Woodland management and public good outputs: Appraising the trade-offs in English woodlands

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ABSTRACT

This paper examines the trade-offs between woodland management for timber and public good outputs in English woodlands. Recent evidence suggests that some public good values may be declining as a result of a lack of woodland management. Such un(der)management has been attributed to the decline in timber values and a reduction in the productivity of woodlands and forests for timber products and the resultant lack of active management. This paper asserts that assessing the management needs of woodlands in order to enhance public good outputs presents a complex challenge and often depends on a variety of factors, such as location, type of woodland, age, condition, substitutability and ownership motivation. However, in most instances a moderate level of management (whether for timber or otherwise) is likely to be beneficial for public good outputs.

Key words: public good, woodland management, under-management, wood products.

INTRODUCTION

This study, based on work commissioned by the Forestry Commission and the Department for Environment, Food and Rural Affairs (Defra), examined the interactions between woodland management and the public good outputs from forestry in a desk-based study. The research problem arose from two unrelated observations: first, that the productive management of English woodlands appeared to be given insufficient emphasis in recent strategic planning and policy making for English woodlands; and second, that ecologists (for example Kirby et al. (2005)) have suggested that lack of management of woodlands can significantly reduce some of the ecological public good values of woodlands. Kirby's observations challenge the notion that benign neglect allows a drift towards naturalness and enhanced public good values. Given that public goods are estimated to generate approximately £1 billion's worth of public benefits annually (Willis et al., 2003), the relationship between public good level and management regime can be seen to merit further exploration.

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 best be stimulated, with the effect of increasing the flow of public goods?

This paper outlines the findings from a literature review on the public good benefits of forestry and the impacts of woodland management on those public goods. The first section gives an overview of the methods used, followed by 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 next section outlines the evidence base relating to woodland management and public good outputs, and finally, a summary of the findings and conclusions are given, outlining possible management regimes to balance the joint

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production of wood products and public good benefits.

It should be stated at the outset that throughout this paper when the term 'woodland management' is used we mean the management of woodland for timber or woody fibre production, unless stated otherwise. We did not consider enhanced management of woodland for game in this study, although we recognise it as a possible driver of woodland management.

METHODS

The main approach for this project was to trawl both academic, policy and grey literature relating to England and more widely. For the purposes of this study, only four public goods were considered: biodiversity, recreation, landscape and carbon sequestration as these were identified by Willis (2003) as having the highest value in terms of public good benefit (see Table 1). 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.

An expert workshop was also held in order to obtain feedback on a circulated draft of the literature review. Workshop participants represented a range of forestry interests, such as timber production, biodiversity, landscape, informal recreation and carbon. This expert panel was invited to assess what the value shifts are likely to be on the varying parameters to estimate optimality for joint production.

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.

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	93.66	2,676
Air pollution absorption	0.39	11
Total	1,022.92	29,226

Total Economic Value

Much of the early work on market failure related to 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 spillover 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. Thus, the total economic value (TEV) includes a valuation of both use and non-use values of financial and social costs and benefits.

As can be seen in Figure 1, the TEV of any woodland consists of both use values and non-use values. Use values 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.

Whilst this study explores public good outputs within a predominantly economic paradigm, there are values ascribed to woodlands and forests that cannot be wholly accounted for in this way. The most obvious of these is biodiversity. It can be argued that woodlands have an intrinsic value for biodiversity regardless of their instrumental value

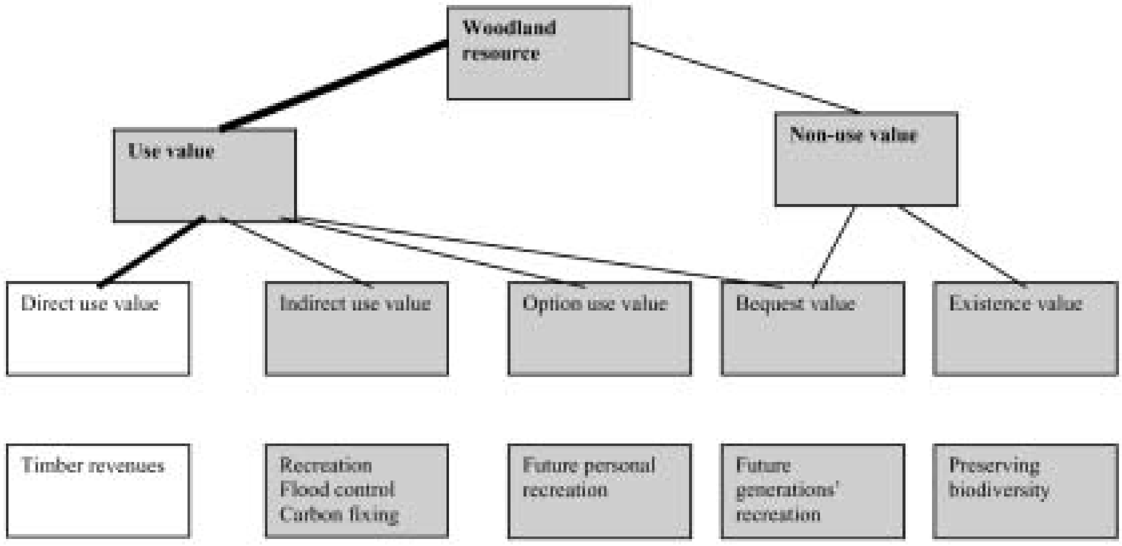

FIGURE 1: The total economic value of woodland (Turner et al., 1994)

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 intrinsic value which inheres in the woodland. It is, therefore, not possible to show empirically what instrinsic 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 a composite (but non-additive) total value (Turner et al., 1994).

Public Goods

The defining characteristic of a public good is that the same units of the good can be consumed by more than one individual (Bateman and Willis, 1999). 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 an 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 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 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).

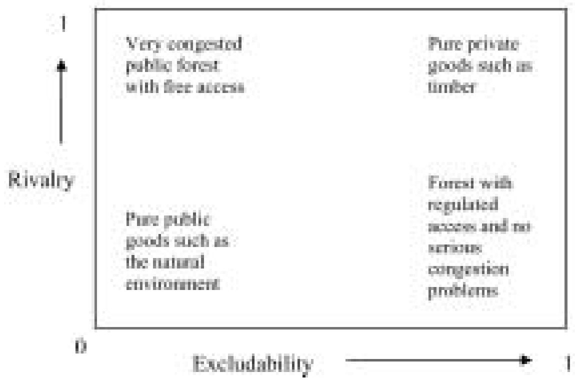

FIGURE 2: Example of impure public goods within forestry (adapted from Mantau et al. (2001)).

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 good or bad (van Huylenbroek and Durand, 2003). For example, the maintenance of rides within a forest for accessibility of harvesting machinery can also be utilized as cycle tracks (see Figure 3). 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) up to a certain point (due to dinishing marginal utility of additional paths).

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 4 illustrates a 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, and results in less profit (with the opportunity cost of biodiversity being the difference between t0 and t1/t2/tn). In practice, an increase in woodland management for timber may well (up to a certain point), be associated with increased value for biodiversity. This is the point on the curve where optimal joint production occurs.

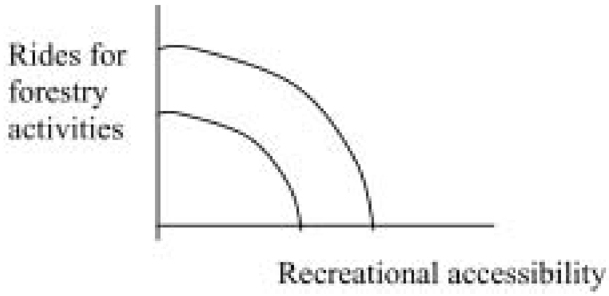

FIGURE 3: Joint production example of forestry rides and recreation

It is this point of complementarity, where both timber (or wood product) production and public good outputs are both maximised that we wish to identify in this study. The following section outlines the evidence base for the impact of woodland management on public good outputs. This evidence can be used to determine the desired balance for public good enhancement.

RESULTS

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 non-market values. However, UK timber prices

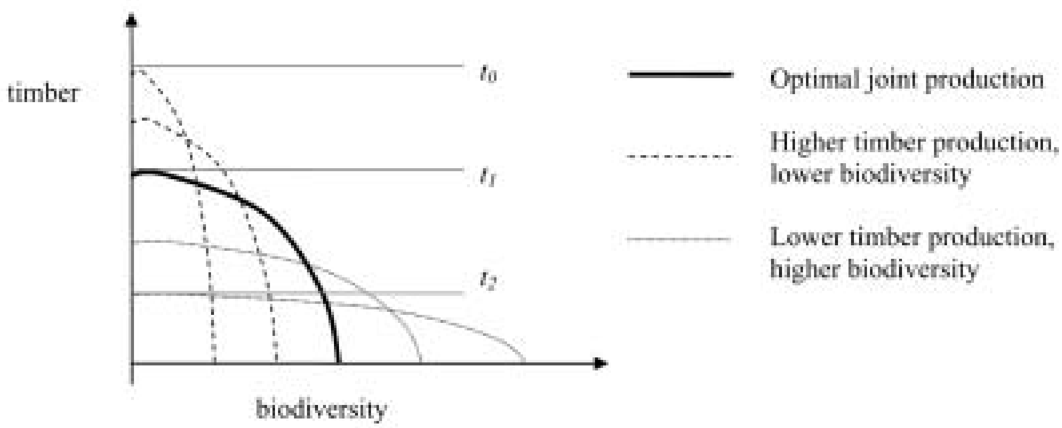

FIGURE 4: Production possibility curve for biodiversity and timber production, showing optimal joint production.

have fallen dramatically over the past 15 years and Britain only supplies around 15% of its requirement for timber, paper, boards and other wood products (FC, 2002). If wood production from forestry in England is economically unviable in much of the woodland and forest estate, this may result in forests that are either under- or unmanaged in relation to the public interest. This un(der)-management may have positive or negative impacts on public good outputs from forestry.

The effect of woodland management on biodiversity values

Recent studies reveal a change in woodland biodiversity over the past 20 years, with an increase in shade-tolerant species and a decline in light-preferring species. This has been attributed mainly to a lack of management (Kirby et al., 2005), as well as agricultural grazing and deer browsing (EN, 2003). Kirby et al. (2005) indicated a decline in the openness of woods, with most decline occurring in large and small glades and paths of less than 5m wide. This has resulted in a decline in ground flora richness and specialist species.

Recent analysis indicates that butterfly species are declining more rapidly than either birds or plants (Thomas et al., 2004). 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).

These habitat changes to shadier conditions 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. Thus, managing a woodland with biodiversity objectives in mind will depend greatly on which species the woodland is being managed for (for example, see the Forestry Commission study (FC, 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). Whilst past woodland management has resulted in the varied mix of floral and faunal species we see today, other forms of management may favour other species.

However, much of the debate about changing biodiversity values has not been couched in the language of public goods or premised on an economic model of biodiversity loss. Indeed, many of the claims of loss of value relate to intrinsic rather than economic values. Whilst this is important, ascribing market values to biodiversity can enable policy mechanisms to encompass much of the value of biodiversity and put it into perspective. An estimate of the non-use values of biodiversity (nutrient cycling, soil formation, watershed protection, waste disposal, pollination, oxygen production, climate regulation etc.) globally is \$16 trillion to \$54 trillion per year (Costanza et al., 1997).

The effect of woodland management on recreational values

The TNS Travel and Tourism (2004) omnibus survey estimated that there were 222 million visitors to woodlands in England in 2004, 21% (46.62m) of which were to FC woods, 33% to local authority woods, 23% to private woods and 7% to woods owned by voluntary organisations (NGOs). 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 2).

Forest recreation levels, and by implication, values are highly spatially-dependent. Woodland users prefer woodland close to where they live (Harrison et al., 1995; Coles and Bussey, 2000; Ward Thompson et al., 2005). Scale is also important, with a suggestion that a minimum of 2 ha required to maximise social value (Coles and

TABLE 2: 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

Bussey, 2000). Woodlands with an open structure and a mixture of species are preferred (Coles and Bussey, 2000). 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 woodlands, relating to fears of personal attack or injury (Burgess et al., 1988; Fisher and Nasar, 1992; Burgess, 1995).

The literature reveals a desire for a mix between wild woodland and a parkland woodland (wood pasture); partly managed but also with a natural feel. Thus the apparent demand for wildwood needs to be tempered by the recognition that many woodland visitors prefer a degree of management. 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. Thus, woodland management that increases recreational benefits may not necessarily be for timber production. The public good value of woodland recreation may well be enhanced simply by improving accessibility (cutting a ride through the woodland), providing a car park and perhaps some interpretation about the woodland.

The effect of woodland management on landscape values

The landscape value of woodlands is also highly spatially dependent, being much higher in urbanised areas than in remote rural areas (CJC Consulting, 2005). 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. Garrod (2003) estimated that an average household was willing to pay £226.56 per year for views of urban fringe broadleaved woodland on journeys. Forested landscapes and local trees can also add value to house prices (Morales, 1980; Anderson and Cordell, 1988; Garrod and Willis, 1992; Garrod, 2003), although when there is over 20% general tree cover, this can reduce house values (Garrod and Willis, 1992).

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.

Ribe et al (2002) suggest that harvest design can mitigate the negative visual impacts of harvesting, although this is only successful for distance and deeper middle-ground views, but not foreground and near-middle views. Ribe (2005) states that if at least 25% of tree cover is retained after harvest, there is no negative effect on aesthetic appeal.

The public good value of carbon sequestration

Of all the public goods examined in this study, carbon sequestration is by far the most complex and least understood. In part this is a function of the difficulty of valuing carbon sequestration and in part a result of the complex processes. 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). Models have been designed to simulate carbon sequestration rates and the complex biological processes, circulation of substances and socioeconomic factors that affect the viability of a forest to sequester carbon. Some models also incorporate carbon emissions from decay, burning of forest products, harvesting operations and timber transportation (Liski et al., 2001).

The value of carbon sequestration is highly dependent on the estimated price per tonne of carbon sequestered (t/C) and the discount rate. With the literature citing a range between £2.66 and £70 per t/C, the total annual value of carbon sequestration in the UK will vary between about £37 million and £983 million. At the higher level the value for carbon sequestration is much higher than that of either biodiversity (£386 million) and recreation (£393 million) as estimated in Willis et al's (2003) study. Taking the median social value of carbon as £14.70 in 2003 and a discount rate of 3.5%, the total value of carbon is £5.92 billion (Brainard et al., 2003).

However, a trade-off exists between timber production and carbon sequestration. Liski et al. (2001) showed that regulating the rotation length of tree stands is an effective way to manage the carbon budget of forests. Longer rotation length favours carbon sequestration. However, the private cost of this is decreased timber harvests and, thus, decreased revenues to landowners (Liski et al., 2001) and a lowering of the NPV of the harvest. Further studies also concur that carbon sequestration is increased with longer rotation of harvesting (van Kooten et al., 1995).

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 (Schlamadinger and Marland, 2000). Natural, undisturbed forests store a large amount of carbon. Undisturbed soils can also accumulate a large amount of carbon over time. 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 large and production low, as in old growth ancient semi-natural forests, carbon sequestration would be favoured. However, when the initial area of standing forest is small and growth rates are likely to be high, fossil fuel substitution through forest biofuel is preferred.

Thus, the location of carbon stores is important. Carbon stocks rise as one moves further south in England, with the south-east containing the highest carbon stocks (Brainard et al., 2003). This is because the south has more older, broadleaved trees in later rotations, whereas much of the stock in northern England is on peat or upland soils, which has reduced carbon sequestration potential (Brainard et al., 2003).

Carbon sequestration 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 other 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. 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 (Huston and Marland, 2003).

Since the majority of woodlands in England comprise mainly broadleaves (67%) (FC, 2005) there may be scope for minimum intervention carbon sequestration forestry. If the current carbon value of £70 per t/C used by the government is taken, carbon sequestration 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.

DISCUSSION

The findings of this study suggest that moderate woodland management in most instances will enhance public good benefits. It has been shown that a lack of management has been cited as a major reason for 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. Management is most likely to impact biodiversity values and recreation values, although this clearly depends on the type of management. Intensive large-scale clearfell will have negative impacts on landscape, albeit for a relatively short period of time until regeneration occurs.

In order to summarise the effects of management on public good outputs, we return to the production possibility curve. Figure 5 illustrates the likely production possibility scenarios for the public goods examined.

For recreation, the public good value is low, or even negative, where no management occurs (except for the minority of users with a preference for 'wildwood'). Public good value increases with modest levels of management, such as ride cutting, some thinning or single tree selection, but decreases again when management levels intensify (such as small group fell or small patch 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.

The availability of other recreational sites (woodland or otherwise) also influences the value of woodland in terms of its public good. 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 recreational public good enhancement is likely to be lowland broadleaved woodlands near to urban areas and where other recreational space is limited and where existing management is at very low or zero intensity.**

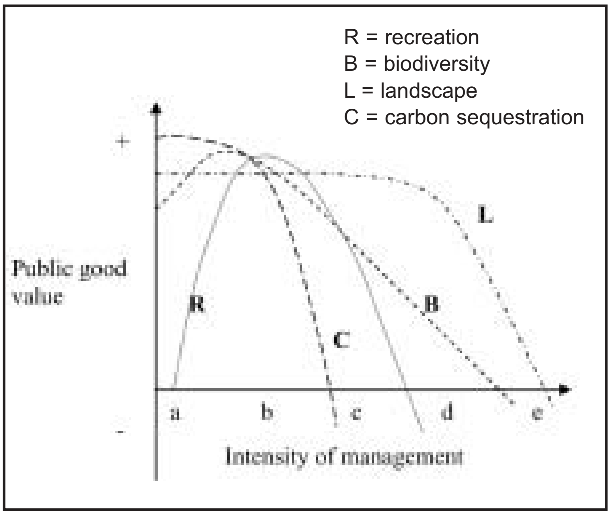

FIGURE 5: Generalised relationships between different public good values and management intensity.

The literature reveals that there is an associated decline in biodiversity with a lack of woodland management. 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 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.

It is likely that minimum management regimes (single tree selection, small group-fell, control of shade-tolerant conifers) are sufficient to increase general biodiversity. Simply allowing more light to reach the forest floor through thinning or ride maintenance will enhance ground flora and light loving species. However, there is no one management regime that will be suitable for all species. Whilst, the curve in Figure 5 shows that intensive management reduces 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 in size, 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. However, most biodiversity recommendations are made by biologists without any reference to the economic value of biodiversity.

- **The priority for biodiversity public good enhancement is likely to be lowland and upland broadleaved, particularly where iconic species are threatened by undermanagement.**

In general, a lack of management or up to moderate management will have no effect on landscape values. Only when large-scale clearfell takes place will this have a negative effect on landscape, albeit for a short period of time. These negative impacts can largely be mitigated by careful harvest design.

- **The priority for landscape public good enhancement is to mitigate the effects of large-scale landscape change near to urban areas or in areas with high tourist values.**

Woodland management for carbon sequestration is perhaps the least well understood of all public goods. Non-intervention old-growth forests appear to have the highest value in terms of stored carbon, with a reduction in carbon storage occurring as management intensifies and timber is removed and the soil disturbed. However, managed woodland in which high yield timber is harvested and re-grown may offer greatest overall economic benefits. 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 priority for carbon sequestration public good enhancement is likely to be semi-natural ancient woodlands.**

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 approach the state of complementarity between timber production and public good outputs identified as the goal of sustainable forest management at the beginning of this paper.

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 78% of English forests and woodlands (FC, 2001). Of this, 60% is in private ownership and 52% 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. Private woodlands also have 3 times the carbon sequestration value of the Forestry Commission estate (Brainard et al., 2003). However, private woodland owners are not a homogenous group, but increasingly consist of a diverse mix of 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 (Slee, 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.

A study undertaken in 2002 to investigate the attitudes and perceptions of private 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.

CONCLUSION

The objectives of the England Forest Strategy (1999) are to deliver social, environmental and economic benefits of forestry together. This integrated approach to the 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). The generally agreed aim is to achieve the optimal state of joint production (see Figure 4) wherein a modest amount of woodland management for timber will result in significant public good benefit enhancement. This paper has shown that achieving this optimal state is a complex process and that a variety of factors will determine the extent to which it can be achieved.

According to CJC Consulting (2005) there is no evidence to support government intervention in timber production. This assertion appears to challenge the notion that enhanced management can lead to increased levels of public good provision. 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 paper, therefore, concludes that in most instances a modest amount of management will have positive impacts on maximized public good outputs. If, as is the case, the market fails to provide the desired level of public goods, the welfare-optimising state has to intervene or other measures have to be taken (Gluck, 2000).

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 it would be required on a continuing basis in order to maintain the level of public good delivered.

Alternatively, economic instruments can be used to internalise the externalities of public good provision. This approach provides financial incentives for the internalisation of positive externalities and financial disincentives for the internalisation of negative externalise (Gluck, 2000). If providing increased public goods results in decreased revenues for the woodland owners, compensation is necessary in order to motivate the owner to manage appropriately. If, as has been shown, modest woodland management has a positive effect on public good enhancement, a cost-effective approach may be to stimulate an active wood product market, whether it be wood fuel or timber. A small investment by government (whether in the form or grant aid or 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. However, there is a need to explain the failure of these short supply chains to evolve endogenously without assistance. If it is establishment costs that limit their creation, public sector intervention might be justified.

It is likely that intervention in order to stimulate woodland management will need to be targeted to those areas or woodlands that can offer the best return. Collecting detailed information is very costly and may prove prohibitive. Thus, there appears to be a case for developing enhanced benefit transfer approaches to show the value surface of public goods to target intervention. GIS tools can be used to indicate woodlands with high public good value added and existing low levels of management, which can be targeted for intervention.

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.

REFERENCES

Amar, A., Hewson, C.M., Thewlis, R.M., Smith, K.W., Fuller, R. J., Lindsell, J.A., Conway, G., Butler, S. and MacDonald, M. (2006). What's happening to our woodland birds? Long-term changes in the populations of woodland birds.

Sandy, Bedfordshire, Royal Society for the Protection of Birds & British Trust for Ornithology.

Anderson, L.M. and Cordell, H.K. (1988). 'Influence of trees on residential property values in Athens, Georgia (U.S.A.): A survey based on actual sales prices.' Landscape and Urban Planning 15: 153-164.

Asher, J., Warren, M., Fox, R., Harding, P., Jeffcoate, G. and Jeffcoate, S. (2001). The Millennium Atlas of Butterflies in Britain and Ireland. Oxford, Oxford University Press.

Bateman, I.J. and Willis, K.G., Eds. (1999). Valuing Environmental Preferences. Oxford University Press, Oxford.

Bateman, I.J. and Lovett, A.A. (2000). 'Estimating and valuing the carbon sequestered in softwood and hardwood trees, timber products and forest soils in Wales.' Journal of Environmental Management 60: 301-323.

Benson, J.F. and Willis, K.G. (1992). Valuing Informal Recreation on the Forestry Commission Estate, Forestry Commission Bulletin 104. Edinburgh, Forestry Commission.

Berger, B. (1996). 'Psychological benefits of an active lifestyle: what we know and what we need to know.' Quest 48: 330-353.

Brainard, J., Lovett, A. and Bateman, I. (2003). Carbon Sequestration Benefits of Woodland. Social & Environmental Benefits of Forestry Phase 2. Edinburgh, Report to the Forestry Commission, Centre for Research in Environmental Appraisal and Management, University of Newcastle upon Tyne.

Burgess, J. (1995). The ambiguity of woodland landscapes. Community Forest in an Urban Context. Coles, R.W., Bussey, S.C. and Heslegrave, W.E. Birmingham, UK, Urban and Community Forestry Research Group, University of Central England: 39-43.

Burgess, J., Harrison, C.M. and Limb, M. (1988). 'People, parks and the urban green: a study of popular meanings and values for open spaces in the city.' Urban Studies 25: 455-473.

Chokor, B.A. and Mene, S.A. (1992). 'An assessment of preference for landscapes in the developing world: case study of Warri, Nigeria, and environs.' Journal of Environmental Management 34: 237-256.

Church, A., Ravenscroft, N. and Rogers, G. (2005). Woodland Owners' Attitudes to Public Access Provision in South-East England. Edinburgh, information note on report to the Forestry Commission.

CJC Consulting (2005). Review of Evidence for the Formulation of Forestry Policy in England, report for DEFRA, CJC Consulting. Oxford, UK.

Coles, R.W. and Bussey, S.C. (2000). 'Urban forest landscapes in the UK - progressing the social agenda.' Landscape and Urban Planning 52: 181-188.

Cook, J. and Beyea, J. (2000). 'Bioenergy in the United States: progress and possibilities.' Biomass and Bioenergy 18: 441-455.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997). 'The Values of the World's Ecosystem Services and Natural Capital.' Nature 387: 253-260.

EN (English Nature) (2003). England's best wildlife and geological sites. The condition of Sites of Special Scientific Interest in England in 2003. Peterborough, English Nature.

FC (Forestry Commission) (1999). 'The England Forest Strategy.'

FC (Forestry Commission) (2001). National inventory of woodland and trees - England. Edinburgh, Forestry Commission.

FC (Forestry Commission) (2002). British Timber Statistics 2001. Edinburgh, Forestry Commission.

FC (Forestry Commission) (2005). Woodland Management for Bats, Forestry Commission for England and Wales, Bat Conservation Trust, Countryside Council for Wales, English Nature.

FC (Forestry Commission) (2005). Forestry Facts & Figures 2005. Edinburgh, UK, Forestry Commission.

Fenton, N.J. and Frego, K.A. (2005). 'Bryophyte (moss and liverwort) conservation under remnant canopy in managed forests.' Biological Conservation 122: 417-430.

Fisher, B.S. and Nasar, J.L. (1992). 'Fear of crime in relation to three exterior site features: prospect, refuge, and escape.' Environment and Behavior 24: 35-65.

FTA (Forestry & Timber Association) (2004). 'A Level Playing Field for Forestry: A manifesto for multi-purpose forestry and a vision for change.'

Fuller, R. J., Chamberlain, D.E., Burton, N. H. K and Gough, S. J (2001). 'Distributions of birds in lowland agricultural landscapes of England and Wales: How distinctive are bird communities of hedgerows and woodland?' Agriculture, Ecosystems & Environment 84(1): 79-92.

Garrod, G. and Willis, K. (1992). 'Valuing goods' characteristics: an application of the hedonic price method to environmental attributes.' Journal of Environmental Management 34: 59-76.

Garrod, G.D. (2003). Landscape Values of Forests, Social and Environmental Benefits of Forestry Phase 2. Edinburgh, Report to the Forestry Commission, Centre for Research in Environmental Appraisal and Management, University of Newcastle upon Tyne.

Gluck, P. (2000). 'Policy means for ensuring the full value of forests to society.' Land Use Policy 17: 177-185.

Hanley, N.D., Willis, K.G., Powe, N.A. and Anderson, M. (2002). Valuing the Benefits of Biodiversity in Forests, Report to the Forestry Commission, Edinburgh, Centre for Research in Environmental Appraisal and Management, University of Newcastle.

Harrison, C., Burgess, J., Millward, A. and Dawe, G. (1995). Accessible natural greenspace in towns and cities: a review of appropriate size and distance criteria. Peterborough, UK, English Nature Report No. 153, English Nature.

Heggie, B. (2001). Public Opinion of Forestry 2001. Edinburgh, HQ Economics & Statistics Unit, Report for the Forestry Commission.

Hickman, S.A., Lee, R.E., Sallis, J.F., Castro, C.M. and Chen, A.H. (1999). 'The association of physical activity change with self-esteem in ethnic minority women: a prospective analysis.' Journal of Gender, Culture and Health 4(4): 281-292.

Humphrey, J.W. (2005). 'Benefits to biodiversity from developing old-growth conditions in British upland spruce plantations: a review and recommendations.' Forestry 78(1): 33-53.

Huston, M.A. and Marland, G. (2003). 'Carbon management and biodiversity.' Journal of Environmental Management 67: 77-86.

Kaplan, R. and Kaplan, S. (1989). Experience of Nature: a Psychological Perspective. Cambridge, Cambridge University Press.

Karjalainen, E. and Komulainen, M. (1999). 'The visual effect of felling on small- and medium-scale landscapes in north-eastern Finland.' Journal of Environmental Management 55: 167-181.

Kirby, K. J., Smart, S. M., Black, H. I. J., Bunce, R. G. H., Corney, P. M. and Smithers, R. J. (2005). Long term ecological change in British woodland (1971-2001), A resurvey and analysis of change based on the 103 sites in the Nature Conservancy 'Bunce 1971' woodland survey. Perth, English Nature.

Kszos, L.A., Downing, M.E., Wright, L.L., Cushman, J.H., McLaughlin, S.B., Tolbert, V.R., Tuskan, G.A. and Walsh, M.E. (2000). Bioenergy Feedstock Development Program Status Report, ORNL/TM-2000/292. Oak Ridge, TN, USA, Oak Ridge National Laboratory.

Liley, D., Brereton, T. and Roy, D. (2004). The Current Level of Butterfly Monitoring in UK Woodlands. Report no. SO4-35, report to the Forestry Commission.

Liski, J., Pussinen, A., Pingoud, K., Mäkipää, R. and Karjalainen, T. (2001). 'Which rotation length is favourable to carbon sequestration?' Canandian Journal of Forest Research 31: 2004-2013.

Magill, A.W. (1992). Managed and natural landscapes: what do people like? Pa PSW-213, USDA Forest Service Res.

Mantau, U., Merlo, M., Sekot, W. and Welcker, B. (2001). Recreation and Environmental Markets for Forest Enterprises. Wallingford, CABI Publishing, CAB International.

McCool, S.F., Benson, R.E. and Ashor, J.L. (1986). 'How the public perceives the visual effects of timber harvesting: an evaluation of interest group preferences.' Environmental Management 10: 385-391.

McGuire, M. (1987). Public goods. The New Palgrave: A Dictionary of Economics. Eatwell, J., Milgate, M. and Newman, P. London, Macmillian Press: 454.

Morales, D.J. (1980). 'The contribution of trees to residential property value.' Journal of Arboriculture 6: 305-308.

Nelson, C.R. and Halpern, C.B. (2005). 'Short-term effects of timber harvest and forest edges on ground-layer mosses and liverworts.' Canadian Journal of Botany 83(6): 610-620.

Ribe, R.G. (1989). 'The aesthetics of forestry: what has empirical preference research taught us?' Environmental Management 13: 55-74.

Ribe, R.G. (2005). 'Aesthetic perceptions of green-tree retention harvests in vista views. The interaction of cut level, retention pattern and harvest shape.' Landscape and Urban Planning 73: 277-293.

Ribe, R.G. and Matteson, M.Y. (2002). 'Views of old forestry and new among reference groups in the Pacific Northwest.' Western Journal of Applied Forestry 17: 173-182.

Ribe, R.G., Armstrong, E.T. and Gobster, P.H. (2002). 'Scenic vistas and the changing policy landscape: visualizing and testing the role of visual resources in ecosystem management.' Landscape Journal 21: 42-66.

Schlamadinger, B. and Marland, G. (2000). Land use and global climate change: forests, land, and the Kyoto Protocol. Arlington, VA, USA, Pew Center on Global Climate Change.

Sheppard, S.R.J., Harshaw, H.W. and McBride, J.R. (2001). Priorities for reconciling sustainability and aesthetics in forest landscape management. Forests and Landscapes: Linking Ecology, Sustainability and Aesthetics. Sheppard, S.R.J. and Harshaw, H.W., (Eds.). New York, CABI Publishing: 263-288.

Slee, B. (2005). The Scope for Reconciling Public Good and Private Forestry in the UK. Small-scale Forestry in a Changing Environment. IUFRO International Symposium, Lithuanian Forest Research Institute.

Thomas, J.A., Telfer, M.G., Roy, D.B., Preston, C.D., Greenwood, J.J.D., Asher, J., Fox, R., Clarke, R. T. and Lawton, J.H. (2004). 'Comparative losses of British buttferlies, birds, and plants and the global extinction crisis.' Science 303: 1879-1881.

TNS (2004). Leisure Day Visits: Report of the 2002/03 Great Britain Day Visits Survey, Report to the Countryside Agency.

Tudor, O., Dennis, R. L. H., Greatorex-Davies, J. N. and Sparks, T. H. (2004). 'Flower preferences of woodland butterflies in the UK: nectaring specialists are species of conservation concern.' Biological Conservation 119(3).

Turner, R.K., Pearce, D. and Bateman, I. (1994). Environmental Economics: An Elementary Introduction. Hemel Hempstead, Harvester Wheatsheaf.

van Huylenbroek, G. and Durand, G., Eds. (2003). Multifunctional agriculture: a new paradigm for European agriculture and rural development. Ashgate, Aldershot.

van Kooten, G.C., Binkley, C.S. and Delcourt, G. (1995). 'Effect of carbon taxes and subsidies on optimal forest rotation age and supply of carbon services.' American Journal of Agricultural Economics 77: 365-374.

Ward Thompson, C., Aspinall, P., Bell, S. and Findlay, C. (2005). '"It Gets You Away From Everyday Life": Local Woodlands and Community Use - What Makes a Difference?' Landscape Research 30(1): 109-146.

Warren, M., Clarke, S. and Currie, F. (2001). 'The Coppice for Butterflies Challenge: a targeted grant scheme for threatened species.' British Wildlife 13: 21-28.

Willis, K.G. and Garrod, G.D. (1991). 'Valuing Open Access Recreation on Inland Waterways: on-site recreation surveys and selection effects.' Regional Studies 25(6): 511-524.

Willis, K.G., Garrod, G., Scarpa, R., Powe, N., Lovett, A., Bateman, I.J., Hanley, N. and Macmillan, D.C. (2003). The Social and Environmental Benefits of Forests in Great Britain. Edinburgh, report to the Forestry Commission.