, high value trees. This causes a reduction in potential carbon storage (Matthews, 1993) as stands are felled before reaching maximum carbon carrying capacity (see Figure 7).

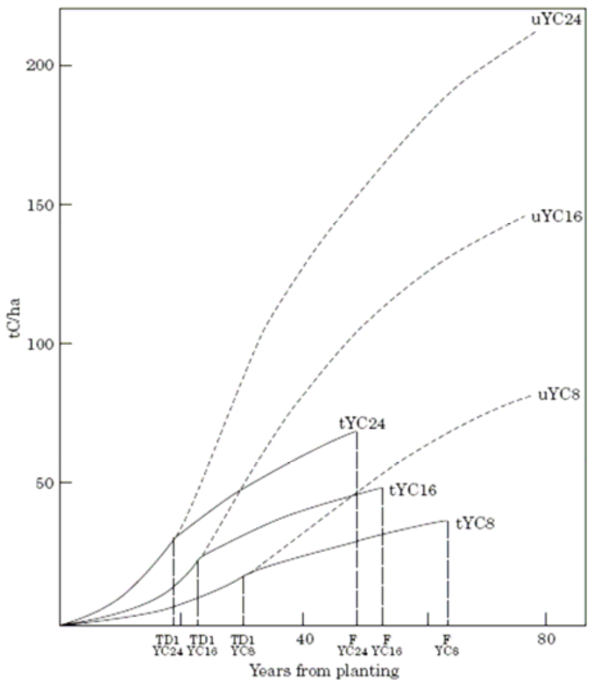

Figure 7: Total carbon storage curves for unthinned and thinned Sitka spruce (discount rate=5%). TD1=date of first thinning (TD1 YC24=date of first thinning for yield class 24 Sitka spruce). Dashed line (and solid line prior to TD1) =total carbon stored in unthinned live wood (uTWCS). Solid line (after TD1) =total carbon stored in thinned live wood (tTWCS). uYC24DuTWCS for YC24 Sitka spruce. tYC24=tTWCS for YC24 Sitka spruce. (Bateman and Lovett, 2000)

The second way of using forests to mitigate an increase in atmospheric carbon dioxide is to substitute fossil fuels with forest biomass (forest biofuel). Many studies have been undertaken to assess the merits or shortcomings of both carbon sequestration versus forest biofuel production. Direct carbon sequestration by trees is temporary; as trees reach maturity the sequestration rate declines because respiration begins to equal or exceed primary production (McKenney *et al.*, 2004). Active management, however, can optimize the carbon sequestration rate of woodlands. There is also the risk of leakages (fires etc.). Tree biomass, on the other hand, is a longer-term measure, in which harvesting and planting can be carried out in perpetuity (Baral and Guha, 2004). It also has a positive impact on rural economies and enhances energy security.

Schlamadinger and Marland (2000) showed that the economics of carbon credits for sequestration depends not only on the rates of productivity but also on the size of the initial standing stock. Natural, undisturbed forests represent a large amount of carbon storage. Undisturbed soils can also accumulate a large amount of carbon over time (Broadmeadow and Matthews, 2003). Disturbance can result in a rapid release of large amounts of carbon that can be re-stored only slowly as the forest re-grows or the soil re-builds (Harmon *et al*. 1990). Thus, Schlamadinger and Marland (2000) conclude that when the initial area of standing forest is small and production is high, fossil fuel substitution through forest biofuel is preferred. However, when the initial area of standing forest is large and production low, carbon sequestration would be favoured. Large areas of slow-growth standing forest is preferable for carbon sequestration and biodiversity. It can also control local climate (Huston and Marland, 2003), assist flood alleviation and control erosion. However, in practice there is likely to be a continuum to balance carbon storage and fossil fuel substitution. Baral & Gaha (2004) conclude that a synergy between bioenergy and carbon sequestration can be achieved through integrated forest systems where stands are thinned and the thinnings used for bioenergy.

Whilst this study is focusing on existing woodlands, it is appropriate to compare the management of existing woodlands for biofuel to new planting. Some studies caution against indiscriminate planting of fast-growing species (often non-native) for bioenergy, claiming that such management can have negative impacts on biodiversity (Beyea *et al.*, 1991; Capparrós and Jacquemont, 2003). Afforestation (carbon sequestration), on the other hand, can have positive benefits for biodiversity (Huston and Marland, 2003). It can be pursued on land that is not suitable for agriculture or intensive forestry, whereas intensive harvest-and-use systems for biomass fuels may need more productive land to be economically viable (Huston and Marland, 2003). Such uses may compete with agriculture (Kszos *et al.*, 2000) or may shift intensive land uses onto less productive lands that contain the most biodiversity (Huston and Marland, 2003). Whilst biofuel plantations have higher animal diversity than agriculture, they have lower biodiversity than natural forests in the same environment (Cook and Beyea, 2000). Thus, carbon sequestration has a net positive effect on both atmospheric carbon dioxide reduction and biodiversity. In general, this mutual benefit is maximised in relatively unproductive forests where biodiversity is high and the forest is economically less favourable for sustainable harvest-and-use systems, such as may be the case in much semi-natural ancient woodland in England (Huston and Marland, 2003).

However, the end use of the harvested timber must also be considered when calculating the carbon balance. If wood is used as a substitute material for concrete or steel in building, it can have a positive impact on the carbon balance. The use of wood in other wood products, such as furniture, also locks up carbon for the duration of the products' lifetime, although this role is of far less significance than the potential savings of wood and wood products in direct and indirect fossil fuel substitution. In the long term, carbon substitution benefits arising from woodland management have the potential to far exceed those resulting from management of standing carbon stocks {Broadmeadow, 2003 #235}.

Whilst naturally forested landscapes can store significantly greater quantities of carbon than those managed for timber production (Harmon *et al.*, 1990; Fleming and Freedman, 1998; Kurz *et al.*, 1998), Seely *et al* (2002) claim that management practices can ameliorate these discrepancies. They conclude that carbon sequestration must be included in regionally integrated forest management plans in which timber production (with its fossil fuel and materials substitution benefits), conservation and recreation are also key objectives. Alternatively, managing competing demands can occur at the landscape scale, where each stand is developed to meet a single objective but the sum total of all the stands satisfies multiple criteria (Seely *et al.*, 2002).

Since the majority of woodlands in England comprise mainly broadleaves (67%) (FC, 2005) there may be scope here for minimum intervention carbon sequestration forestry. If the current carbon value of £70 per tC used by the government is taken, carbon has the highest value in terms of public good provision. Further investigation is required in order to determine the appropriate management of English temperate forests in terms of carbon sequestration, fossil fuel substitution and materials substitution. This may well include a range of management regimes that incorporate carbon sequestration alongside management for wood fuel and timber. Specific points that should be considered in a more in-depth analysis are listed below:

- Clarification of the extent to which a non-zero carbon sequestration value can be attributed to existing woodlands, as opposed to newly-created woodlands.

- Identification of key forest management options in existing woodlands that might lead to significant carbon sequestration and quantification of the carbon benefits of those options

- Clarification of the trade-offs in potential greenhouse gas mitigation impacts of managing forests to conserve carbon and using wood as a renewable resource.

- Identification of the key forest management and wood utilisation options that deliver significant "no-regrets" greenhouse gas mitigation.

- Opportunity-mapping for forest management/wood utilisation options, both for existing woodlands and for evaluating the case for newly-created woodlands.

A summary of the positive and negative impacts of WMFT on carbon is given in Table 13.

Table 13: The positive and negative impacts of WMFT on carbon.

Positive Impacts	**Negative Impacts**
Substitution of fossil fuels with carbon-lean wood fuel.	Short rotation lengths can reduce standing carbon stocks.
Substitution of materials (e.g. concrete, steel) with carbon-lean timber (in buildings, furniture etc.).	Soil disturbance can cause carbon release.

Expert workshop

In order to critically assess and reinforce the findings from the literature review an expert workshop was held on 22nd March 2006. 43 individuals were invited to the workshop, representing interests in biodiversity, recreation, timber production, economics and policy (Table 14). 26 attended the workshop (a full list of participants can be found in Appendix 1) although several of those unable to attend submitted their comments to the workshop questions and draft literature review in absentia.

Table 14: Invitees to expert workshop

Organisation	No. invited	Area of expertise
Forestry Commission	1	Climate change
	2	Biodiversity
	1	Recreation
	1	Landscape
	1	Historic environment
	2	Policy
	1	Economics
Forest Enterprise	1	Timber production
	1	Forest planning
	1	Recreation
Defra	1	Policy
English Nature	3	Biodiversity
Countryside Agency	1	Countryside issues
Woodland Trust	3	Biodiversity/recreation
Forestry and Timber Ass.	2	Timber production
Small Woods Association	1	Woodland management
England Forest Industries Partnership	1	Forest industry
RSPB	2	Biodiversity
English Heritage	1	Historic environment
Sussex Wildlife Trust	1	Biodiversity
University	4	Academic research/consultancy
National Trust	2	Historic environment
Country Land & Business Association	1	Recreation
Bat Conservation Trust	1	Biodiversity
Butterfly Conservation	1	Biodiversity
Woodland Heritage	1	Wood products
Private woodland owner	2	Woodland management
John Fish Harvesting	1	Timber harvesting
Euroforest	1	Timber harvesting
Swindon Borough Council	1	Community Forest

A summary of the literature review findings was circulated to the participants prior to the workshop in order to give them sufficient time to read and consider the evidence. The workshop was introduced with an overview of the theoretical concepts and a summary of the initial findings before the break out sessions in which the participants explored the issues in more detail. Participants were divided into three groups to discuss the following:

- Assessment of the draft literature review, identifying any omissions or areas of disagreement.

- Does woodland management provide public good benefits? If so, what sort of management and in what location?

- Policy options for woodland management.

The full workshop session questions can be found in Appendix 2 of this report.

The workshop sessions provided a lively and informative debate on the issue of public good provision through woodland management for timber. Each group consisted of individuals representing different interests which enabled a better-rounded and broader picture of the issues to be gained. Each group completed the workshop session handouts and a representative from each group summarized their findings during the plenary session at the end of the day. This allowed all participants to share their views and express their concerns to the whole group. The plenary session was digitally recorded and used together with the completed session handouts to compile the findings outlined in Appendix 3.

These findings were used to ground-truth the literature review and to identify the main issues relating to woodland management and public good outputs. There was a range of views expressed, which highlighted the complex nature of balancing the provision of multiple outputs from the forest resource. However, overall it was felt that a moderate amount of management would be desirable in order to achieve an enhancement of public good benefits. What that management would entail would depend on the type of woodland, the management objectives, its location and the economic viability of management.

The following section outlines the conclusions from the evidence base gathered in this study and the expert workshop findings.

Summary of Evidence and Recommendations

The aim of this study was to examine the provision of public goods associated with the management of woodland for timber and wood products in England. While it was broadly agreed that WMFT can enhance public good outputs, this was seen to be highly dependent upon the location, time, type of woodland, management objectives of the owner and external agencies, scale and condition of the woodland. It was not seen as possible to be too prescriptive about a management regime that will be appropriate in all types of woodland, or indeed for all types of public good outputs.

With this caveat in mind, the following sections outline the public good outputs and appropriate woodland management, as well as options for stimulating WMFT.

6.1 Does WMFT enhance public good outputs?

The findings of this study suggest that minimum to moderate WMFT will enhance public good outputs. It has been shown that a lack of management has been cited as a contributory factor in the decline in biodiversity values in English woodlands (EN, 2003; Kirby *et al.*, 2005; Amar *et al.*, 2006). However, management is likely to affect different public goods in different ways. However, the general view is that thinning is usually appropriate for all woodland types (conifer, broadleaf, mixed), except in situations where this is not appropriate due to wind-throw hazards or where there are special objectives or wilderness values to consider.

It is also noted that public good benefits can be delivered through general woodland management, and not necessarily WMFT. Table 15 illustrates the range of woodland management activities that may enhance public good provision, highlighting the added value of WMFT on public good outputs. There is also income associated with WMFT which does not arise with general woodland management. Thus, WMFT will entail either a lower net cost, breaking even or a profit to the woodland owner. If WMFT can be stimulated to provide an income for the woodland owner, this will encourage increased levels of management.

Table 15: Woodland management activities that may have a public good benefit

Management activities for timber production ▪ Felling ▪ Thinning ▪ Road construction ▪ Coppicing ▪ Replanting/regeneration
Management activities often associated with woods managed for timber ▪ Ride cutting and maintenance ▪ Control of shade-tolerant conifers ▪ Control of deer, squirrels, rabbits
Management activities independent of timber production ▪ Game rearing ▪ Wood pasture ▪ Recreational infrastructure and facilities (car parks, toilets etc.)

Low levels of intervention are likely to be most appropriate in ASNW, in which the integrity of the existing ancient woodland is the desired objective. Clearfelling is likely to take place mainly in coniferous plantations, although this may be appropriate in some broadleaved or mixed woodland, particularly if the objective is a change of land use (for example, restoring regenerated scrub woodland to moorland).

6.1.1 Biodiversity

The location effects are largely irrelevant for non-use public good values for biodiversity. However, there may be some preference for accessible forests near to urban areas or holiday areas for those biodiversity values that have a use value (for example, bird watching or nature tourism). Hanley *et al.* (2002) (who adopted Garrod & Willis 1997 as the basis for their estimates) published the most comprehensive and inclusive assessment of non-use value of biodiversity in UK. The study showed a preference for improving biodiversity values in lowland new broadleaved native forest and upland native broadleaved woods.

Depending on the species or group of species that a woodland is being managed for will determine what type of management might be appropriate. It is likely that low intervention management regimes (single tree selection, small group-fell, thinning and control of shade-tolerant conifers) are sufficient to increase biodiversity. Diversifying the structure of the canopy and understorey of even-aged high forest by gap creation and thinning will enhance biodiversity. As already mentioned, there is no one management regime that will be suitable for all species. Whilst intensive management generally has a negative impact on biodiversity, if managing for a particular species that requires clearfell habitats (such as the wood lark) intensive clearfell management may be the most appropriate regime (although some deadwood and veteran trees should be retained). Conversely, small areas of undisturbed canopy, up to 2 ha, should be maintained to provide a temporary habitat for species such as bryophytes (Fenton and Frego, 2005), lichens, fungi, invertebrates, small mammals, and birds, and to encourage dispersal (Humphrey, 2005; Nelson and Halpern, 2005). Thus, each woodland will require its own management plan which specifies the target species for action.

- ***The priority for stimulating WMFT to achieve biodiversity enhancements is likely to be lowland and upland mixed and broadleaved woodland.***

6.1.2 Recreation

For recreation, the public good value is low, and may even be negative, where no management occurs. Public good value increases with modest levels of management, such as ride cutting, some thinning or small group fell, but decreases again when management levels intensify (such as largescale clearfell). However, recreational values are highly spatially determined, with woodland areas close to urban areas being of much higher value than more remote rural woodlands. Mixed or broadleaved woodlands are also preferred for recreational use. This would suggest that lowland broadleaved woodland has the highest recreational value and should be the focus for recreational management. Although other woodland situations, such as upland sites, may be more suitable for recreational activities such as mountain biking.

The availability of other recreational sites (woodland or otherwise) also determines the recreational public good value of a woodland . A woodland close to an urban area where there are no other areas of public open space will be of more value than a woodland surrounded by other areas of public open space. Thus, those woodlands close to urban areas that are non-substitutable by other areas of recreational space should be considered as priorities for recreational public good enhancement.

- ***The priority for stimulating WMFT to achieve informal recreational public good enhancement is likely to be lowland broadleaved woodlands near to urban areas where other recreational space is limited.***

6.1.3 Landscape

In general, a lack of management or up to moderate management will have no effect on external landscape values. Only when large-scale clearfell takes place in areas of visibility is this likely to have a negative effect on landscape, albeit for a relatively short period of time. These negative impacts can largely be mitigated by careful felling design. In some instances, however, clearfell can improve the landscape by opening up vistas. Internal landscape values can be significantly improved by management activities.

- ***The priority for stimulating WMFT to achieve landscape public good enhancement is in woodlands near to urban areas (for both external and internal landscape benefits).***

6.1.4 Carbon

Woodland management for carbon is perhaps the most complex of all public goods. Non-intervention old-growth forests appear to have the highest value in terms of carbon sequestration, with a reduction in carbon storage occurring as management intensifies and timber is removed and the soil disturbed. However, a managed woodland in which high yield timber is harvested and re-grown may offer greater overall benefits and provide substitution of fossil fuels and substitution of materials (such as concrete or steel). In this regard, it is important to consider the long-term use of the harvested timber. If the wood is not used as fuel, the carbon will be stored for the duration of the timber's lifetime, whether it be as roof struts in a house, fencing posts or a hand-crafted wooden bowl. The location of the woodland for the production of wood fuel or timber is likely to be important in order to minimise the need for transporting the harvested fuel or timber great distances to consumers or saw mills.

- ***The role that WMFT can play in achieving carbon sequestration public good enhancement will vary with woodland type, site conditions, growth rate and location. These aspects will determine the optimal balance between sequestration and fossil fuel and materials substitution. However, it is clear that in most cases WMFT has a significant, positive, role to play.***

6.1.5 Summary

Thus, it can be seen that in general a moderate management regime such as thinning, single tree selection, small group fell, alongside areas of non-intervention is likely to optimize the joint production of public and private goods within woodlands and forests.

The evidence suggests that these goals are most likely to have the largest effects and benefits in broadleaved woodland, mainly in lowland areas. Non-Forestry Commission ownership accounts for 82% of English forests and woodlands (FC, 2005). Of this, 60% is in private ownership and 76% of non-Forestry Commission woodland is broadleaved. Much of this private broadleaved forestry estate is located in the lowlands close to urban areas and so provides opportunities for delivering public good benefits. However, private woodland owners are not a homogenous group, but increasingly consist of a diverse mix of traditional, agricultural and non-agricultural or semi-urban woodland owners. Anecdotal evidence suggests that almost 50% of rural land purchasers have no previous experience of rural land management, yet the motives for owning woodland are weakly researched (Quine *et al.*, 2005). Further investigation is needed on the motivations of private woodland owners in order to guide forest policy in enhancing public good benefits from these woodlands.

The scale on which management is carried out must also be considered. Whilst every woodland is individual and may require a particular type of management, broader landscape scale management must also be considered. Ecological processes and individual organisms are not constrained by management blocks or ownership boundaries (CJC Consulting, 2005), thus forest policy requires a landscape ecology element. Woodland exists within the broader landscape matrix, and the wider landscape issues (such as connectivity, fragmentation, corridors) can have implications for management objectives. Small farm woodlands can provide an important link for wildlife, acting at a stepping stone to other larger areas of habitat, despite their possible lack of value for timber. Wider notions of green infrastructure planning are being introduced in various parts of the UK and suggest a need to balance the aspirations of woodland owners against those deriving from a broader societal interest.

Thus, WMFT to enhance public good outputs involves a range of possibilities. Specific operations may include the following:

- Ride cutting. This would increase edge effects and allow access. It is an inexpensive and simple way of managing neglected woods, especially small blocks of broadleaved woodland mid-rotation. Although rides are historically a means of accessing woodland for management purposes or sporting shooting, the provision of nothing more than ride renewal may offer substantial public good benefits.

- Coppicing. This is a very effective method to produce certain types of timber. It could be adapted to produce fuelwood and minor produce, while at the same time increasing species richness. The possibilities for woodland types suitable for coppicing might be: oak standards over hazel, chestnut, hornbeam, ash, sycamore and oak. A range of broadleaved scrubby woods could be regenerated to coppice on a short (15-20 years) rotation.

- Thinning. This is a very effective management regime that can enhance biodiversity by increasing light to the forest floor. It can also improve recreational values by opening up woodlands and improving access. It is also more likely to produce more saleable sized material and increase future value in all woodland types.

- Clearfelling. An even-aged system of well-designed small coupes. This produces a mosaic of age classes between coupes and is most likely to be profitable.

- Shelterwood systems. This involves the long-term retention of over-wood while the majority of the area regenerates, either naturally or artificially. Shelterwood can be carried out in strips (Wagner’s Blendersaumschlag) or as a pepper-pot approach.

It effectively retains older trees and prolongs rotations, which is likely to improve the landscape view and diversity. However, in an economic sense, it does allow some harvesting of larger trees.

- Selection systems. This is irregular forestry and provides an intimate mixture of different age classes. This system maintains ground cover permanently and is thus aesthetically pleasing, but it is only possible with predominantly shade tolerant species on windfirm sites. It is complicated to operate irregular systems, but it can produce a continuous stream of varied produce.

6.2 Options for stimulating management of woodlands for timber and wood products

If it is desirable to stimulate WMFT we need to examine ways that this can be achieved. This section outlines possible options for stimulating management, ranging from direct government intervention to doing nothing. It is likely that a range of options will be required to meet the varying demands of the English forest estate. The current policy measures are demonstrably inadequate for stimulating appropriate management of woodlands for timber and wood products, as demonstrated by the lack of woodland management in woodlands at present.

In order to consider stimulating WMFT, it is likely that a range of approaches will be required. As has been shown, public good values vary depending on location, type of woodland, past management and so on. Likewise, the potential for timber products for woodlands will also vary depending on the age, species mix, condition, location and past management of the woodland. However, in order to assess which mechanisms are appropriate in which circumstances, each mechanism needs to be measured against a set of criteria to determine its suitability. Some mechanisms may be appropriate in some circumstances, but not in others. In order to test the delivery mechanism, the following criteria are suggested:

- Is the mechanism flexible and can it be targeted?
- Is the mechanism cost-effective?
- Is the mechanism equitable?
- What is the practicality of application?
- Are there any perverse effects of the mechanism?

With all of these considerations in mind, the following approaches to stimulate woodland management may be considered. As already noted, it is likely that a range of these approaches will be required in order to deal with the heterogeneous mix of woodlands and woodland owners.

6.2.1 Information, Advocacy and Exhortation

With the increase in new woodland owners, who may or may not have a background in land management, there is a need to educate and provide advice and information. There is a need for skills development, education and advice, which can range from consultancy, contracting skills, to simply providing a forum for sharing best practice and experience. Various woodland network groups exist, such as the Woodland Initiatives Network (funded by the Forestry Commission and the Countryside Agency, and hosted by the Small Woods Association), in order to support woodland owners and link up wood producers with consumers.

Providing woodland owners with the practical advice and skills required in order to better manage their woodland resource is vital, especially for those new woodland owners with no background in land management. Altruistic ownership in order to preserve a piece of woodland for wildlife may result inadvertently in neglect, degradation and a lowering of biodiversity values if the owner is not aware of appropriate management options. Providing owners with access to information and advice on woodland management will enable them to make informed choices about managing their woodland. One way of introducing such information to new woodland is through information aimed at the new woodland owner, such as the new booklet produced by the Forestry Commission, "So you own a woodland?". The guide includes basic information on the need for woodland management, possible management objectives and includes a range of resources for the woodland owner to access if required.

Further information could be provided in this way, informing woodland owners of the public good benefits of woodland. It could also provide an outline for developing their own woodland management plan, including an overview of grants available. For example, if a woodland owner decided to manage their woodland for biodiversity, the guide could suggest basic practical management techniques to do this, plus providing details of how to apply for an appropriate grant and information on where to go for advice on more specific management goals. If the owner wished to improve the woodland habitat for bats, the guide would give details of appropriate resources to assist in this (e.g. Managing woodlands for bats brochure published by the Forestry Commission and the Bat Conservation Trust). Information on making money from recreation in woodlands can be found on the website www.naturallyactive.org.

Good practice and successful woodland management could be shared in the form of demonstration projects. Forest Enterprise may be able to facilitate this, providing advice and sharing their experiences with private woodland owners. There is good evidence from the farming community that action research and practical engagement of landowners and managers can provide a platform for enhanced environmental management of rural resources. Such projects require skilled facilitation and it can be important to engage keystone individuals who can provide important endorsement of the approach.

There is also a need to rebuild the relationship between Private Woodland Officers and their clients. There is a large reservoir of goodwill between foresters and woodland owners, and "outreach" will be a critical factor in achieving better management and hence enhanced public benefit. However, such advisers might benefit greatly from engagement with best practice extension practices in other rural land using sectors.

6.2.2 Market Mechanisms

Small-scale market mechanisms may work best by reconnecting consumers and producers. By encouraging small-scale supply chains more of the value stays locally. As mentioned in the above section, developing skills and networks to share knowledge and advice will help to stimulate local production and small-scale markets for locally produced products.

With the likely increase in energy requirements from wood fuel (due to the rise in fossil fuels prices) and the government's commitment to increasing the renewable energy sector, this presents a potentially growing market for low grade timber from England's woodlands. The domestic log market is booming but depends on supplies of the right species in the right places, a combination that does not always occur. Much of the timber that would have gone to the now-closed Sudbrook mill would need a long period of expensive drying before it becomes marketable as a quality product, and with production largely in the hands of small operators, this represents a financial burden. As the market develops, this will, no doubt, be dealt with, but it must be remembered that the weak link in the chain is not the woodland owner, more the self-employed chainsaw operator, or the contractor with a harvester that needs to keep moving.

Using woodchips or pellets for energy generation clearly has a future, as the practical problems are confronted and resolved. Small material is difficult and expensive to harvest, especially in small parcels; water content in UK conditions is high and productivity is low. Wage rates and overheads are at their highest in Southern England and the job itself is physically arduous. There is also a growing scarcity of reliable contractors. If the driver of woodland management is to be biofuel, all these factors need to be addressed. This could be achieved by building the market. If there are domestic or industrial consumers for fuelwood, then the demand, and the woodland owners' incomes will rise, woods will be thinned and coppiced, and public benefit increased. However, in order to maximise the benefit to UK woodlands, such production would need to be able to compete with the cheaper imports, such as woodchips from Scandinavia.

The market for commercial recreation, including game shooting and paint-ball games, to a large degree regulates itself. It could well be revitalised by encouraging joint projects, again possibly between state and private owners to invent new opportunities or improve the scope of existing ones (see, for example, www.naturallyactive.org). The market for hardwoods shows a worrying tendency to decline; the loss of St Regis, a customer for perhaps 250,000 tonnes of low grade hardwood pulpwood a year is the latest casualty in a long list which has seen the closure of a catalogue of mills and sawmills. However, there has been a significant investment in softwood processing, with three new sawmilling lines installed in the south east of England. The challenge for these is to find the raw material they need and how they play a part in taking forward woodland management.

A key issue in using the market to stimulate enhanced woodland management is whether policy can overcome some of the initial obstacles to market development. If the market can operate effectively once the new supply chain is functioning, the case for public support in establishing these new chains is very strong. In effect, the policy intervention is justified by helping to overcome the transformation costs and transaction costs of establishing a new system.

6.2.3 Grant Systems

A study undertaken in 2002 to investigate the attitudes and perceptions of woodland owners to public access revealed that the availability of grants related to the provision of public access was unlikely to attract much interest from woodland owners. The study suggested that there would be more positive attitudes towards grant aid that related to the broader motivations for improving woodland management (Church *et al.*, 2005). Whilst most of the woodland owners in the study had benign attitudes towards public access, with 80% already having public access in their woodlands, they were more interested in boosting the commercial potential of their woodlands through appropriate incentives.

Direct intervention occurs mainly through the provision of grants. However, there needs to be a balance of public money allocation between the private and state sector. Complicated map-based grant schemes, such as the EWGS, are often off-putting to the private woodland owner. Such schemes required complex form-filling and are often perceived as inaccessible or not worth the effort. Grants received often do not cover the extra cost to the woodland owner of providing long-term management for the provision of public goods. The grant system needs to be simple and straightforward for both parties of the grant aid and should be targeted towards utilizing existing un(der)managed woodlands rather than planting former agricultural land with short rotation coppice.

Capital grants for woodburning projects on any scale, and for contractors' equipment will help this process. The state has a major role to play in this arena. Half of the St Regis intake, over 100,000 tonnes a year, comes from FC woodlands in England. The opportunity to form marketing groups based on state woodlands now exists. However, to achieve this the Forestry Commission may need to engage with smaller scale contractors and reorientate their thinking to the development of local wood energy supply chains. They could provide exemplar projects.

Throughout the UK, there are likely to be scores, if not hundreds, of examples of small-scale renewable energy projects funded by public projects such as Leader+ or other European or UK grant schemes. If a small proportion of this expenditure was devoted to effective dissemination of best practice, this might assist new entrants and help to avoid oft-repeated mistakes.

In some instances, a revised Dedication scheme might be appropriate and simpler to administer. If woodland owners are willing to dedicate their woodland to mitigate climate change, for instance, a scheme which supports such management with grants and advice might be appropriate. Woodland owners in the scheme would be encouraged to adopt minimum intervention approaches which highlighted the carbon storage capacity of the standing timber, as well as developing a wood fuel supply to substitute fossil fuel use.

6.2.4 Fiscal

A raft of taxation measures affect woodland owners and small woodland businesses. Taxation is a complex subject reserved to the UK Government, however a number fiscal measures may be relevant to the delivery of woodland management and deserve further examination.

Income Tax
Up until the 1990s, taxation treatment of woodlands was the private sector's main driver. The Schedule B/D election stimulated owners to carry out major expansion of planting, and allowed expensive maintenance and refurbishment projects to be carried out. While timber activities benefit from the fact that timber income is non-taxable, perhaps such an approach could be revisited in order to stimulate management for timber in situations where market failure exists.

Value Added Tax
Again, there is a case for favourable treatment for a whole range of goods and services delivering woodland management. As of 1 January 2006 wood-fuelled boilers are charged at the reduced rate of 5% VAT (HMRC, 2006). Further measures may encourage an increase in demand for more sustainable sources of energy and help to stimulate woodland management in order to meet these demands.

Carbon Credits

The government has a commitment in the climate change programme review to consider market-based systems for carbon trading in the land management sector. Woodland owners and groups of woodland owners could be allowed to benefit from trading in carbon credits. This could well create a competitive market for carbon credits derived from woodland management, which could be traded for cash with carbon-inefficient businesses in search of "green" credentials.

Council Tax
In order to encourage woodland management that improves public good benefits, perhaps woodland owners should receive a direct payment from, say, a hypothecated component of local council tax.

Other Tax Measures
There are also Corporation Tax, Capital Gains Tax and Inheritance Tax measures relating to woodland. Changes to these may merit examination in the context of delivering public benefit through woodland management.

6.2.5 Innovation

New policy in this area should be aimed at linking up the small-scale supply chain, perhaps through co-operatives and partnerships. An example of this may be small wood fuel power plants that are serviced by local woods. This can create an opportunity to heat a small community or significant public building complexes such as schools or old people's homes. Such an approach could be incorporated into spatial planning. In areas of high fuel poverty (due to an increase in energy prices) it may be appropriate to target these for alternative fuel systems such as wood fuel.

Government support could help to encourage innovative and entrepreneurial activity by providing training and equipment grants or loans. The LEADER programme provides an example of how small rural businesses and partnerships might be nurtured.

6.2.6 Regulation

After the 1992 United Nations Conference on the Environment and Development in Rio and the second Ministerial Conference on the Protection of Forests in Europe (MCPFE) in Helsinki in 1993, the government adopted a forestry policy which promoted sustainable forest management. The policy is two-fold: the sustainable management of existing woodlands and forests and an expansion of tree cover. The UK Forestry Standard sets out the framework by which the forestry policy is administered and assessed. This regulatory framework attempts to mitigate any negative impacts that might arise from management that does not adhere to good practice guidelines. Grants and felling licences are only given to those who confirm to good practice.

However, in order to encourage woodland management it may be appropriate to relax felling licences for thinning. There is, however, a danger that stimulating the market for management of woodlands for timber and timber products could result in over-management and over-felling, leading to a reduction in public good benefits. There is, therefore, a need for regulation and compliance monitoring in order to ensure that any management enhances rather than compromises public good benefits.

This could be achieved by developing UKWAS to provide a key force in promoting sustainability, regulation and marketing. Wood fuel standards could also be established to ensure high quality wood fuel for the consumer, and maintaining high quality woodland for public good benefits.

Certification, especially through partnerships between owners, may provide a practical way to provide both public good benefits and economic profitability. Such partnerships could involve individual state woodlands as a catalyst. Partnerships may also be an appropriate way to tender for funds for the development of sustained management plans. UKWAS also has the potential to manage certification of carbon credits.

6.2.7 Research and Development

Continued research and development underpins market development (e.g. new finger-jointing techniques) and technology transfer. Development of best techniques for harvesting (whether for timber, pulp, board or wood fuel) that is both economic and viable for profit, as well as minimizing any negative effects on public good outputs, is required.

There is a need for further research and enhanced knowledge transfer in the woodfuel arena. A great deal of work has been undertaken elsewhere in Europe on the development of both the technology, its assessment under working conditions and the development of the necessary supply chains. Further work on the transferability of this understanding to a UK context is an urgent need.

Further research is also necessary on the motivations of woodland owners. Anecdotal evidence suggests that many new private woodland owners are motivated by altruistic objectives, in terms of preservation, or perhaps as a future investment. Understanding these motivations and the knowledge systems of private woodland owners will be crucial in determining appropriate mechanisms for ensuring maximized public benefit.

6.2.8 Non-Intervention

Non-intervention has the benefit of having no cost to the state, or to the private woodland owner. The life-cycle of a woodland occurs over a long time-scale and so the deterioration in un(der)managed woodlands today may simply be a stage in that life-cycle. If they are left unmanaged, it is likely that storm damage will provide canopy gaps to benefit biodiversity. However, there are risks with this approach if most woods at the landscape scale are at a similar (shaded) stage. Doing nothing may not be the best option for biodiversity, but is likely to be a good second-best (Rackham, 2001).

In terms of carbon sequestration, non-intervention measures are probably the most appropriate for ASNW. If carbon sequestration is deemed as having the highest value in terms of public good (depending on what rate per tonne of carbon is used), management for carbon storage has to be deemed of considerable importance. However, if other objectives, such as recreation and biodiversity are required in the short-term, it is likely that some form of minimum intervention will be required.

6.2.9 Conclusion

Again, it has been demonstrated that there is not a one-size-fits-all approach to woodland management for timber and wood products. In order to stimulate such management it is likely that a range of options will be required, and their suitability assessed under different circumstances. Table 16 illustrates the likely pros and cons of each of the mechanisms addressed when tested against the criteria identified above.

Table 16: The pros and cons of mechanisms for stimulating woodland management for timber and wood products.

	Flexibility	Cost-effective	Equitable	Practicality	Perverse effects
Information & advice	Highly flexible and can be adapted to suit particular outputs from forestry, whether it be pulp, furniture, wood fuel, timber.	Can be very expensive to do properly.	Can bias those who have background in forestry. New woodland owners with no forestry experience may not know where to go for advice.	Unlikely to achieve much in isolation, but an essential part of any package of incentives.	The provision of too little or inadequate information could lead to inappropriate management.
Market-based	Can generally be adapted to suit particular outputs.	Generally cost-effective, with likely multiplier effects, but only where there is genuinely marketable produce.	May have a bias towards those with the skills, expertise, knowledge and financial ability to trade. Smaller producers may be at a disadvantage.	May be issues relating to the suitability of the wood material for the desired purpose, scarcity of skilled contractors, competition from abroad.	In order to be economically viable too much timber may be removed which may lead to reduced public good benefits. Thus, regulatory regimes are also needed.
Grant systems	Can be targeted to those areas in which desired management is required.	Can be costly, but can result in specific desired outcomes.	Will bias those woodlands that are targeted for intervention (e.g. undermanaged semi-natural broadleaved woodland in lowland England near to urban areas may be considered a priority).	Requires complex administration structure and monitoring.	May take away trade from already established wood product suppliers – i.e. a redistribution of trade.
Fiscal	Can be targeted to act as a deterrent to undesired activities and to encourage desired activity.	Generally cost effective.	Only helps those with a tax problem. It will be of no help to charities etc.	Requires change in fiscal regulation – can be easy with the right policy.	May provide tax incentives to woodland owners who would carry out the desired activities anyway.

	Flexibility	Cost-effective	Equitable	Practicality	Perverse effects
Innovation	Can be targeted to achieve particular outputs in particular areas.	Cost-effective.	Will bias those partnerships or schemes with particularly innovative or dynamic individuals.	Practical on the local scale.	Care must be taken not to simply re-distribute trade from one business activity to another. E.g a new partnership of wood fuel producers causing existing wood fuel suppliers to go out of business.
Regulation (including certification)	Can provide certain standards and guidelines.	Cost-effective.	May discriminate against small woodland owners, for which certification may be too expensive to achieve.	Practical for setting a broad base-line.	None anticipated, although regulation may not mitigate all potentially negative impacts of increased management.
Research & Development	Flexible to deal with perceived R&D needs – although those needs must be identified first.	Can be costly and time consuming.	May only be financially viable for technologies that promise high returns.	Not always possible to identify where to target research needs.	The future impacts of new technologies can often not be foreseen, so there is an element of unpredictability.
Non-intervention	Can be targeted to selected woodlands.	Cost-effective.	Generally equitable, although small-scale timber producers may not be able to afford to have areas of non-intervention forest.	Not always practical if a woodland is maintained for timber outputs, or has high intensity recreational use.	Many have negative effects on some public goods, especially recreation and in some instances, biodiversity.

Conclusion

In order to achieve sustainable forest management, the social, environmental and economic benefits of forestry need to be delivered together. This integrated approach to a multipurpose forest resource involves finding the balance between the provision of non-marketable public goods (environmental and social benefits) and private goods (e.g. timber production). From a societal perspective, we are aiming to achieve the optimal state of joint production (see again Figure 4) where a modest amount of woodland management for timber and wood products will result in enhanced public good outputs.

This report has shown that achieving this optimal state is a complex process and that a variety of factors may determine the extent to which it can truly be achieved.

According to CJC Consulting (2005) there is no evidence to support government intervention in timber production. However, although the production of timber itself may not incur public good benefits, its associated activities may well have a positive impact on these public goods. This report, therefore, concludes that in most instances a modest amount of management will have positive impacts on public good outputs. Since these public benefits cannot be provided purely through market forces, due to market failure and the large level of externalities, there is a case for government support.

One option would be to simply support woodland management for public good outputs. For example, ride cutting for access or thinning to allow light to reach the forest floor for biodiversity. Such intervention would enhance public good outputs, although would be required on a continuing basis in order to maintain the level of public good delivered. This approach, therefore, fails to deliver economic sustainability.

Alternatively, and perhaps a more cost-effective approach, may be to stimulate an active wood product market, whether it be wood fuel or timber, for instance. A small investment by government (for example, in the form of grants or loans or the provision of advice and/or subsidized training) could stimulate small-scale supply chains and enable the external benefits of public good provision to be internalised within wood production as a joint product. Such an approach could provide a win-win situation, where the woodland owner receives an economic benefit from managing his/her woodland and by doing so, public goods are enhanced.

In conclusion, in order to enhance public good outputs from forestry in England it is likely that modest levels of management will be required. However, there is not a one-size-fits-all approach. As has been shown, various factors influence the ability of a woodland to provide public good benefits, and need to be taken into account when designing policy mechanisms to maximize public good and woodland management for timber and wood products.

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Appendix 1

List of attendees of expert workshop 22nd March 2006

Project contractors:
Prof Bill Slee, University of Gloucestershire
Julie Urquhart, University of Gloucestershire
David Taylor, forestry consultant

Steering Group:
Sandy Greig, Forestry Commission
Alec Dauncey, Defra
Brian Mahony, Forestry Commission
Chris Inglis, Forestry and Timber Association

Expert Group:
Hilary Allison, Woodland Trust
Caroline Bedell, Country Land & Business Association
Mark Broadmeadow, Forestry Commission
Caroline Bulman, Butterfly Conservation
Mick Cooper, woodland manager
Ray Hawes, National Trust
Dr Gabriel Hemery, University of Oxford & Woodland Heritage
Judith Gauler, John Fish Harvesting
Emma Goldberg, English Nature
John Hollis, private woodland owner
Mardi McGregor, Confederation of Forest Industries
Jo O'Hara, Forest Enterprise
Marcus Sangster, Forestry Commission
Dr Peter Savill, University of Oxford & Woodland Heritage
James Swabey, Forestry Commission
Nigel Symes, RSPB
Michael Thomson, Forestry Commission
Helen Townsend, Forestry Commission
Judith Webb, Forestry and Timber Association
Tony Whitbread, Sussex Wildlife Trust
Jonathan Wilshaw, Swindon Borough Council & Great Western Community Forest
Tim Yarnell, Forestry Commission

Appendix 2

Workshop Session Questions

Workshop Session 1: Critical assessment of initial project findings

Question: Are these findings a fair assessment regarding the impact of woodland management on public goods?

Please identify:

(1) Any omissions in the findings relating to the impacts of woodland management on public good benefits.

(2) Areas where you disagree with the findings, and why.

(3) The important issues and concepts (e.g. location, woodland type, age, owner motivation etc.) relating to woodland management and public good outputs.

Workshop Session 2: Woodland management and public good benefits

Question: Does woodland management provide public good benefits?

If so, please identify:

(1) What are these public good benefits?

(2) What sort of woodland management (clearfell, thinning, shelterwood etc) is likely to increase public good benefits?

(3) In what circumstances is woodland management likely to have a negative impact on public good outputs?

(4) Is woodland management likely to be more beneficial in some types of woodland rather than others?

(5) Is woodland location (e.g. urban/rural, remote/accessible) likely to have an effect on public good value and woodland management?

(6) With the responses to the above questions in mind, are there particular types of wood utilisation (e.g. wood fuel, saw log timber, pulp wood) that are likely to maximise public good provision?

(7)

Workshop Session 3: Policy options for woodland management

Question: What are the policy options for effectively delivering the desired woodland management regimes without unintended or perverse consequences?

Please consider:

(1) Are existing policy measures appropriate for enabling the desired woodland management regimes?

(2) If not, what sort of policy measures are required for developing the desired management regimes?

(3) Are there potential market mechanisms by which the desired management regimes can be encouraged?

Appendix 3

Workshop Findings

Issues relating to woodland management

The first issue regarding woodland management concerns the definition of what we mean by woodland management. Once again it is stressed that in the context of this study when we refer to woodland management that we mean woodland management with timber or woody fibre production as an output. Some of the participants felt that this was limiting and could perhaps omit other types of appropriate management (such as for purely conservation or amenity purposes) in which timber output was not possible or desirable, but from which distinct public good benefits might be derived. They felt that woodland management should be viewed as a broader activity, with silvicultural management only one aspect of this. One group suggested that perhaps it would be more appropriate to manage woodlands for public goods and that if an economic benefit from wood products was also produced this would be a bonus. This indicates that in spite of some of the literature making a connection between woodland management for timber outputs and public good outputs, this was not universally endorsed as an appropriate way of enhancing those public good values.

Ownership patterns were also considered an important aspect when considering woodland management. Management by the Forestry Commission as a state owner represents a very different opportunity to that of an individual private owner, with different objectives and perceptions of what appropriate woodland management may entail.

The characteristics of a particular wood must also be taken into consideration when designing a management plan. Issues such as sense of place, local community involvement and public pressures influence the type of woodland management that may be appropriate. This observation suggests that there is a need to caution against any blanket spatial strategy and better understand local meanings and values.

Issues relating to public good values

The participants agreed with the existence of public goods in woodlands. However there was some concern over how public goods are valued and how the benefits are measured. These concerns related both to the valuation techniques and the fact that values are expressed in economic terms. The first concern was especially apparent in connection with carbon sequestration in which the public good value of carbon varies from £2.66 to £70 per tonne of carbon sequestered. This will inevitably impact the perceived importance of a particular public good and will relate to the particular value ascribed to that good. For example, in the Willis *et al* (2003) study on the social and environmental benefits of woodland, the value of £6.67 tC for carbon was used, giving a total annual value of about £94 million. If the higher value of £70 tC (used by the Treasury) is used the annual value of carbon rises to about £987 million, far in excess of the annual values for recreation (£393 million) and biodiversity (£386 million) estimated in Willis *et al* (2003). Concerns were expressed as to how valid valuing carbon sequestration in this way is given the large variations in value of estimates made.

Appropriate woodland management

Some participants felt that woodland management should be planned at the forest management unit or landscape scale, while others felt that it should be specific to an individual woodland. However, all agreed that appropriate management depends strongly on woodland type, location and time. It was felt that thinning, clearfell and group felling are appropriate if well-planned and of appropriate scale and design, especially when carried out for a particular bird species (e.g. woodlark), where rotational management is valued, if woods are unstable and other management is not possible or for land use change. It was felt that thinning is almost always appropriate for all woodland types (conifer, broadleaved, mixed), except in cases where there is another specific interest or if wilderness is the value. Tree removal can provide spin-off benefits, such as wood piles (dead wood habitat), areas for car parks or picnic areas.

The main conclusion was that all types of woodland management are appropriate at different times and in different places, ranging from coppicing, ride management, diversity of the ride structure, clearfell in some areas, non-intervention, pasture woodlands, fire breaks, deer control etc. The challenge of good woodland management is to select appropriate management regimes for particular places.

It was felt that woodland management will only have a negative impact in instances where best practice guidance is not followed or where there are special values (such as insensitive management of old-growth forests or veteran trees).

Variability in woodland management

The overriding view of the participants was that most types of woodland management can be appropriate but this is highly dependent on the needs of each particular wood or forest unit. Issues such as the characteristics of a particular woodland, the location, visibility, site, scale, time, woodland condition and management objectives would all determine what type of management may be appropriate. There was a general consensus that there is not a one-size-fits-all approach, but that a spectrum of management interventions should be deployed.

It was felt that the location of woodland is important for some public good benefits, but not all. Recreation is highly spatially dependent, and to a lesser extent landscape. Biodiversity value is less determined by location, except in instances where it has a use value, such as wildlife watching or nature tourism. Location is not an issue for carbon sequestration, although some participants felt that it is (however this is likely to depend more on the quality and type of timber rather than the location).

Policy options

Most of the participants felt that existing policy measures are not appropriate as evidence suggests that desired woodland management is not occurring (especially thinning) leading to degraded and under-managed woodlands. It was felt that market mechanisms are what drive woodland management, but there is no market at the moment and thus, a lack of woodland management. Concern was expressed over the potential to lose the option for future timber production and the opportunity to meet a future energy need, if woodlands are allowed to further degrade and be under-managed. It was, therefore, deemed desirable to encourage woodland management despite the inability of the market to do so at present.

Seven policy options were suggested as having potential to deliver improved public good benefits through woodland management.

Market Incentives: Small-scale market mechanisms may work best by reconnecting producers and consumers. By encouraging small scale supply chains more of the value stays local. However, competitiveness could also be fostered through a tendering process.

Direct Intervention: This occurs through the provision of grants. However, there needs to be a balance of public money allocation between the private and state sector. Grants should be targeted towards utilizing existing un(der)managed woodlands rather than planting former agricultural land with short rotation coppice. However, it was also noted that the grant system is complex and this can be off-putting to a small-scale private woodland owner.

Taxation: This would involve imposing a tax similar to the landfill tax to impose a tax for environmental disbenefits. Thus, if a woodland owner wanted to carry out an activity within his woodland that reduced public good benefit but maximised commercial profit, there would be tax levied, along the lines of the polluter-pays principle

Advice: This would help to moderate markets in the public interest. UKWAS should also be stimulated to be more of a key force in promoting sustainability, regulation and marketing.

Research: Further research is needed to understand the issues of woodland management and public good provision better. Wit was seen as necessary to know what are the perceptions of private woodland owners and how can they be stimulated to improve public good benefits in their own woodlands. Further clarification is needed on the complex issue of carbon sequestration versus short rotation coppice.

Training: Skills and training from consultants/contractors on appropriate woodland management. This would provide support, encourage innovation and develop capacity building.

Private partnerships: This should be aimed at improving the supply chain by linking up producers and consumers. An example of this may be small wood fuel power plants that are serviced by local woods. This has the opportunity to heat a small community. Such an approach could be incorporated into spatial planning. In areas of high fuel poverty (due to an increase in energy prices) it may be appropriate to target these for alternative fuel systems such as wood fuel.