Methodology for Monitoring New Woodland in England

Final report for Defra and the Forestry Commission

CJCCONSULTING
economics environment countryside

November 2003

Methodology for Monitoring New Woodland in England

CJC Consulting

with

George Peterken

Julie Martin, Julie Martin Associates

Janet Riley, Rothamsted Research, Harpenden

November 2003

CJCCONSULTING

45 Southmoor Road Oxford. OX2 6RF

T/F 01865310088

M 07884436514

Email: r.crabtree@zetnet.co.uk

www.cjcconsulting.co.uk

Contents

Acknowledgements

We wish to thank members of the steering group for helpful comment, Joanne Fisher and Mairie Simm (FC) for WGS data extraction, and the consultees who replied to our consultation exercise. Keith Kirby of English Nature was particularly constructive on the biodiversity section, as was Tom Nisbet on hydrology and Pat Snowdon on economics. We benefited from the detailed comments of Hilary Allison and colleagues at the Woodland Trust on several aspects of our draft proposals.

Abbreviations

AONB	Area of Outstanding Natural Beauty
CAP	Common Agricultural Policy
CCA	Countryside Character Area
CS	Countryside Stewardship Scheme
CWC	Community Woodland Contribution (originally the Community Woodland Supplement)
CWS	Community Woodland Supplement
DEFRA	Department for Environment, Food & Rural Affairs
DETR	Department for Environment, Transport & the Regions
EFS	England Forestry Strategy
EN	English Nature
ERDP	England Rural Development Programme
FC	Forestry Commission
FE	Forest Enterprise
FWS	Farm Woodland Scheme
FWPS	Farm Woodland Premium Scheme
GIS	Geographical Information System
MAGIC	Multi-Agency Geographic Information for the Countryside
NIWT	National Inventory of Woodland and Trees
NWDA	Northwest Development Agency
OS	Ordnance Survey
PBRS	Public Benefit Recording System
SSSI	Site of Special Scientific Interest
UKFS	United Kingdom Forestry Standard
WGS	Woodland Grant Scheme

1 Introduction

1.1 Context

Since 1988, over 60,000 ha of new woodland has been created in England with grant aid under the Woodland Grant Scheme (WGS), Farm Woodland Scheme (FWS) and Farm Woodland Premium Scheme (FWPS). Evaluations of these schemes have been undertaken, culminating in the recent evaluation of WGS/FWPS by Clegg *et al*. (2002). The Forestry Commission has also sponsored a large number of economic studies to quantify the non-market benefits from woodlands, the most recent of which is the review of social and environmental benefits undertaken by Wills *et al*. (2003).

A lack of information typically limits these studies. Specifically, the WGS/FWPS evaluation concluded that 'as there is no system of longer term biological and compliance monitoring in place, it is not possible to evaluate these contributions (to the environment) conclusively either quantitatively or qualitatively'. In addition evidence on the cost and benefits of schemes is required as part of evidence-based assessment of government priorities (e.g. University of Cambridge *et al*, 2002).

1.2 Objectives

The project aims to define suitable monitoring strategies to identify and quantify the various public benefits (and disbenefits) that previous and future grant aided woodlands produce. A range of options is required including a least cost option.

More specifically, it is important to design a monitoring strategy such that:

- Observations about benefits from individual woodlands can be aggregated to indicate the benefits derived from a grant aid scheme, an element of a scheme (e.g. payments for access) or new woodlands in different locations and contexts.
- Observations cover a diversity of benefit values so as to inform the design and targeting of policy in the future.

The remit was interpreted as requiring a primarily technical rather than economic study. However, we wish to point out, as does Snowdon (2003), that it may be difficult to interpret physical measures if there are no associated values. In the extreme, it may not be obvious whether change constitutes a benefit to the public or not.

1.3 Scope

1.3.1 Types of Benefit

Woodlands can produce benefits to society that include improvements to the landscape, opportunities for recreation, and contributions to biodiversity. They may also, on occasion, produce disbenefits through poor design or location, and the loss of provious output. In order to provide a starting list of benefits for consideration we refer to forestry policy objectives, the aims of the current grant schemes, and recent benefit studies.

The England Forestry Strategy (Forestry Commission, 1998) has four key elements:

- Forestry for rural development which covers forestry's contribution in the wider countryside including the contribution of both new and existing woodlands to the rural economy, timber and marketing opportunities and to contribute through upstream and downstream job creation.
- Forestry for economic regeneration which refers to forestry's role in strategic land use planning including the restoration of former industrial land and creating a green setting for future urban and urban fringe development.

- Forestry for recreation, access and tourism which focuses on providing more and better public access to woodlands, ensuring that woodland and forests continue to be used for a wide range of recreational pursuits as well as complementing and supporting the tourist industry.
- Forestry for the environment and conservation, which embraces the role that woodlands can play in conserving and enhancing the character of our environment and in delivering the government's objectives for nature conservation, biodiversity and climate change.

The WGS scoring scheme used to rank applications aims to deliver benefits from:

- Rural development
- Economic regeneration
- Recreation, access and tourism
- Environment and conservation
- Landscape enhancement
- Additional factors (farmer applicants, community involvement).

The WGS also scores according to size, indicating that some benefits (or value for money) are expected to be greater per ha in larger woods.

From 1997 the aims of the FWPS have been: "To enhance the environment through the planting of farm woodlands, in particular to improve the landscape, provide new habitats and increase biodiversity. In doing this, land managers should be encouraged to realize the productive potential of woodland as a sustainable land use".

Willis *et al.* (2003) reviewed the value of GB forests in producing social and environmental benefits. They specifically examined recreation, landscape, biodiversity, carbon sequestration and air pollution absorption. Benefits from improved hydrology and reduced water pollution were not examined and other evidence indicates that these are likely to be very site specific (CJC Consulting, 2003).

Capitalised benefits of £29,226m (c £1,000m per year) were derived in total for these social and environmental benefits (Willis *et al*., 2003). These benefits refer to existing woodland including the FC estate, and not specifically to new planting. Benefits from new planting would be smaller, particularly for recreation because the majority of new planting does not have rights of access.

The above evidence indicates the following benefits from new woodlands that need to be assessed for inclusion in a monitoring scheme:

- Biodiversity, habitat and species enhancement
- Landscape and amenity
- Recreation, access and tourism
- Carbon sequestration
- Economic regeneration
- Rural development
- Community involvement

1.3.2 Other benefits and disbenefits

Air pollution reduction

Benefits from reduced *air pollution* are thought to be generally small (Willis *et al*., 2003). For this reason, and the fact that any technical monitoring would be highly specialised, we exclude air pollution from this study.

Hydrological impacts

New woodland can influence the *hydrological cycle* beneficially. Run-off is reduced by the increased interception of rainfall by trees when compared with herbaceous vegetation and variation in the rate of run-off is dampened by improved percolation into woodland soils. New woodland on floodplains will hold up flows, which is generally helpful in flood control if the woodland is located in headwaters or above flood-risk sites downstream. Riparian woodland also reduces erosion and siltation, and woodland can form a habitat buffer between agriculture and watercourses, which reduces eutrophication and improve water quality and fish stocks.

Nisbet (2003) considers that there are good reasons to believe that the benefits to water quality from the planting of new woodland on agricultural land could be high. Key benefits include: the cessation of fertiliser and pesticide inputs leading to reduced leaching and run-off of these chemicals to groundwater and surface supplies; the cessation of regular site cultivation resulting in a reduction in the risk of soil damage, sediment run-off and siltation in watercourses; and a significant reduction in the risk of microbial contamination of surface waters due to the removal of livestock.

Woodland may also have negative impacts on the hydrological cycle. interception and transpiration can further reduce already low flows, and trees on riverbanks can interfere with river management and fishing.

Attributing benefits from reducing agricultural pollution to forestry policy is contentious since these impacts are most properly dealt with within agricultural policy which may offer lower cost options that afforestation (CJC Consulting, 2003). Nisbet (2003) states that the monitoring of benefits to water quality could be based on monthly sampling and chemical analysis of local streams or soil waters. But this would be difficult at the scale of individual woodlands and require costly instrumentation. We do not therefore consider that it could be part of a relatively low-cost monitoring operation.

Health benefits

Woodlands can also provide *benefits to health* by improving quality of life through physical or psychological impacts. Evidence such as that from Ulrich (1984) on the benefits from natural views to post-operative patients is frequently quoted. However, specific evidence on the scale of benefits from woodlands is sparse, and in valuation studies it is likely that the value of heath benefits is measured as a component of recreation and landscape values. CJC Consulting (2000) reviewed the literature and concluded that measuring health impacts of woodlands would require a major technical study. At the current state of knowledge there seems to be no obvious way of directly measured heath impacts under a simple monitoring scheme. We also understand that a consortium which includes FC intend to launch a specific study on health benefits. This topic is therefore excluded.

1.3.3 Benefits attributable to policy

It is important to be clear about the benefits that are to be included. The aim may be to monitor *all benefits to society*. If this is the case then private benefits to the owner (timber, sport shooting etc.) should be included. However, it would be erroneous to attribute these benefits solely to policy (through grant aid) because private capital is also involved in grant-aided woodland investment.

If the aim is to monitor *policy benefits* (those attributed to government intervention, usually through grant aid), then it is usual to only consider additional benefits (over what private action would have produced; see 1.4)) and only include those benefits for which policy intervention is justified. CJC Consulting (2003) reviewed the case for intervention through grant aid and concluded that grant aid for new woodlands to produce timber and fix carbon could not normally be justified where markets for the outputs were in place or could be developed.

Nevertheless, a monitoring scheme should not be unduly limited to situations where intervention can be clearly justified given present conditions. One aim is to provide additional information that will assist policy design in the future. Accordingly, we retain carbon sequestration on the list and add timber value at the request of the steering group.

1.3.4 Disbenefits

Although planting guidelines attempt to minimise negative impacts, it is still possible for woodlands to produce economic, social or environmental disbenefits. These are most likely when planting reduces the non-market benefits provided by the previous land use. Such effects can be included by calculating *net* benefits, although in practice these may be difficult to estimate.

1.4 Issues in monitoring

Monitoring strategy

The design of a monitoring scheme has to account for the costs of monitoring and the benefits from additional information. We propose a pragmatic approach that balances up (a) the gains from better information in terms of justifying and informing policy and (b) the additional costs of measurement. This will lead the monitoring to concentrate on those benefits that are:

- Important in terms of the level of benefit delivered;
- Where current information is inadequate for accurate benefit measurement – and the marginal gain from more precise information is high; and where
- Measurement is feasible and cost is not excessive in relation to the additional precision achieved.

It is logical to devote less effort to those benefits/disbenefits which current evidence suggests are relatively unimportant, and where greater precision will not change this conclusion. However, if information on such aspects can be obtained at minimal additional cost it may still be worth including them.

Additionality of benefits

Some new planting will occur without grant aid. If the aim is to measure *policy benefits* it is only the additional planting and associated benefits that should be included. Additionality estimates are based on what landowners say they would have done with land had woodland incentives not been available. Face to face or postal surveys are required. Estimates are available in evaluation studies (see for example, Clegg *et al*., 2002; CJC Consulting, 2003; Crabtree *et al*., 2001),

The case for estimating additionality in new monitoring is not very strong and we do not recommend this. It would require surveys of owners and, where woodlands were planted some years before, it is doubtful whether reliable estimates of additionality could be obtained. We suggest that estimates are best made as part of formal scheme evaluations.

Time scale of benefits

The flow of benefits from a woodland typically varies over time, depending on the type of benefit. Most typically, the resource increases in size and value (e.g. for biodiversity and amenity) as the woodland matures. Monitoring can measure the flow of benefits being delivered at the time monitoring occurs, and repeat visits could be used to provide new estimates as woodlands mature.

However, policy reviews cannot wait for completion of a woodland cycle of 40+ years. It is therefore important to predict forward the benefits expected from young woodlands. This requires models of benefit change. Some are well developed (e.g. for timber and carbon sequestration) whereas those for landscape, access and biodiversity are less refined.

It is usual to convert future resource values, or flows of benefits over time, to present (capitalised) values using discounting (H. M. Treasury, 2003). This is only possible where benefits can be quantified, and it is most commonly applied to the monetary value of benefits (e.g. Willis *et al*., 2003). In principle, any benefit estimates should be designed to estimate the benefits over an agreed horizon which might be a woodland cycle or a fixed time period. In practice, this is more or less difficult depending on the ability to predict future benefits and quantify them.

Spatial case of benefits

Benefits need to be characterised by a spatial scale. Often this is national, but carbon sequestration has a global context and some benefits are local or regional in that they are highly context-dependent (e.g. economic regeneration, rural development). The development of WGS towards a more regionally based policy suggests that for many benefits it is their contribution to the regional agenda that will be important in the future. A monitoring scheme should take account of this spatial and contextual dimension to benefits.

Average and marginal benefits

It is important to distinguish between the average benefits from new woodland and the marginal benefits from new (additional) woodland. It is possible for there to be large positive average benefits for new woodland when considered in aggregate, yet additional planting may be producing disbenefits from loss of open space or loss of landscape diversity.

A monitoring scheme should ideally be able to identify the way in which benefits vary with design, location and context such that sites producing low or negative benefits are identified and policy is adjusted accordingly.

1.5 Approach

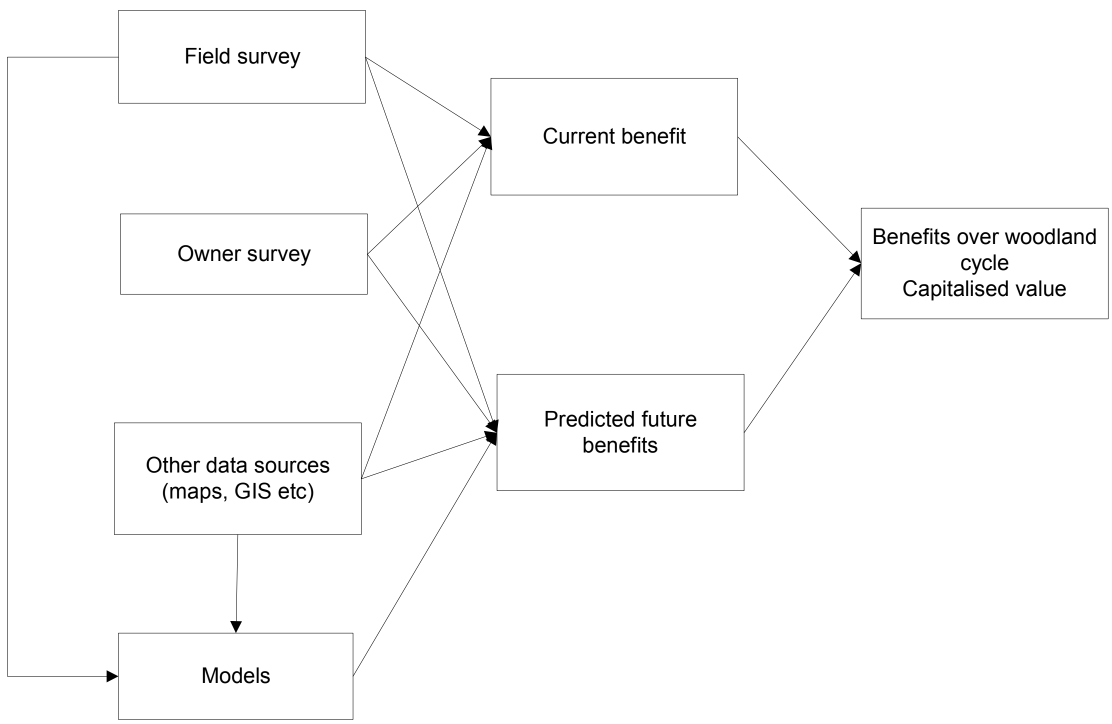
Information on current and predicted future benefits can be obtained from:

- Field surveys
- Surveys of owners
- Other data sources that assist in quantifying benefits and providing information for predicting future benefits. These include maps and GIS analysis.
- Models for predicting future benefits.

For each benefit the aim is to assess the best combinations of these information sources so that the scale of benefits and how they vary over time can best be assessed.

Figure 1.1 gives the information sources for measuring current and predicted benefits.

Figure 1.1 Schematic diagram showing information sources for predicting benefits.



1.6 Consultation

We sent a draft report to 28 consultees with expertise various aspects of woodland benefit monitoring. Key elements from the responses are incorporated in the text.

2 Benefit monitoring

2.1 Biodiversity

2.1.1 Assessing biodiversity in new woods

Two general requirements can be identified:

- A method for assessing biodiversity in individual new woods. This allows individual schemes to be assessed, permits an analysis of the factors that determine the biodiversity in individual woods, and thereby can help refine recommendations for the design and location of individual schemes.
- A method for assessing new woodland as a whole (i.e. groups of woodlands or part/whole schemes). This takes into account between-wood diversity in addition to within-wood diversity and will be important in identifying benefits at a larger scale.

New woodland may also be assessed according to the change it brings about in the pattern of woodland, i.e., at a landscape scale. The current pattern and stand contents of all woodland in a district can be assessed against criteria for assessing forest habitat networks, and the likely impact of new woodland can be expressed as a change in this assessment. This is considered in section 2.1.6.

The main questions relating to both individual new woods and new woods as a whole appear to be:

1. What has been the biodiversity change within the new wood, and are these changes gains or losses? Strictly, both ‘before’ and ‘now’ data from the new wood itself are needed to assess change on the ground now occupied by the new wood, but in some circumstances it may be possible to regard adjacent ground as a pointer to the condition of the site before afforestation. The biodiversity of the site before it became woodland is almost never available and cannot be determined retrospectively, though an experienced ecologist may be able to make a reasonable qualitative guess. Since 1995, previous land use has been recorded in the WGS database as arable, grassland or non-agricultural (see Section 3).
2. What have been the biodiversity changes around the wood? The problems of estimating change within a new wood apply also to changes in the surroundings. A new wood may harbour predators of species in surrounding land, and it may alter downstream hydrology. An owner would know if there have been any changes in adjacent land use, and whether these have been consequential on the creation of the new wood.
3. How does the new wood contribute to the wider landscape pattern, and has this potential biodiversity benefits? This would be assessed on the basis of general principles.
4. What are the prospects for long-term future development? This requires extrapolation from knowledge of succession and the factors that influence it.

Recommendations on new woodland design and locations, derived from an analysis of biodiversity in individual woods and the factors that influence it, would enable existing advice on individual woods and the restoration of forest habitat networks to be refined.

2.1.2 Some basic relationships

When a new woodland is created, or allowed to develop naturally, there is a change in the vegetation structure. In addition to the growth of tree cover, ground vegetation changes from a mixture of herbs, forbs and small shrubs, some of which are light-demanders, to a lower biomass mixture of shade-bearing species. Ferris-Kaan (1995) and Humphrey *et al*. (2003) brought together contributions on various aspects of new woodland creation.

The transformation takes 10-40 years. New planted woods generally close canopy in 10 or so years, but naturally regenerated woods take longer. Either way, there is a transition period, during which trees and shrubs become established, but before they shade out the light-demanding ground vegetation.

The transition from non-woodland to woodland is often not a complete change from one state to another. Change may be buffered by:

- Trees and shrubs already on site that provide a woodland habitat 'in anticipation' of the new woodland. These often take the form of hedges and hedge trees on the margins of the new woodland.
- Retention of open spaces within the design of the new woodland, often as rides.

Pre-existing species are either lost from the site, or retained as an 'inheritance' from the preceding land use. Retention is maximised where:

- Woodland species are already present, associated with trees and shrubs already on the site.
- Site characteristics and the preceding land use favoured the presence of woodland species, even in the absence of trees. Meadows, streamsides, rock outcrops, bracken patches, marshes, semi-natural pastures all contain a proportion of species that will survive the transition to shaded woodland conditions.
- Permanent open spaces are designed into the new woodland.

The biodiversity of new woodland is the sum of (i) biodiversity inherited from the preceding land use, (ii) introduced biodiversity, and (iii) immigrant biodiversity.

Inherited biodiversity is determined by the land use preceding the new woodland. If this is arable or ley grassland the inheritance will be minimal. It will be significant if a hedge and mature trees, or semi-natural habitat is included.

Introduced biodiversity is usually limited to the planted trees and shrubs. However, there is increasing interest in planting suitable ground flora (Francis and Morton, 2001; Packham *et al.* 1995)

Immigration requires that source populations are available in the surrounding countryside, and that individuals from these populations can move naturally to the new woodland. The probability of a particular species reaching a new woodland is an expression of (i) the characteristics of the species, (ii) site characteristics, and (iii) the spatial relationships between the new woodland and pre-existing woodland *sens. lat*. in the surrounding countryside.

At any given time, the number of species present in a new (secondary) woodland is a function of several factors, between which there are numerous interrelationships:

- Area. This alone accounts for c. 45% of the total variation.

- Inherent habitat diversity within the site, i.e, variety of soils, aspect, hydrology. This diversity is a large component of area as a factor.
- Designed habitat variety, i.e, the pattern of planting and open spaces, the variety of trees planted.
- Variety of planted/naturally regenerated tree and shrub species. This probably affects the diversity of invertebrates.
- Area of open space habitat, which determines the area of a major component of diversity and the length of internal edge habitats.
- Management, i.e. silvicultural interventions. This determines stand structure, development of mature stand components, degree to which permanent open spaces remain free of excessive shade.
- Proximity to sources of species for woodlands. In particular, whether new woodland is adjacent to existing woodland, thereby eliminating barriers to colonisation.
- Shape. Determines the edge/interior ratio; capture of species on the move.
- Topographical position. Some locations are particularly good for capturing species, e.g., streamsides.
- Time, i.e, increasing age of site as woodland. This determines the time available for immigration, development of a diverse stand structure, development of large trees and coarse woody debris.
- Introduced plant species (usually none).

2.1.3 Long-term development

The broad pattern of secondary woodland is known from (i) a few direct long-term observations of particular woods and (ii) chronosequence studies of secondary woods originating at different ages.

Findings from these studies can be taken to predict how new secondary woodlands will develop, even though the secondary woods created in the last 15 years or so are developing on sites that have been more intensively cultivated than secondary woods forming before the 20th century, and in a context with fewer sources of woodland species. The very long term and chronosequence studies therefore represent a best-case scenario. The few available studies were located in the Midlands and eastern England, and none has been undertaken in or on the margins of the uplands, so caution is needed when generalising.

The classic very long-term study of secondary woodland development on farmland is located at Rothampstead Experimental Station, where the Broadbalk and Geescroft Wildernesses were allowed to revert to woodland in the 1880s. Plant lists have been recorded at irregular intervals from which the general trends in this small, unmanged secondary wood were recently evaluated by Harmer *et al.*, (2001). Despite the incompleteness of the record, the following seemed clear:

- Maximum vascular plant diversity occurred before canopy closure.
- Most original species were eliminated at canopy closure.
- Despite some turnover of shade species after canopy closure, the long-term trend was slowly upwards.
- Many species in a nearby ancient wood failed to colonise.
- Some shade-bearing species colonised a nearby meadow, but failed to colonise the

woods. This indicated some inherent resistance to later colonisation by established vegetation.

- Hedges provided routes by which a few species colonised.
- Soils, which were initially alkaline, developed acid topsoil.

Another classic study was of an 18th century secondary wood on the Lincolnshire Wolds (Woodruffe-Peacock, 1918). This recorded observations by one individual over half a century. It demonstrated in qualitative terms:

- Turnover of vascular plant species, i.e., many species colonised for short periods, then died out.
- The mechanisms by which species reached the wood. This was the paper that recognised the historic importance of the trowser turn-up as a means of seed dispersal.

The most comprehensive chronosequence study was also in central Lincolnshire (Peterken and Game, 1981; 1984). Historical records were used to identify secondary woods originating at different periods from the 17th century onwards. The study showed:

- Many species in ancient woodland failed to colonise secondary woods, or did so only rarely and over short distances. These are sometimes called 'ancient woodland indicators'.
- Secondary woods of 3 ha and above were generally poorer in vascular plant species than ancient woods of the same size.
- The number of species in secondary woodland did not increase with time, once the initial phase of colonisation was passed. However, the probability that some slow-colonising species would reach a secondary woodland did increase with time, i.e., they were more likely to be found in 18th century secondary woods than younger woods, other factors being equal.
- Proximity to an ancient wood was important for colonisation. The chance that species associated with ancient woodlands would colonise secondary woods across unwooded ground fell away steeply with distance.

These findings have been confirmed and extended by later studies in continental Europe. Amongst the quantitative findings that can reliably be extrapolated to British conditions are:

- The rate at which the invasion front of typical woodland ground flora species (*Anemone nemorosa, Lamium galeobdolon, Convallaria majalis, Polygonatum multiflorum*) moves into across woodland is 0.05 – 1.15 m per year (Bossuyt *et al*., 1999).
- The probability that isolation-sensitive species (i.e., ancient woodland associates) will colonise a distant new wood drops almost to zero if the new wood is situated more than 200m from an existing population (Butaye *et al*., 2001).

A further study of secondary woods in central Lincolnshire has quantified the importance of open space habitats to the biodiversity of new woodland (Peterken and Francis, 1999). Vascular plant species that require open spaces (i.e., they would vanish if land within the wood were to be completely shaded by trees and shrubs) accounted for up to

55% of the total flora of a wood. In fact, the relative importance of open space species showed a stepped relationship according to wood size:

- Very small woods, below 3 ha. Open space species make up 0-30% of the flora. These woods generally have no rides or other permanent open spaces.
- Small woods, 3-25 ha. Open space species make up 0-55% of the total flora, the proportion increasing steeply with size. Woods of more than 3ha generally have rides, but the chance that at least part of these remains unshaded by neighbouring stands increases with size.
- Medium and large woods, 25 ha and above. Open space species make up 30-55% of the total flora. These woods invariably include rides, and they are large enough to ensure that some part is always unshaded, usually because the woods are used for timber, game, etc.

These points have been made in relation to vascular plants. However, there is evidence that the main features apply to most groups of species. Slow-colonising species have been identified amongst butterflies, beetles, flies, slugs, mosses, liverworts, and epiphytic lichens. Fungi are poorly known, but there seems little doubt that some associates of mature timber habitats are also slow to colonise, even onto trees that have acquired the required maturity.

The colonisation of new woodland by insects was reviewed by Key (1995). Few studies of invertebrate diversity in secondary woods have been undertaken, but several important general points seem widely accepted:

- Many invertebrate species are slow to colonise new woodland, and some are almost totally confined to ancient habitats.
- Some species are slow to colonise because they depend on mature structures, such as water-filled rot holes in trees, large pieces of deadwood, or fruiting bodies of fungi that develop in mature woodland. Mature trees with rot holes take several decades at least to develop. In new woodland, deadwood begins to build up only after 25 years (Francis *et al.,* 1996).
- The diversity of insects that depend on particular tree species is very large. The richness of the insect fauna in a particular wood will depend on which species are planted, and on the variety of planted species.
- Open spaces within woods are particularly important habitats. They not only support species that depend on, say, grassland, but also have rich assemblages at the edges between open ground and tree-covered ground.
- Proximity of new woodland to existing woodland and to other semi-natural habitats significantly improves the rate at which species colonise new woodland, since colonising distances are short, and barriers to colonisation are minimal.

The exceptional group appears to be birds (Fuller *et al*., 1995). Even new, remote woodlands develop a rich avifauna if the woodland itself develops a diverse structure and includes a mixture of tree and shrub species. Woodland size is important, for several species are reluctant to use very small woods (less than 2 ha), and those that do rarely stay for long. Maturity is also a factor, for some species cannot use a wood until trees have developed holes. But, on the whole, if the size and habitat is right, the appropriate bird species will colonise.

A quite different aspect of biodiversity is mycorrhiza (Merryweather 2001). Mycorrhyzae are important components of semi-natural communities, where they play a major role in nutrient uptake by vascular plants. Many vascular plant species cannot function without a mycorrhizal association, and each vascular plant species has particular mycorrizal associates. Woodland mycorrizae are generally different from those of non-woodland semi-natural vegetation. The degree of difference varies with the type of vegetation, being larger for moorland and heathland, smaller for meadow and pasture. Although there are many gaps in knowledge, the main understandings that affect new woodland are as follows:

- Ancient, semi-natural wood retain a close approximation to natural mycorrhizal associations.
- Ancient woods converted to plantations will have damaged mycorrhizal associations, due to site preparation (ploughing, draining) and massive change of tree species.
- Crop species and cultivated ground have few mycorrizae, and the species present are inappropriate to the woodland and other semi-natural communities. New secondary woodland is therefore unlikely to have an appropriate inheritance.
- Planting trees, even if they are site-native, on unwooded ground will not guarantee the successful generation of woodland mycorrizal associations.
- This lack of appropriate mycorrizae will limit the colonisation of many woodland ground vegetation species. This condition will persist for decades, possibly centuries, in isolated secondary woodlands, especially those on formerly cultivated ground.
- The best chance of developing secondary woodland with a full complement of mycorrhizal associations would be to expand from the margins of an ancient woodland.
- In an isolated secondary woodland, innoculation of mycorrhizae will have very limited value. However, ‘innoculation’ with ‘spadefuls’ of ground vegetation and soil will eventually be more successful.

2.1.4 Estimating biodiversity

Approaches to estimating biodiversity benefit can be based on:

- Species. Assessing the actual species present on site. This is a direct measure of biodiversity for those groups of species actually surveyed.
- Habitats. Assessing the actual habitats present on site. This is an indirect measure of biodiversity, but it allows statements to be made about all groups of species.
- Proxy variables. These are easily measured attributes that are known to correlate with biodiversity.

Current biodiversity can be estimated directly mainly from species and habitats. Future biodiversity can be predicted from current biodiversity, proxies and an understanding of succession and landscape-scale species movements.

The detail of the estimates can be considered at three levels:

1. Remote information, i.e., sources that do not require a visit to the site.
2. Simple field assessment, based on a single site visit.
3. Comprehensive field assessment.

1. Estimating biodiversity from remote sources

The sources of relevant information include:

- The grant application, which gives size, shape, date of establishment, a list of trees and shrubs, and limited information on the land use preceding woodland creation.
- Soil type, recorded in broad terms by the Soil Survey of England and Wales.
- NIWT and other mapped information, which show topographical position, existing woodlands nearby, adjacent watercourses and possibly preceding land type (discussed further in Section 3)[1].

Collectively, these would allow an experienced ecologist to anticipate the diversity and the species likely to be present. If detailed studies were available providing well-tested correlations between the features on these sources and biodiversity in new woods, they might allow firm statements to be made about the benefits from new planting. However, detailed studies of this kind are unlikely to be available.

Remote sources are highly unlikely to be enough to provide a general or a site-by-site assessment. They would also lack credibility in the eyes of ecologists.

2. Simple field assessments

(i) Species

Vascular plants are readily identified, always visible, ecologically meaningful, and form a substrate for many herbivorous species. They are relatively unseasonal in the sense that much the same list can be compiled at any season, though a proportion of species may be present only as dormant seeds. Bryophytes and lichens are just as visible, even less subject to seasons than vascular plants, but ecologically specialised and more difficult to identify. Birds, butterflies, larger fungi, etc., are less visible and strongly seasonal: their biodiversity cannot be assessed at a single visit. On this basis, vascular plants provide the best simple means of assessing biodiversity.

The simplest approach would be to compile a species list for the whole site on a single visit. The list could be annotated to show which species are abundant, the majority being simply ‘present’. It could also be annotated to show whether the abundance is in wooded ground, open ground, or both.

Analysis:

- The simple list provides a score, which can be related to the species-area regression for the age of woods (time since planting). Sites above the line would have above-average diversity for a wood of a particular size.
- Alternatively, the scores can be used as a league table, the position of a site in the league being determined by area, site diversity, etc., i.e., the species list itself integrates the various factors that influence biodiversity.
- The simple list can be refined by discounting widespread weeds (using a pre-determined list) and species of eutrophicated ground (e.g., nettles). The modified score would be a more meaningful assessment of the biodiversity of species of semi-natural habitats.

---

[1] The precision of Soil Survey and NIWT information in relation to small woodland areas requires more detailed assessment.

- Each species has ecological ‘meaning’. Using perhaps the Ellenberg scores and plant strategy typescales, the list can be used to (a) characterise site conditions, and (b) assess the development of particular habitats, such as wetland, grassland, heath.

(ii) Habitats

The simplest approach would be to score the presence of particular features. For maximum efficiency, these could be set out on a standard recording sheet.

The general character could be assessed by combining basic vegetation and soils in a 5 x 3 matrix. The boxes could be used to record presence, or an attempt can be made to partition the whole area between the combinations.

	Wet, poorly drained	**Mesic**	**Dry, well-drained**
Closed-canopy woodland			
Open-canopy woodland (usually pre-thicket) with shrub species planted or colonising			
Open-canopy woodland lacking shrub species			
Scrub, i.e., comprising just shrub species			
Unwooded ground, glades and rides			

Other habitat features that would be worth recording, either on a presence/absence basis, or with simple quantification are listed below:

- Mature trees
- Marginal hedges
- Ditches
- Open water
- Flowing water
- Mire
- Self-sown trees and shrubs

The value of these features would be twofold: (i) as possible explanatory variables for the variation in number of plant species in each site, and (ii) as variables that might allow future levels of biodiversity to be predicted.

Analysis:

- Simply adding the number of boxes ‘present’ would give a rough index of habitat diversity.
- By recording the area of wooded and unwooded ground, combined with the habitat features, it would be possible to run an analysis of the species lists to explain variation, and identify the principal factors affecting biodiversity. If the significant factors turn out to be measurable from remote sources, this analysis would enable estimates to be made of other sites without the need for field visits.

(iii) Proxy variables for predicting future development

These would be determined from maps, GIS, Phase 1 survey maps, etc.

Area

- of the whole site. This can be judged against species thresholds (see above).
- of permanent open space habitats. Provides a direct measure of potential for grassland conservation.
- Amount of new interior woodland, more than 50m from margins.

Location

- Adjacent to existing wood (and combined area of new and existing wood).
- Distance to nearest wood. Judged against colonising distances of woodland species.
- Distance to nearest ancient wood. Judged by colonising distances.
- Proportion of wooded land within 2km. Judged against 30% cover threshold (Peterken 2002).

Topographical relationships. Features in the surrounding countryside that are likely to enhance biodiversity development in new woodland.

- Flowing water enters or touches site.
- Woodland upstream of site.
- Hedges link new wood to pre-existing wood.
- Adjacent semi-natural grassland, heathland, etc.

Analysis would concentrate on assessing the number of positive features.

(iv) Conclusions

This simple field assessment would:

- Provide a semi-quantitative expression of the current value of a new wood in terms of (i) habitat diversity and (ii) plant species.
- Allow simple analyses of the factors influencing plant species diversity, which could be used to develop recommendations for new woodland location and design.
- Enable the prospects for improvement to be estimated from (i) landscape context, (ii) size of wood, (iii) size of open spaces within the wood, and (iv) diversity of self-sown tree and shrub species.

The resources required would be approximately:

- Time on site for recording plant list and habitat features, about 2 hours for most sites, possibly more for largest sites. Good botanical skills required.
- Travel time per site. Could be minimised if new woods were sampled in clusters.
- Time examining maps, GIS sources. A standard site record sheet would be required. If a large number of individual sites are scored as a single exercise, the time per site would be fairly short, say 1 hour.
- GIS databases from which landscape-scale features can be measured.

3. More comprehensive field assessment

The simple field approach could be elaborated in several ways. The issue for each would be: is it worth the money?

1. Plant recording could be more detailed. Kirby (2003) advises that 5 x 5m

quadrats could be recorded very quickly and would give additional information on the relative importance of species and the ways in which community/assemblages are developing. These need not be permanently marked. A minimum of 10 plots, randomly located through the wood, would provide a good quantitative basis for comparison between sites at one time and as a basis for quantifying change.

2. On-site recording of other species groups, such as birds, butterflies, beetles, fungi. This would provide a more comprehensive biodiversity assessment. However, the additional groups would require repeated visits to achieve an assessment, i.e., higher costs and delays, and a greater range of expertise. Birds may be relatively simple to record, but invertebrates are notoriously seasonal, and would require both repeat visits and equipment (e.g., pitfall traps). The appearance of fungi is fickle. If we accept that, say, 4 repeat visits are needed, and the costs of identification and equipment are greater, we should expect at least a five-fold increase in costs, or a five-fold decrease in the number of sites sampled.
3. Repeat the simple survey. This would provide some indication of the pace of change, but only after, say, a lapse of at least 5 years. Each repeat would double the overall cost. This would be new information on actual ecological development, but it would be received in 'real time'. It would be essential that precise electronic records of methodology and measurements were kept in order to have the option of a repeat survey.
4. Research projects designed to understand the long-term nature of secondary woodland development. The aim would be to track development for the first 150 years, by which time 'old-growth' stands should have developed. This would have to be based on the chronosequence approach, i.e., the use of secondary woods established long ago, and it would, in effect, be elaborating on previous work. Enlarged chronosequence studies offer the best chance of estimating the long-term potential of today's new woods, and it would be possible to include a range of species groups. This would be a research project, not a monitoring exercise. It would be constrained by the availability of suitable woods, and by the inherent problem that past woods originated in a different context of traditional agriculture (best case scenario, mentioned above).
5. Experimentally, one could enrich new woodland by introducing suitable species, then monitor the effects. Again, the most detailed work of this kind so far appears to relate to vascular plants. Enriching new woods would be a management experiment and a research project. The project would determine the effects of enrichment and form a basis for cost/benefit assessments of enrichment. Results would take many years to come, however.

These various elaborations involve either (i) a trade-off between comprehensiveness, sample size and cost, or (ii) a substantial wait for increased understanding of biodiversity development in secondary woodland.

2.1.5 Implementing a simple field assessment

Sampling of sites

- Number of sites should be sufficient to allow an analysis of the factors that influence the number of plant species present. Since these factors include both site properties and the properties of the surrounding land, the number of sites required could be quite large.

- Stratify by size to ensure that the full size range is fully represented.
- Stratify by time since planting to elucidate succession in early stages, which is likely to be rapid. Possible case for concentrating on oldest schemes to show maximum effects of planting.
- Cluster samples to a few, representative areas to minimise travel time to sample sites. Visits to a small of ancient woodlands within a cluster may be useful as a reference point. Any clustering should avoid concentrating samples within a particular (large) estate or designated area/district, within which local policies may dominate regional characteristics.

Scoring
Plant lists

- Score by number of species, or by pre-determined sub-sets.
- Sub-sets based on 'woodland species', 'grassland species', i.e., discounting widespread, catholic 'weed' species.

Habitat features

- Simple count of features may be sufficient, but a weighted scoring system may be more helpful.

Proxy variable models for predicting future development

Research results and those from the monitoring survey could be used to develop an index of future biodiversity benefits, based on non-linear scoring. It is beyond the project to develop this in detail but the following are suggested as elements of a possible approach:

- Partition the total score: 45% to area, 25% to location, 30% to topography.
- Area: Log scale, with steps at 3 ha and 25 ha.
- Location: say, 20 for adjacent to ancient woodland, 10 for adjacent to other woodland, 5, 2 and 1 for 100m, 200m, 500m separations respectively; 5 for 30% woodland cover within 2 km, 2 for 20-30% and 1 for 10-20%.
- Topography. Weighted scores for each attribute.
- Planted stock, combined with self-sown trees and shrubs from field record, could be used to predict long-term stand structure and composition.

This approach should not be based solely on vascular plant data, since the diversity of some groups (e.g., birds, bats, invertebrates) is determined as much by habitat structure as by vegetation composition. A more comprehensive approach is therefore indicated, i.e. a research project designed specifically to develop models that would predict several biodiversity measures from proxy variables.

2.1.6 Woodland Trust criteria

The Woodland Trust in *Expanding our horizons* has developed criteria by which new woodland may be assessed, namely (i) the density of ancient woodland cover; (ii) percentage of woodland which is semi-natural, (iii) cumulative core area of semi-natural habitats, and (iv) area of old growth. They say that these can mostly be measured remotely, and thus that the assessment can be undertaken at least cost in time and resources. They contrast this with on-site assessments that require costly fieldwork, divert specialists from other work, and can only realistically take into account selected aspects of biodiversity.

This represents a fundamentally different approach. Rather than assessing the new woodland, individually or collectively, the Woodland Trust seeks to assess the benefits of the change in the overall pattern and content of woodland brought about by new woodland. They see new woodland as a contribution to a network of forest habitats, i.e., theirs is a landscape-scale approach.

The development of forest habitat networks is a goal of the England Forestry Strategy. Criteria will be required for (i) assessing progress in general, and (ii) assessing the impact of any particular proposal to change (increase or decrease) the existing pattern of woodland. The Woodland Trust's criteria would form a key component of such an assessment.

However, these criteria appear to be inappropriate for assessing new woodland. Any new wood will not change the density of ancient woodland cover, and will not add to the area of old-growth until the 22nd century. Most will be planted, and would only marginally qualify as semi-natural, at least until a mature structure has developed. In so far as new woodland is likely to be land coming out of cultivation or intensive grazing, it will add to the core area of semi-natural habitats, but again the new woodland would be only marginally semi-natural for some time.

The Woodland Trust criteria need a stronger research base, and need to be refined. For example, the black-and-white approach that regards ancient woodland as sharply distinct from (and better than) other woodland is unduly simplistic. Likewise, the sharp distinction between semi-natural and other stands needs to be refined by some recognition of the continuous variable that is 'naturalness'. At this stage, therefore, the extra effort of field assessment is justifiable, especially if it leads to refinement of models for assessing changes in the woodland pattern at a landscape scale.

2.2 Landscape and amenity

2.2.1 Policy context and guidance

One of the aims of new woodland planting under the WGS and the FWPS is to improve the landscape. The UK Forestry Standard (Forestry Commission, 1998a) indicates that woodlands should enhance quality of life; conserve important heritage features including cultural, historic and designed landscapes; and enhance landscape quality. The Forestry Standard refers to woodlands as a highly valued and visible component of many landscapes. It highlights:

- the need for special attention to be paid to landscape issues in areas such as National Parks;
- the relevance of countryside character in helping to assess the wider impact of woodland proposals;
- the need for careful thought before changing the appearance of the landscape by creating a new wood;
- the need to evaluate the impact of different stages of woodland development in the years ahead;
- the need to take account of viewing direction, distances, scale and the number of people whose enjoyment could be affected.

More detailed guidance on landscape issues in relation to new woodland is also provided in the Forestry Commission's landscape design guidelines (Forestry Commission, 1992, 1994).

This list of issues corresponds closely with the range of landscape and amenity benefits and disbenefits that is generally recognised in current landscape assessment guidance (Landscape Institute and Institute of Environmental Assessment and Management, 2002; and Countryside Agency and Scottish Natural Heritage, 2002), namely effects on:

- landscape character and quality (or condition), that it the distinct and recognisable pattern of elements that occurs consistently in a particular type of landscape, and that state of repair of that landscape;
- landscape value, that is the relative value attached to different landscapes, for example through the application of local or national designations to particular areas features; and
- visual amenity, that is the benefits that views of an area or site afford to people's perceptions and enjoyment of the countryside.

2.2.2 Landscape and amenity benefits of new woodland

As for biodiversity, the benefits of new woodland need to be considered at two scales, first at the broad landscape scale, where we need a method for monitoring the benefits of new woodland as a whole, and second at the scale of the individual new woodland.

At the broad landscape scale the primary concern is with effects on the character and quality of the landscape (nationally, regionally and sub-regionally). At the scale of the individual new woodlands, more detailed local considerations relating to landscape value and visual amenity come into play, including issues of woodland design. Landscape and amenity benefits of new woodland accrue incrementally over time – but much more quickly than for biodiversity. Significant benefits are generally in place by the time of canopy closure.

Landscape character and quality

A very important benefit of new woodland is its contribution to landscape character and quality. The maintenance and enhancement of countryside character and distinctiveness have been promoted by the Countryside Agency through its Countryside Character Initiative and ongoing work on the Countryside Quality Counts (Nottingham University Consultants Ltd, 2003), and by non-governmental organisations (Campaign to Protect Rural England, 2003). The countryside character approach has been endorsed by government in the Rural White Paper (DETR, 2000). In addition, countryside character is increasingly used by Defra as a framework for design, monitoring and evaluation of agri-environment schemes.

In our view, therefore, monitoring based on landscape character and quality is essential. Although qualitative and judgement-based, there is a growing body of relevant information and expertise, and strong support for the use of character as a tool for evaluating the significance of land use change. It should therefore be possible to develop a systematic approach that will yield consistent, useful results.

The key question that needs to be asked is, does the new woodland 'fit' with landscape character i.e. does it contribute positively to wider landscape patterns? This requires consideration of:

- Extent – the extent of new woodland planted in a given time frame, relative to existing levels of woodland cover within the area;

- Location – how well the location of the new woodlands relates to the area's landform, geology and existing woodlands (woodland creation that extends or reflects existing woodland patterns often brings landscape as well as biodiversity gain);
- Character – whether the type and size of new woodlands are generally appropriate to the character of the surrounding landscape (for example broadleaved riparian woodland, linear shelterbelt planting, hangers);
- Need – whether there is a recognised need for new woodland in the locality, in terms of landscape and visual amenity or other specific landscape objectives such as restoration of derelict land.

The principal sources of relevant background information are:

- the Countryside Agency's Countryside Character Area (CCA) map and descriptions;
- the emerging CCA indicator profiles that are being prepared as part of the Countryside Quality Counts project;
- county and district landscape character assessments.

The CCA map, descriptions and indicator profiles could inform monitoring work at the broad landscape scale; while the county and district landscape character assessments could inform monitoring at the level of the individual woodland.

Monitoring of this kind could be undertaken remotely using published sources and GIS mapping such as the NIWT and the interactive maps on the Defra MAGIC website (which shows CCAs and WGS applications). Alternatively FC resources could b used.

Landscape value

New woodlands may affect landscape value in a number of ways. They may enhance the perceptual aspects of the countryside such as scenic beauty, tranquillity or wildness; they may restore cultural, historical or design features or associations; and they may contribute to nature conservation and biodiversity. Conversely, new woodlands may obscure or result in the loss of such landscape characteristics and features.

By paying special attention to landscape issues associated with new woodland in designated landscapes such as National Parks and Areas of Outstanding Natural Beauty (AONBs), there may be particular scope to benefit these important, nationally valued landscapes. However, in recent years it has been argued (DETR, 2000 and others) that enrichment of the countryside as a whole is just as important as conservation and enhancement of designated landscapes – hence the development of the countryside character approach. As this approach covers the whole country, there is probably no need to give special attention to the effects of new woodlands in designated landscapes at the broad landscape scale. Monitoring of the benefits/disbenefits to countryside character and quality, as described above, should suffice.

However, at the scale of the individual new woodland, it is important to understand how the woodland affects valued landscape characteristics and features. Here there may be benefits (for example, restoration of designed woodlands) but disbenefits may also be common. There is a need to consider factors such as:

- Historic features – Does the woodland affect field patterns or other historic landscape features such as ridge and furrow, industrial archaeology, or traditional buildings?
- Cultural and recreational landscapes – Are there any important cultural or literary associations that are affected? Has the woodland led to loss of public open space or open country?
- Designed landscapes – Does the woodland affect designed landscapes of historic

importance such as parkland and woodland around country houses?

Identification of such benefits/disbenefits would require review of individual WGS applications, desk study, field survey and possibly also interviews with landowners. Again, the MAGIC website would be an important research resource.

Visual amenity

The third area in which new woodland may offer benefits is visual amenity. This is closely linked to landscape character, quality and value but reflects the particular contribution that woodlands may make to the landscape in terms of visibility and views. It also encompasses the design or aesthetic characteristics of new woodland, on which the Forestry Commission has provided extensive guidance (see for example, Forestry Commission, 1992 and 1994).

Visual amenity benefits are relevant mainly at the scale of the individual woodland. At the broad landscape scale, some researchers (MLURI *et al*., 1996) have attempted to establish the visual benefits of new woodland by measuring the extent of its visibility, and its visibility compared to that of other woodlands in the area (as an indicator of its prominence in views), aggregating the results by region. However, in our view this type of analysis is not particularly meaningful, as visibility and visual prominence do not necessarily mean that there will be landscape benefit – indeed they could suggest visual intrusion and hence disbenefit.

It has also been suggested in some cost-benefit studies that the benefits of urban forestry, seen by large populations, far outweigh those of rural forestry, seen by relatively few viewers. Even so, it is probably more useful to design a field survey that covers all these aspects i.e. visibility, type of viewer, and nature of the view in a more rounded, qualitative way, as recommended in good practice guidance on landscape and visual impact assessment (Landscape Institute and Institute of Environmental Assessment and Management, 2002).

This may include consideration of visual issues:

- Viewpoints – Which are the principal viewpoints and how far away are they from the woodland? Are important scenic outlooks from towns, villages, recreational land or walking routes affected?
- Viewers – How many viewers are affected and how sensitive are they to changes in view (recreational viewers and local residents are generally deemed to be more sensitive than say passing motorists)?
- Intrusion/obstruction – Does the new woodland intrude upon or obstruct existing views?

The field survey may also include consideration of design or aesthetic issues. The following three factors, referred to in Forestry Commission landscape design guidelines and adopted in the Scottish evaluation of the FWPS (MLURI *et al*., 1996), are probably most relevant:

- Scale – How well does the new woodland relate to the scale of landscape elements and features in their immediate surroundings?
- Shape – Does the shape fit well with landform, land cover and field patterns?
- Edge effects – Does the woodland edge appear natural or unnatural?

2.2.3 Evaluation and monitoring

When evaluating and monitoring the landscape and amenity benefits and disbenefits of new woodland, it is probably simplest to assess the effects as if the woodland were mature, i.e. at the canopy stage, assuming that the woodland's appearance when mature will be similar to that of similar woodland types in the local area. In this section, we outline possible monitoring strategies for each of the types of effect described above. The monitoring aims to answer the specific questions that were posed for each effect.

Landscape character and quality – mainly remote

Context is central to evaluation of the benefits of new woodland to landscape character and quality i.e. the benefits are heavily dependent on the new woodland's landscape setting. Therefore any monitoring programme must be based on spatial/GIS data. Ideally, data should be analysed by CCA and aggregated by government region and nationally.

There are important links to be made with the Countryside Agency's Countryside Quality Counts project, led by Nottingham University Consultants Ltd, which is developing indicators of change in countryside character and countryside quality, using the CCAs as the main analytical framework.

The monitoring programme might comprise the following general steps:

- Review CCA descriptions (Countryside Commission and Countryside Agency, 1998-99). Draw out information on:
  - distinctive woodland location, type, size (from land cover section of write-up);
  - change in woodland cover (from changing countryside section of write-up);
  - requirements for future woodland planting (from shaping the future section of write-up).

  A similar exercise has already been undertaken as part of work on indicator development within the Countryside Quality Counts project and could provide a useful starting point.
- Use NIWT updated digital mapping or Land Cover Map 2000 to measure existing levels of woodland within each CCA (Land Cover Map 2000, if feasible, may be the better source because the NIWT includes only woods over 2 ha in size). Use WGS data to measure extent of new woodland in a given time frame (say five or ten years). Calculate percentage increase in woodland cover by CCA.
- Examine location and character of new woodlands within each CCA as a desk-based GIS exercise or using the MAGIC website interactive maps. Compare new woodland location, character, etc with the information drawn from CCA descriptions.
- Evaluate for each CCA as a whole the level of benefit and degree of 'fit' of new woodlands with the landscape using a simple scoring system such as that shown below.

	Score (1= low to 3=high)		
Measure of benefit or 'fit' with CCA	1	2	3
Extent – % increase in woodland cover			
Location – are new woodlands well located			
Type – are new woodlands of appropriate character			
Size – are new woodlands of appropriate size			
Specific objectives eg urban fringe, derelict land, community woodland – are these met			
Total for CCA			

The work would need to be undertaken by experienced landscape planners using their professional judgement. If required, it could be validated by stakeholder input. Similar stakeholder work is already being undertaken as part of the Countryside Quality Counts project, for which regional landscape consultative groups have been established.

The remote monitoring work could, if required, be supplemented and verified by a similar field survey of a sample of new woodlands, stratified by CCA, broadleaved/mixed/conifer, age, size and location relative to urban areas. At this level, the reference point for the evaluation would be local authority landscape character assessments (or specific local woodland design guidance, if available).

Landscape value – mainly field based

The effects of new woodland on valued landscape characteristics and features generally need to be evaluated in the field. They are context-dependent at a detailed level, for example where new woodland may affect the setting of a scheduled monument or open access land.

Initial work could be undertaken remotely to establish the general scale and distribution of effects and to identify sites that should be subject to field survey. However, the nature of the effect, i.e. benefit or disbenefit to historic, cultural, recreational and designed landscape features, could probably only be determined in the field.

A monitoring programme might comprise the following general steps:

- Identify WGS new woodland applications affecting relevant statutory and non-statutory designations – this could be done by Defra using MAGIC; spatial patterns could also be viewed on MAGIC interactive maps.
- Analyse percentage of new woodlands within or in close proximity to each type of designation, to include: National Parks; AONBs; Heritage Coasts; Environmentally Sensitive Areas; Scheduled Monuments; Registered Battlefields; Open Country; Historic Parks and Gardens (all these designations except open country are already held on MAGIC; open country GIS mapping is held by the Countryside Agency).
- Design and conduct desk and field survey of a sample of these new woodlands. As explained earlier, there is probably no need to look separately at benefits/disbenefits of new woodland in nationally designated landscapes (National Parks, AONBs, Heritage Coasts, Environmentally Sensitive Areas).
- However for the other designations it may be useful to record and analyse (at national and regional level):
  - whether the designation was recognised in the application;
  - whether the new woodland brings benefits (restoration, enhancement);
  - whether the new woodland brings disbenefits (damage to landscape setting, damage to specific features, loss of access or visibility).

Simple yes or no answers could be recorded for each of these questions and the results aggregated. The findings should give a clear indication of the degree to which the WGS and FWPS contribute (or otherwise) to the conservation and enhancement of our most valued historic, cultural, recreational and designed landscapes.

The monitoring would require general environmental expertise; specialist landscape expertise would be desirable but not essential.

Visual amenity – field based

This evaluation and monitoring work would focus on visual and aesthetic/design factors. These are very heavily context-dependent and definitely require field survey. As outlined above, the principal factors to be considered are visibility and viewpoints, viewers, nature of the view, and issues of scale, shape and edge effects.

A monitoring programme might comprise the following general steps:

- Identify a sample of new woodlands stratified by CCA, broadleaved/mixed/conifer, age, size and location relative to urban areas.
- Collate information about sample sites eg WGS application data, OS maps, background information from MAGIC.
- Design and conduct a field survey of these new woodlands. We suggest a simple three point scoring system, for example
  - viewpoints – low, medium, high importance
  - viewer numbers/sensitivity – low, medium, high
  - intrusion/obstruction – low, medium, high
  - scale – insignificant, in scale, dominant
  - shape – positive, neutral, negative
  - edge effects – graded, intermediate, sharp

The scores could be aggregated and analysed nationally, regionally and by CCA. This would give an indication of the contribution that new woodlands created through the WGS and FWPS make to visual amenity at different scales, and the quality of the woodland design that is being achieved.

The monitoring would require specialist landscape expertise, including a good appreciation of woodland design issues.

Proxy measures

Lastly, it is worth considering briefly if there are any proxy measures or models that could be used to predict levels of landscape and amenity benefit.

At the simplest level, the percentage increase in woodland cover gives a broad indication of landscape benefit, but this assumes that new woodland is always beneficial to landscape character, which of course is not the case – for example where woodland is inappropriately sited in relation to landscape character or replaces other valued landscape elements such as open space. Willis *et al.* (2003) found that the principal landscape benefits were from visible broadleaves set in an urban context. It would be important to include such information on benefits in both the on-site measures and an proxy assessment.

In relation to visual amenity, objection rates to new woodland on visual grounds might provide a proxy measure of visual/aesthetic benefit/disbenefit, if suitable statistics were available from WGS consultations with local authorities and other statutory organisations. In practice, however, it may be difficult to separate out objections made on visual grounds from objections made on other environmental grounds.

In future, research on landscape indices that describe the pattern and structure of the woodland landscape might provide a measure of the degree of ‘fit’ of new woodland with the surrounding landscape. Forestry Commission website material (Forestry Commission, 2003) on indicators of sustainable forestry suggests that some preliminary work on this subject has been undertaken by Forest Research but is still in its early stages.

2.2.4 Implementing the monitoring

In terms of GIS datasets and analysis the principal requirements would be for mapping of new WGS planting sites and CCA boundaries, and analysis of the extent of new WGS cover by type (broadleaved, mixed, conifer) and by CCA. Data on areas of new planting greater than 2 ha in size can be found on the NIWT digital mapping (older woodland sites were mapped from aerial photography but more recent plantings are being mapped annually from WGS applications); details of land with WGS agreements are also held on MAGIC. The Forestry Commission itself could easily undertake this basic analytical work.

Remote evaluation of benefits to landscape character and quality using a scoring system such as that outlined would produce a clear indication of the benefits of new woodland to the landscape resource and to the public in terms of quality of life. Its particular merit would be to show the *relative* benefits achieved by planting in different parts of the country, and the degree to which planting contributes to improvements in countryside character and quality. Implementation would require a modest research study (perhaps £30-50k), ideally linked to the ongoing Countryside Quality Counts project. Future monitoring could perhaps be linked with monitoring under that programme.

Field evaluation could be undertaken by means of a combined survey of a single sample of woodlands across the country, to cover all three sets of factors – landscape character and quality, landscape value and visual amenity. This would achieve economies of scale compared to separate surveys. A survey of this kind would require a fairly large sample. As for biodiversity, a random element would be needed to meet statistical requirements, but stratification by CCA and other factors (see section 2.2.3) would be beneficial. A minimum of 3-5 sites per CCA (of which there are 159) would help to ensure that a good range of landscape and woodland types is represented. In terms of survey time, each site might need say 1 hour for desk study and 2 hours for field survey. This excludes both time for collation of desk study material, and also travel time.

As indicated earlier, field surveyors ideally would need a landscape background to help them deal with issues of landscape character, visual impact and forest design. Alternatively general environmental surveyors might be employed, provided they were given special training and guidance.

2.2.5 Conclusions

Landscape and amenity benefits are seen as an important reason for new woodland planting and there is a strong need for their evaluation and monitoring. New woodlands can make a key contribution to quality of life and to the conservation and enhancement of England's distinctive landscapes. However, for this contribution to be positive and effective the new woodlands must demonstrate a 'fit' with the landscapes in which they are sited. They must bring no harm to historic, cultural, recreational and designed landscapes and indeed should contribute positively to the conservation and restoration of these landscapes. Lastly, new woodlands must of course perform better in terms of visual impact and design standards than past woodland plantings, which generated considerable levels of concern, particularly in upland areas.

Of the monitoring strategies outlined above, **remote landscape character monitoring** is the most important and potentially valuable in our view. It represents the best tool for optimising and targeting the landscape benefits of new woodland in a strategic way. It fits well with other work being undertaken by Defra on agri-environment and the Countryside Agency on monitoring change in countryside character and quality. In addition, it could provide a useful focus for stakeholder involvement in future development and refinement of the WGS. While experimental to some degree, there is now a growing body of experience in this type of landscape evaluation and monitoring. It should not be costly, because it can be carried out remotely.

Field surveys as an add-on to remote landscape character monitoring are strongly recommended, to provide a more rounded view of the effectiveness of the WGS in landscape and amenity terms. They may be more useful for highlighting the *disbenefits* rather than the benefits of new woodland, and may enable the WGS to be implemented more effectively in future, for example by providing better guidance and advice. It would be possible, through a combined field survey of a single sample of woodlands across the country, to cover all three sets of factors – landscape character and quality, landscape value and visual amenity – with some economies of scale. However, field survey work is likely to be considerably more costly than remote landscape character monitoring.

Field surveys alone would provide much less information on the important contextual benefits of new woodland and hence the results are likely to be less useful in strategic planning of new woodlands at national and regional level, especially given their relatively high cost.

Proxy measures of landscape and amenity benefit could provide some basic background information on the benefits of new woodlands. They may hold some potential for the future but are probably of limited value now.

2.3 Recreation, access and tourism

2.3.1 Policy context

New woodlands may provide opportunities for access and recreation in one of two ways:

- Contractual arrangements under the WGS (to obtain the Community Woodland Contribution).
- Provision on the part of the owner without contractual obligation.

The great majority of owners prepared to offer access are thought to apply for the Community Woodland Contribution (CWC) of the WGS, which has been available since 1992. Applicants agree to provide free access for the public for a period of 10 years. The eligibility rules state that the woodland must be within five miles of the edge of village, town or city where there are few other types of woodland available for recreation. In principle, applications are only considered where there is less than 1 ha of accessible woodland per 500 head of population within 5 miles of the application boundary. The aim is to avoid providing incentives where the woodland access is not likely to provide sufficient benefit to give value for money from public expenditure. However the evaluation of the supplement (Crabtree *et al*., 2001) concluded that 20-30% of sites did not provide value for money, usually because of limited use.

Other owners may provide access over part or the whole of any new woodland without a contractual obligation to do so. They may have applied for the CWC and been unsuccessful or may not have applied. Many local councils and conservation groups may be expected to offer access without a contractual obligation to do so.

Any monitoring of access benefits should concentrate on CWC woodlands and those where there is evidence that access is likely to occur (e.g. ownership/management by conservation trusts and local authorities). We have not investigated the latter but there were 1,788 sites receiving CWC grant aid (to March 2003) covering 9,408 ha. Some early entrants into CWC will now have ended their 10-year contracts but it is not clear which continue to allow access on a permissive basis.

2.3.2 Approaches to measurement

The public benefit from access to new woodlands is most easily measured in physical terms by the use made of the woodland – indicated by the number of people using the wood and the number of visits made. The quality of the experience is also important in determining benefit although this is likely to be correlated with use.

Various approaches have been used to measure or indicate benefit, as follows:

- Technical assessment of the access opportunities using a scaling system to measure the quality on offer.
- Automatic counting of users or direct counting/interviewing on random days.
- Interviews with owners/managers to gauge access use.
- Interviews with users or potential users (e.g. the local public) to determine use of the wood and (in economic studies) the wellbeing gained from access to the wood.
- Indirect estimates of the contribution to the local access stock using GIS methods.

Of these, the technical assessment is least cost but indicates little about actual use or benefit. It is quite possible for this approach to indicate public benefits that are illusory. The public may choose not to make much use of woodland, which appears to provide new access opportunities because there are better local opportunities or because local awareness of the access is poor.

Counts of users are very informative, and where this is done in person, it can be coupled with interviews to gain more information about the user experience. However, this is very expensive. Automated methods can be used but it is doubtful if these could be justified on cost grounds. Counting is best reserved for specialised studies on access since it cannot be integrated into single-visit site monitoring. FC has developed methods of monitoring public use of FC woodlands and these could be applied to non-FC sites where access is important.

Interviews with owners/managers have been used to discover more about attitudes to access provisions and its problems (e.g. Garrod *et al*., 1998). However, as a source of benefit information (e.g. numbers using a wood) this will be unreliable and may be biased upwards in order to justify grant aid.

Crabtree *et al*. (2001) in their evaluation of the Community Woodland Supplement (CWS) used a postal survey of people in the locality of new woodland which avoids the high cost of personal interviews. This was used to measure benefit in economic terms ('willingness to pay') for new access on a sample of GB woodlands. The study highlighted the importance of communicating information about access to new woodlands because a high proportion of local people were unaware of access rights to CWS woodlands in their locality.

GIS methods were used by Garrod *et al.* (1998) to assess the value of additional access in a region (measured as length of rights of way in relation to population size). Woodland Trust (2003) inform us that, together with FC, they have completed a GIS inventory of accessible woodland in England. We have not explored this further but it offers the potential to develop a remote indicator of benefit in terms of other opportunities in the vicinity.

2.3.3 Evaluation and monitoring proposals

Comprehensive evaluation

Assessing the benefits from access and recreation ideally requires extensive surveys of users or potential users. It is not something that can be done effectively with single site visits, interviews with owners or through remote methods. We conclude that it requires specific and detailed studies. Since an evaluation of the scheme was undertaken in 2001 there is no immediate case for any monitoring. However, a further study may be required as access policy develops and the findings of the evaluation are incorporated into policy.

As part of other field monitoring

It is worth exploring the case for incorporating access assessment as part of other field monitoring. This would not strictly assess benefits but merely opportunities. As such it is not a substitute for a detailed benefit evaluation but could provide useful background information for future evolutions. A field visit could assess:

- Whether there is evidence that woodland access is available to the public.
- Quality of on-site information for the public on access availability.
- Availability of car parking.
- A technical assessment of access and recreational provision on a scoring basis.

The WGS database would indicate whether the site was receiving or had received CWC grant aid. For sites where the 10-year contract had expired it would be important to determine whether access was still available.

If the Woodland Trust FC inventory of accessible woodlands were comprehensive and available, this could be used to indicate other local access opportunities and hence provide a measure of *potential* benefit from new accessible woodlands.

2.3.4 Long term benefits

Since most access is currently provided under a 10-year contract, the provision of access is only known with certainty for the contract period. In these circumstances it is not possible to project benefits forward beyond contact expiry. The best that monitoring can achieve is to provide limited information on access provision at the time of the visit.

2.3.5 Benefits to tourism

Benefits to the national and local economy from tourism depend on the attraction that new woodlands provide for visitors from outside the local area, and the impact of this attraction on their expenditures. In the short term, it seems unlikely that new woodlands would have much impact on tourism because impacts on the wider landscape and access opportunities are small. Over the longer term, effects may be more significant.

Little is known about the contribution that forests and woodlands make but the Forestry Commission has commissioned a study to investigate the economic impacts of tourist use of forests. Results are not yet available but the method relies on extensive interviewing of visitors at a number of woodlands.

The case for inclusion of tourism effects can only be assessed after the FC study is completed. This might provide a guide on the future benefits to tourism from new planting. We doubt if monitoring of visitors to young woodlands can provide any useful information for the analysis of tourism effects.

2.3.6 Conclusion

The case for monitoring of access and recreation benefits is not currently strong in view of the recent evaluation of the CWS. However, it is worth considering a limited assessment of access provision on sites already being monitored for biodiversity etc. The additional time on site would be small (30 mins) and no specialised skills would be needed.

There are 1,788 CWC sites out of 19,081 in WGS (9.4%). If an access element were included in the monitoring, some stratification would be necessary in the sample frame to raise the proportion of CWC sites.

2.4 Timber value

2.4.1 Policy context

It is difficult to make an economic case for timber as a valid objective for policy intervention. Care must be taken in attributing timber as a benefit flowing from grant aid, and we consider that there is very little to justify monitoring the ‘benefit’ from timber *per se*.

However, timber output from grant-aided woodlands may be of indirect interest because:

- It is necessary to estimate tree growth rates for the calculation of carbon sequestration (see below). If a decision is taken to measure carbon sequestration, then timber potential can be derived at minimal cost.
- Timber output is an important determinant of the impacts on the economy because of related activity in harvesting and processing. This will be most relevant in rural areas characterised by weak economic performance (see 2.7 below).

2.4.2 Monitoring

With small-scale ‘non-commercial’ woodlands there is uncertainty over the extent and timing of any future harvesting. This is probably the largest imponderable in the estimation of timber output. Interviews with owners are unlikely to give much clarity because future intentions are often unknown or are taken by a different owner. We suggest that measures are based on ‘potential timber value’.

Potential output can be measured directly in the field, but with young woodlands this may add little to remote estimation based on growth models. Techniques are well established by the FC for timber yield estimation, and the most cost effective method is to use FC models coupled, if necessary, with ‘ground truthing’ to reduce the estimation values for bare ground, shrubs and poor establishment.

2.5 Carbon sequestration

2.5.1 Review

The net benefit from carbon sequestration by new woodlands is the amount of carbon sequestered per year, adjusted for any losses (e.g. where planting is on peat soils) combined with the value per tonne of carbon sequestered. Simple models have predicted the rate of sequestration in woods as a function of growth rate and tree species (e.g. Dewar and Cannell, 1992; Crabtree, 1997). In the recent study for the Forestry Commission, Brainard *et al*. (2003) used a more complex model that incorporated species, growth rate and soil conditions. It also accounted for the carbon sequestered in soils and leaf litter, and modelled the impacts on net carbon sequestration of planting on deep peat soils. Harvesting and utilisation of timber (when this occurs) create carbon emissions and attempts were made to estimate these effects.

Estimates of the social marginal cost of carbon vary enormously (see reviews by Willis *et al*, 2003 and CJC Consulting, 2003) dependent on the context and assumptions made. Pearce (2003) argues that the base case cost is £2.66-£6.0 per t, whereas Clarkson and Deyes (2002) under different assumptions produced an estimate of £70 per t. Permits for carbon trading are currently trading at around £3 per t. The expected development of carbon markets in the future will clarify the value of carbon within the global trading framework.

Some caution should be exercised over whether it is appropriate to treat sequestered carbon as a benefit to grant aid policy. CJC Consulting (2003) argued that the role of intervention by government should be to assist in the development of markets for carbon and not to sequester carbon *per se*.

2.5.2 Prediction of benefit

The measurement of ‘benefit’ is fairly straightforward once a set of assumptions for the modelling has been selected. The selection of model is beyond the scope of this study but whatever the model the main the main determinants are:

- Species
- Yield class – can be estimated from species and location
- Cover
- Soil type – peat or inorganic soils.

These variables can be obtained from the WGS database, yield class models and soil maps. It would be one-off exercise to apply a model such as that of Brainard *et al.* (2003) to any specified new woodland or woodland scheme.

2.5.3 Field monitoring

The case for field monitoring depends on the additional information it would provide. Given the uncertainty in other elements of the carbon sequestration and value calculation we doubt if any additional precision obtained by field monitoring would be worth the effort.

2.6 Economic regeneration

2.6.1 Policy context and benefits

New woodlands may contribute to the regeneration of previously industrialised areas by providing improved environmental services to residents and employees. They may also help to attract new investment and in-migration of people. Within policy, the regeneration objective forms part of the EFS, and new planting in economic regeneration priority areas receives additional points in the WGS scoring system. Major schemes to deliver economic regeneration are also being undertaken through new planting by Forest Enterprise and a North West Development Agency/FC partnership. The only assessment of forestry investment for regeneration is that of the FE Capital Modernisation Fund investment by Selman (2003).

The English Community Forestry programme aims to 'use multi-purpose forestry to improve the countryside around towns and cities by restoring areas scarred by industrial dereliction, creating sites for recreation and sport, forming new habitat for wildlife, and making outdoor classrooms for environmental education' (Countryside Agency, 2000). Where new planting takes place in a community forests, it receives additional WGS scoring points and higher levels of planting grant.

The costs and benefits of new woodlands for economic regeneration are reviewed in CJC Consulting (2003). The direct benefits of planting in regeneration priority areas to residents and visitors, through improved landscape, amenity and access opportunities are assessed in other sections of this report. It may be that there is something special about regeneration areas - benefits may be higher per £ invested because of the low starting point for environmental quality. This is implied in the special measures taken under EFS and WGS policy for regeneration areas.

The indirect benefits from new woodlands in inducing inward investment are much more difficult to quantify (CJC Consulting, 2000; 2003). Multiple factors determine rates of inward investment, and new woodlands are only likely to be a measurable factor in the more extreme, derelict and abandoned landscapes. Even there, to measure this effect would be challenging and to do it as part of a general monitoring programme, impossible.

FC and the NWDA have a £23m Newlands scheme, in phase 1 of which 435 ha of brownfield land is to be converted to woodland. They have developed an expert-based scoring system (Public Benefit Recording System, PBRS) to measure the expected benefits from woodland creation in order to prioritise the selection of sites for planting. Scores are developed for social, access, economic and environmental benefits. For example, the access score is based on measures of the presence of public right of way, proximity of other pubic open space, and accessibility by road, train, cycle and bus.

In the PBRS, benefits are largely determined by location and proximity measures, i.e. measures of potential or predicted benefit. Whist this is a sensible approach for targeting expenditure, there remains a need for evaluation in order to determine the actual benefits delivered through regeneration schemes.

2.6.2 Proposals for monitoring

The methods outlined in other sections of this study for monitoring landscape, amenity and recreation benefits can be applied to regeneration areas. But benefits in a regeneration context would ideally (i) measure net benefits, taking into account the previous land use, and alternative uses of the land to forestry within the economic development context, and (ii) measure knock-on benefits in regenerating the local economy.

Measuring impacts on regeneration would be a difficult task and one that is better suited to a specialised study. The specific new planting undertaken by Forest Enterprise or FC/NWDA for economic regeneration would provide a case study route for measuring benefits to regeneration under grant-aided planting. Nevertheless, given the sizeable benefits that may accrue from woodlands in an urban context it would be useful to include an urban dimension to any monitoring even if the particular case of economic regeneration is dealt with separately.

2.7 Rural development

2.7.1 Context

The WGS scoring system scores positively for woodlands planted in Rural Priority Areas, and farm woodland policy under the ERDP assists farm diversification and adaptation to CAP reform by offering farmers an alternative land use.

There are a number of 'rural development' initiatives in which the FC is a key partner providing support for planting through WGS and challenge funding (FC, 2002). One is the South West forest where, in 2001/02, the FC incentive payments totalled £1.523m on 607 ha (mean £2,509 per ha). It is important to assess the impacts of such measures on local economies.

The usual measures of performance are expenditure-driven and focus on the contribution to local/regional employment and incomes in targeted rural areas. There will be both direct and knock-on effects as expenditures flow through the local economy. Ideally, a net impact would be derived, that takes account of employment foregone by displacing some alternative land use (often agriculture).

The FC commissioned a number of input-output studies to measure these impacts (e.g. PACEC, 2000 and CJC Consulting (2003) have estimated impacts from new woodlands. Employment, income and expenditure mainly takes place at establishment and harvesting (if this occurs). At other times, there are no impacts because there is no economic activity. With the small woodlands typically planted in England, these economic impacts are very small when averaged over a forest cycle. They are often trivial when assessed in the context of the business of the owner (which may be a large farm), when own labour and capital are used for the planting. This makes estimation of impacts difficult.

2.7.2 Monitoring

Any approach requires an interview with the owner to estimate the direct effects on income and employment to date, with some prediction of whether harvesting is likely. On small amenity woodlands it is usual to assume that 'commercial' harvesting will not take place. Where planting has taken place some years before, it is unlikely that owners can provide reliable evidence on the income and employment effects. In addition, where businesses use own labour to establish a woodland there are often no measurable employment effects. Knock-on effects cannot be estimated without a major and specific study on the suppliers of services.

We are therefore dubious about the practicality and reliability of monitoring rural development impacts on small woodlands as part of a monitoring programme which is likely to get most benefit information by concentrating on woodlands at least 5 years old. Much better would be to set up a separate study (or component of the monitoring programme) that concentrated on sizeable plantings monitored shortly after establishment to obtain more precise data.

2.8 Community involvement

2.8.1 Benefits

Woodlands offer social benefits (in addition to access and recreation) where involvement in the planning and management of woodlands by local people strengthens communities and reduces social exclusion. However, there is not much evidence to suggest that local communities have a substantial input in the creation of most woodlands. The most likely cases are where:

- There is access to the woodland and users build up a sense of ownership because of the public rights they enjoy.
- Woodland is owned by a local authority or conservation group.

The evaluation of the Community Woodland Supplement (Crabtree *et al*., 2001) found that community involvement was generally quite limited on privately owned land even where landowners were obliged to consult the local community and obtain their support. Contrasting with this, the WGS evaluation in England found a significant degree of community involvement especially in schemes organised by local authorities and conservation groups. There are also schemes that involve individuals directly in tree ownership or sponsorship, hence creating a different type of involvement but one that can lead to a strong sense of participation. Woodland Trust (2003) state that their 'Woodlands on Your Doorstep' programme created 175 community woodlands in England.

2.8.2 Monitoring

Ideally, monitoring would consist of research to identify how local people relate to specific woodlands and identify involvement from their perspective. This is a major undertaking that could not form part of routine monitoring. Some information could be gained from interviews with landowners or agents. Whilst this is not costly, it is less effective as an indicator than direct contact with the community. At the minimum, an interview could establish the presence or absence of community involvement in the different elements of woodland development, management and use. Definition of what constituted a community would be required. This could, for example, refer to a number of categories of 'community' such as local people or organisations, representatives of local people (e.g. local authorities), conservation communities etc.

Such monitoring would not measure the extent of involvement, merely whether it existed on not, and its characteristics. Even so, this would provide some insights in the way in which communities were or were not involved in grant-aided woodlands. It would amplify the evidence already gained in the WGS and CWS evaluations.

3 Data sources

3.1 WGS database

This is the main source of data on new planting since 1992. There are no reliable data on planting before 1992. The best approach is to use the WGS 'plan' as the basic unit of search and analysis. Information for a plan is available on the main technical and grant-aid aspects of the woodland, including:

- Area
- % conifers, broadleaves
- Location - grid ref, FC region
- dates of application and grant payments
- Details on applicant and grant recipient (applicants are also classified by type).
- Elements of WGS on which payment is made (e.g. CWC)
- Previous land use (limited information before 1995)
- Whether FWPS applicant.

3.2 FWS database

FWS operated from 1988 to 1992 when it was replaced by the FWPS. FWS details are not included in the WGS database. Annual payments on woodlands are made for 20-40 years from planting depending on species.

The database is not considered by Defra to be totally reliable. However, it includes the following information relevant to this study.

- Details on size or woodland, % conifers, date of planting
- Location by grid reference
- Details of occupier.

3.3 FWPS database

FWPS has operated from 1992. The Defra database contains details of:

- Size or woodland, % conifers, date of planting
- Location by grid reference
- Details of occupier.

The WGS database contains an FWPS tag indicating whether an FWPS application was made. Even so, it is impossible to relate the WGS and FWPS databases. This is a serious problem for use of the FWPS database. We suggest that only the WGS database is used since none of the benefit measures we propose require that special consideration be given to planting by farmers.

3.4 Countryside Stewardship and ESA databases

We have not explored this aspect because the Steering Group did not intimate that they wished agri-environment sites to be considered. Woodland Trust (2003) note that there have been significant expenditures on woodlands under CS and imply that these sites should be included in monitoring. However, apart from orchards, the CS investment is as capital items which are not mapped under the GIS system. We conclude that any woodland monitoring should concentrate on the WGS scheme.

3.5 Remote datasets

The key datasets are expected to be:

- NIWT – the most complete woodland inventory dataset available.
- 1991 population census.
- CCA – available on MAGIC.
- Specific OS derived datasets (e.g., contours) in vector format capable of interrogation.
- Census and other social and economic datasets.

If is were the intention to measure variables such as connectivity and density of existing woodland in the proximity to new woodland, repeatable and well-defined techniques would need to be developed. This may require quite extensive development to deliver robust and meaningful methods.

4 Proposals for the design of a monitoring scheme

4.1 Summary of options

Table 4.1 (see next page) summaries the content of Section 2 and suggests practical options for a monitoring programme.

4.2 Main options

Table 4.2 summarises the main monitoring options proposed in Table 4.1. A minimum cost option would be to take only A and C. B would be costly to add but could give valuable information on other taxa. Information on D and E could be added at some additional cost, mainly in remote data analysis. If D were included, it would then be relatively straightforward to calculate carbon sequestration benefits.

Table 4.2 Options for monitoring

	Benefit	Type of monitoring	Number of field visits	Field expertise required
A	Biodiversity Basis field survey plus analysis of remote data and modelling	Field based- vascular plants and habitats, coupled with analysis of remote data and modelling to predict future benefits	1 visit (could be repeated every 5 years)	Experienced ecologist
B	Biodiversity More comprehensive field survey assessment plus analysis of remote data and modelling	Field-based- other species (e.g. birds) coupled with analysis of remote data and modelling to predict future benefits	4 visits (could be repeated every 5 years)	Species specialists
C	Landscape character and quality Analysis of remote data plus field survey	Part field-based and part remote data assessment.	1 visit	Specialist landscape skills
D	Timber value	Based on field assessment/ predictive modelling using remote datasets	1 visit (could be repeated every 5 years)	Forestry skills may be needed
E	Recreation and access	Field and remote dataset assessment of potential benefits	1 visit (could be repeated every 5 years)	No specific skills

In all cases, use of sites more than 5 years old is proposed for field monitoring. We note that Woodland Trust (2003) has the view that field monitoring is 'extremely resource-hungry' and that the cost implications (of the field monitoring) are huge. Our view is that some field, monitoring is necessary, to adequately measure biodiversity and landscape benefits and to produce professionally credible results. The field assessment of biodiversity would also be invaluable for understanding the factors that determine biodiversity gain, and facilitating the interpretation of remote data in the future. For these reasons we remain at variance with the Woodland Trust on this aspect. The set-up costs of remote data analysis and modelling are likely to be considerable.

These proposals do not include any interviews with owners. Such interviews would add some additional information to A, B, D, E. It is possible that such interviews could be undertaken by a combination of post and telephone in order to reduce costs. This would need piloting to discover how effective it was.

Table 4.1 Summary of monitoring proposals

Type of monitoring and analysis	**Basic field survey of site (Current benefits)**	**More detailed site survey (Current benefits)**	**Owner/agent survey (Past, current and predicted future benefits)**	**Other datasets including map information (Current benefits and predicted future benefits)**	**Models (Predicted future benefits)**
Biodiversity	To measure habitat diversify and plant species though presence of vascular plants, habitat features. Measure additional proxy variables for developing models to improve predictions.	Recording of other species (birds etc)	Not relevant except to obtain information on alternative land use	Essential to complement modelling in predicting future benefits	Important for predicting future benefits. Information from field monitoring would be used to expand existing knowledge.
Repeat?	Could do every 5 years to get new information on ecological development	Could do every 5 years to get new information on ecological development	No	Yes if field visits repeated	Yes if field visits repeated
Priority for monitoring?	Essential	Not essential – may be desirable but high cost	Not essential	Essential	Desirable
Resources	1 visit, minimum 2 hours on site experienced field ecologist	4 visits, time dependent on species recorded. Requires specialised skills for each species recorded	Only do as part of another interview	Not estimated	Not estimated
Landscape character and quality	To determine landscape value and visual amenity benefits	N/A	N/A	To determine benefits to landscape character and quality	N/A
Repeat?	NO	N/A	N/A	NO	N/A
Priority for monitoring?	High	N/A	N/A	Essential	N/A
Resources	1 visit average 2 hours per site. Specialist landscape expertise		N/A	Not estimated. Experienced landscape planner	N/A
Recreation, access and tourism	As an addition to an existing site visit to determine whether the site is accessible to the public and a technical assessment of the provision	Not recommended as part of general monitoring – more suited to a specialised study	Only as an addition to an existing interview to determine owner's access intentions	Only as part of a specialised access study	N/A

Repeat?	Only if visit is made for some other purpose.	N/A	NO	NO	N/A
Priority for monitoring?	High but only as an add-on	N/A	Low	N/A	N/A
Resources	Very small – no skills required	N/A	Very small	N/A	N/A
Timber value	Estimation of establishment and harvestable yield and value	NO	To measure harvesting intentions	As input to modelling of growth rates	Simplest means of predicting growth rate and potential timer output.
Repeat?	After 10 years to measure yield class	N/A	NO	NO	NO
Priority for monitoring?	Very low	N/A	Low	High	High
Resources	Not estimated- forestry skills	N/A	Small	FC could undertake	FC could undertake
Carbon sequestration	Same measurements as for Timber Value	NO	NO	Do alongside growth rate estimation	Modelling element essential in any study
Repeat?	NO	NO	NO	NO	NO
Priority for monitoring?	Very low	N/A	N/A	Uncertain	Uncertain – existing studies probably provide adequate information
Economic regeneration	NO – specialised study required which could be built into the evaluation of FE and FC/NWDA regeneration woodlands	N/A	NO	NO	NO
Rural development	NO – specialised study required on selected sites	NO	To inform on employment and income impacts, and economic benefits foregone – but special study needed	To obtain locational variables describing rural priority areas	Detailed study on selected sites is the preferred approach
Priority for monitoring?	N/A	N/A	Uncertain	Uncertain	Uncertain
Community involvement	NO – specialised study required involving interviews with relevant communities	NO	To obtain some information on community involvement and benefits	NO	Detailed study ideally required
Priority for monitoring?	NO	NO	Ideally requires a specialised study to obtain community perspectives	N/A	N/A

4.3 Sampling of the population of new woodlands

Monitoring that relies only on information from remote datasets can operate on the whole population of WGS sites, or any subset, since cost will barely be affected by the number of plans examined. Where an element of field monitoring is needed, cost will depend on the number of site visits and their spatial layout. A sampling approach will be most cost-effective. The aim in selecting a sample of sites is to:

- Provide a sample frame such that results can be raised to a population level (e.g. scheme, part scheme, region).
- Concentrate on plans expected to provide relatively high benefits since these will be most informative for policy.
- Maximise cost-effectiveness by using clustering where possible to reduce travel and site search costs

It is important to decide whether benefit measures for biodiversity and landscape are needed region by region (rather than simply a national scale). If a region-by-region analysis is needed, then the sampling frame must have representation in each region. If not, a clustered sample could be used to reduce travel costs.

The key variables that might be available and could be used to develop a sample frame for examining diversity in public benefits are:

- Biodiversity – area of woodland, connectivity to other and ancient woodlands (there is some doubt as to the feasibility of measuring connectivity).
- Landscape and amenity – proximity to user population, countryside character assessment, proximity to existing woodland and % woodland cover in the vicinity (it is not clear at this stage how these would be measured).
- Recreation and access - area of woodland, presence/absence of permissive access (in part indicated by CWS grant aid), proximity to user population.

4.4 Sample frame

A sample frame can only be designed after options are selected from Table 4.2, and a budget is specified. Here we work through one example to indicate some of the issues involved. We assume that options A, C and D are selected. We use the following as stratification variables since they are easily measured and can be linked to payment rates and entry conditions in grant schemes:

- Woodland size (actual WGS area).
- Proximity to population (indicator: within/not within 1 mile of 10,000 population).

We use the early 1991-1997 WGS plans as the basic units. These include FWPS but not FWS plans. The earlier WGS schemes will allow more precise measurement of biodiversity benefits than later schemes.

There are 10,530 WGS plans on which grant as been paid in the 1991-1997 period. The mean area is 2.51 ha and median 1.26 ha. The size distribution is given in Table 4.3 below.

Table 4.3 Size distribution of woodlands, WGS, 1991-1997

Area (ha)	Number of plans	Number within 1 mile of 10,000 population
<1	4,368	852
1.01-2	2,684	486
2.01-3	1,353	255
3.01-4	649	127
4.01-5	408	87
5.01-10	713	185
10.01-20	239	62
>20.01	115	27
Total	**10,530**	**2,083**

The majority of the woodlands are very small. To cover the range of sizes and to make certain that there is representation of large woodlands where benefits are expected to be proportionally greater, we investigate stratification into 3 size groups:

- Small < 1 ha
- Medium 1-10 ha
- Large >10.0 ha

Table 4.4 shows the number of sites in each cell. There are relatively few large 'urban' woodlands in the 1991-1997 WGS population.

Table 4.4 Number of WGS woodlands, 1991-1997, by size and proximity to population

Area	Within 1 mile of 10,000 population (urban)	Outside 1 mile of 10,000 population (rural)	Total
Small < 1 ha	852	3,516	4,368
Medium 1-10 ha	1,142	4,666	5,808
Large >10.0 ha	89	265	354
Total	**2,083**	**8,447**	**10,530**

If Option E (Table 4.2) were to be included, it would be important to obtain sufficient representation of CWS sites (possible also including local authority/conservation group sites) sites where access is guaranteed by contract or likely to be permitted. It is thought that there are only 550 CWS woodlands in the 1991-1997 tranche of planting, of which 329 lie within the 10,000 population zone. We have not analysed the data in detail, but it is likely that in a 12-cell stratification (3 areas by urban/rural by CWS/non-CWS) some cells would have very small numbers of plans.

4.4.1 Size of sample and cluster sampling

The sample size depends critically on the finance available and the precision required in the benefit estimates. One function of the pilot would be to assess the between-site variability more precisely and hence provide a better basis for selecting a sample size in the main monitoring.

If the only interest were to raise the sample to a WGS scheme level, proportional sampling would be most efficient. Table 4.5 shows the distribution of a sample of 180 sites.

Table 4.5 Proportional sampling of the WGS population 1991-1997

Area	Within 1 mile of 10,000 population (urban)	Outside 1 mile of 10,000 population (rural)	Total
Small < 1 ha	15	60	75
Medium 1-10 ha	19	80	99
Large >10.0 ha	1	5	6
Total	35	145	180

Large sites and 'urban' sites are of particular interest because they may provide greater benefits per ha. Proportional sampling fails to account for this, so we should fix a minimum sample size per cell. If we fix the minimum sample number per cell to be 30, one possible sample frame is given in Table 4.6.

Table 4.6 Proportional sampling of the WGS population 1991-1997 with a minimum sample size

Area	Within 1 mile of 10,000 population (urban)	Outside 1 mile of 10,000 population (rural)	Total
Small < 1 ha	45	90	135
Medium 1-10 ha	49	110	159
Large >10.0 ha	31	35	66
Total	125	235	360

If we concentrate primarily on the large sample sites (urban and non-urban) then clearly these sample sizes are not present in adequate numbers if we reclassify by CWS/non-CWS and the regional groupings. We could weight inversely the large sample sites, so that more are selected from this category.

Other alternatives are to change the size categories or to extend the time beyond 1997 to obtain more (but younger) woodlands.

A clustered sampling approach would reduce travel and site search costs. The sample would be selected from a limited number of, say, 25 km squares. However, this may reduce the variation in ownership if multiple woodlands were selected from the same ownership. It could also give rise to problems in obtaining a sufficient representation of large woodlands. An initial assessment of the distribution of plans across FC regions would be undertaken because this information has already been extracted. The design of such a sample frame and its feasibility would need to be explored more fully in the pilot monitoring.

5 Summary and conclusions

5.1 Summary

The project aimed to define suitable monitoring strategies to identify and quantify the various public benefits (and disbenefits) from grant-aided woodlands.

A detailed examination was made of the range of benefits that woodlands may deliver and their appropriateness in a general monitoring scheme. Hydrology, air pollution and health benefits were excluded either because they were restricted in scope, required specialised monitoring methods or because the evidence for significant benefits was unclear. The following were included in the appraisal:

- Biodiversity, habitat and species enhancement
- Landscape and amenity
- Recreation, access and tourism
- Timber value
- Carbon sequestration
- Economic regeneration
- Rural development
- Community involvement

Of these, we do not recommend that carbon sequestration, economic regeneration, rural development or community involvement are included in a general monitoring scheme. The benefits are either already documented or would tend to occur on only a minority of sites. More specific or specialised assessment would be appropriate.

For the remainder, some information on benefits could be obtained from map and other remote information sources. Remote assessment would probably be sufficient to estimate potential timber output and carbon sequestration benefits.

A combination of remote and filed monitoring is most appropriate for biodiversity, landscape and recreation. Some field monitoring is considered essential to provide credibility in the assessment.

Table 4.1 lists the monitoring proposed for each type of benefit, and the most policy-relevant low cost options are summarised in Table 4.2. To define the appropriate balance of remote and field monitoring needs a more detailed investigation of the scope for remote assessment (see below). We suggest possible sampling schemes for selecting field sites but a number of issues discussed below need to be addressed before any sampling frame can be produced.

5.2 Conclusions

The project has been driven by its main aim which was to design a monitoring strategy. However, a strategy can only be defined when its objectives and budget are stated. The need for better evidence on the benefits delivered from grant-aided woodlands is clear, but the project has raised a number of fundamental questions about how to achieve this. These are:

What is the concept of benefit?

Whist some benefits are self-evidently economic in scope because of the context in which they are interpreted (e.g. carbon sequestration, rural development), this may be less obvious for hydrological, biodiversity and landscape impacts. Often in evaluation studies such benefits have been measured in technical terms using expert assessment. However, considerable progress has been made in recent years in measuring environmental benefits in monetary terms (e.g. Willis *et al*., 2003). Both approaches have their limitations. The valuation methods rely on the preferences of the public who may be poorly informed. It is difficult to apply the methods at a detailed level, but they do allow comparisons between benefits because all benefits are measured in monetary terms. With technical scoring methods it is not possible to compare technical measures across benefits. Many technical evaluations of schemes have been confined to ‘processes rather than results’ (Haskins, 2003) but that will not be a problem with the methods proposed here.

We assumed that the focus for measuring biophysical and landscape changes was technical since the Forestry Commission has recently completed a major environmental economics study on benefits from woodlands. Technical monitoring will tell Defra what grant-aided woodlands deliver in terms of a specified benefit (e.g. how much biodiversity or visual amenity). They will be less useful for answering questions about where public expenditure should be directed (e.g. woodlands with high biodiversity output or woodlands with high visual amenity) because comparison between benefits is not possible when there is no common system of measurement for the different benefits.

We suggest that the steering group needs to clarify the type of benefit information that is required and the policy context in which it will be used, because this drives the methodology.

Which benefits?

Certain benefits are delivered by the majority, if not all, grant-aided woodlands. These include impacts on carbon sequestration, biodiversity and landscape. Most woodlands, however, only produce a subset of all possible benefits, For example, recreation benefits only occur where there is public access, and urban amenity can only occur in urban areas. Similarly, economic regeneration, rural development, hydrological and air pollution benefits are likely to occur on only a minority of sites.

We conclude that some benefits cannot sensibly be included in a general monitoring scheme because of their restricted scope or need for specialised assessment (e.g. economic regeneration, hydrology). We suggest that the steering group should not look on the proposed monitoring as delivering on all benefits but to fill in gaps in existing knowledge. This requires a listing of currently available information and an assessment of its adequacy for policy needs. This will lead to a more coherent basis and focus for additional monitoring.

Which monitoring methods?

Remote monitoring using GIS and other national datasets is attractive because it can be applied to the whole population of sites and is potentially cheaper than field monitoring. Timber and carbon sequestration benefits can probably be measured to sufficient accuracy by remote methods alone. However, some field monitoring is required at least for biodiversity and some aspects of landscape and recreation in order to provide information not available from remote sources. It would also add credibility to the monitoring.

Before a ‘correct’ balance between remote and field assessment can be made it is important to investigate further what can be derived by remote monitoring so that the role of field work can be better defined.

Which woodlands?

Simply monitoring the benefits from WGS-aided planting (and associated farm woodland planting) in order to produce a statement of aggregate benefits is unlikely to be the best use of resources for policy development. Logically, evaluation of past investment is only of value if it informs policy decisions in the future. A more informative approach would be to stratify any sampling to inform future policy on where net benefits from public investment are likely to be highest. This would also aim to avoid grant-aided creation of low benefit woodlands. Following this line of argument, effort would be concentrated on identifying sites expected to show extremes of benefit, and measuring the benefits where existing information is inadequate to achieve this.

Whilst measuring benefits from previous grant aided investment is important, monitoring should also be designed to inform on the future development of incentives for forestry.

A regional dimension?

With the increasing move to regionalisation of woodland policy in order that policy delivers on regional priorities it may be important that monitoring informs on benefits delivered at regional scale.

The implications of this need further investigation in particular for field monitoring where the costs could be high because of the need for a higher number of field sites

5.3 The way forward

Apart from clarifying the above issues, we suggest that a more detailed investigation of some aspects is required before any field level pilot monitoring is undertaken:

- Produce a more detailed listing of information sources on benefit values and gaps in existing knowledge. The role of monitoring would not be to provide complete *de novo* information on benefits but to supplement existing knowledge.
- Produce a *modus operandi* for using a mix of existing and new measures (from monitoring) to meet policy needs.
- Explore with FC the population of WGS sites and their classification (e.g. by access, region, regeneration areas etc.). This would provide an important overview of the potential benefits as related to location and type of grant aid. It would assist the steering group to take the project forward by providing key statistics on existing grant-aided woodlands in relation to benefits produced.
- Investigate further, in collaboration with FC, the role of remote datasets to measure benefits in particular to landscape and biodiversity. This would provide more information on the precision of datasets, the use of new datasets (e.g. on countryside character) and the feasibility of measuring important determinants of benefit such as connectivity.

6 References

Bossuyt, B., Hermy, M., and Deckers, J. (1999). Migration of herbaceous plant species across ancient-recent forest ecotones in central Belgium. *Journal of Ecology*, 87, 628-638.

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

Butaye, J., Jacquemyn, H. and Hermy, M. (2001). Differential colonisation causing non-random forest plant community structure in a fragmented agricultural landscape. *Ecography*, 24, 369-380.

Campaign to Protect Rural England (2003). *Lie of the land.* Campaign to Protect Rural England, London.

CJC Consulting (2000). *Economic Benefits of Community Forests*. Report to the Countryside Agency. CJC Consulting, Oxford.

CJC Consulting (2003). *Economic Analysis of Forestry Policy in England*. Report to Defra and H. M. Treasury. CJC Consulting, Oxford.

Clarkson, R and Deyes, K. (2002). *Estimating the Social Cost of Carbon Emissions*. GES Working Paper 140. London: HM Treasury. Available at http://www.hm-treasury.gov.uk/Documents/Taxation_Work_and_Welfare/Tax_and_the_Environment/tax_environ_index.cfm

Clegg J, Firn Crichton Roberts, CJC Consulting and Ecoscope Applied Ecologists (2002). *Evaluation of Woodland Creation in England under the WGS and FWPS*. Report to DEFRA and the Forestry Commission.

Countryside Agency (2000). *England's Community Forests*, Countryside Agency.

Countryside Commission and Countryside Agency (1998-2000). *Countryside Character*. Eight regional volumes. Countryside Commission and Countryside Agency, Cheltenham.

DETR (2000). *Our Countryside: the future.* Cm 4909. The Stationery Office.

Crabtree, J. R. (1997). Policy Instruments for Environmental Forestry: Carbon Retention in Farm Woodlands. In Adger, W. N., Pettenella, D. and Whitby, M. *Climate change Mitigation and European Land use Polices*, p 187-198, CAB International, Wallingford.

Crabtree, J. R., Chalmers, N., Thorburn, A., MacDonald, D., Eiser, D., Potts, J. and Colman, D. (2001). *Economic Evaluation of the Community Woodland Scheme.* Report to the Forestry Commission. Macaulay Land Use Research Institute, Aberdeen.

Crabtree, J. R., Chalmers, N. and Eiser, D. (2001a). Voluntary incentive schemes for farm forestry: uptake, policy effectiveness and employment impacts. *Forestry*, 74, 455-465.

Dewar, R. C. and Cannell, M. G. R. (1992). Carbon sequestration in the tree, products and soils of forest plantations: an analysis using UK examples. *Tree Physiology* 11, 49-71.

Ferris-Kaan, R. (1995). (ed.) *The ecology of woodland creation*. Wiley, Chichester.

Francis, J. L. and Morton, A. (2001), Enhancement of amenity-woodland field layers in Milton Keynes, *British Wildlife*, 12, 244-251.

Forestry Commission (1992). *Lowland Landscape Design Guidelines*. Forestry Commission, Edinburgh.

Forestry Commission (1994). *Forest Landscape Design Guidelines.* Forestry Commission, Edinburgh.

Forestry Commission (1998). *The England Forestry Strategy*. Forestry Commission, Cambridge.

Forestry Commission (1998a). *The UK Forestry Standard*. Forestry Commission, Edinburgh.

Forestry Commission (2002). *Annual Reports and Accounts Great Britain and England*. Forestry Commission, Edinburgh.

Forestry Commission (2003). *UK Indicators of Sustainable Forestry*. Forestry Commission website www.forestry.gov.uk

Francis, J. L., Peterken, G. F. and Hill, D.A. (1996). Designing, managing and enhancing farm woods to maximise environmental benefits. *Aspects of Applied Biology*, 44, 1-8.

Fuller, R.J., Gough, S. J. and Marchant, J. H.(1995). Bird populations in new lowland woods: landscape, design and management perspectives. In, *Ferris-Kaan (1995), pp 163-182.*

Garrod, G., Willis. K., Raley, M. and Ruddin, M. (1998). *Economic Evaluation of Access Provision in the MAFF Agri-environment Schemes*. Final report to MAFF. University of Newcastle upon Tyne.

Haskins, C. (2003). *Rural Delivery Review*. Report to Defra.

H. M. Treasury (2003). *The Green Book: Appraisal and Evaluation in Central Government*. H. M. Treasury, London. Available at www.hm-treasury.gov.uk

Harmer, R., Peterken, G., Kerr, G. and Poulton, P. (2001). Vegetation changes during 100 years of development of two secondary woodlands on abandoned arable land. *Biological Conservation*, 101, 291-304.

Key, R. S. (1995). Invertebrate conservation and new woodland in Britain. In, *Ferris-Kaan (1995), pp 149-162*.

Kirby, K. (2003). Consultee communication.

Landscape Institute and Institute of Environmental Assessment and Management (2002). *Guidelines for Landscape and Visual Impact Assessment,* second edition. Spon.

MLURI *et al.* (1996). *Evaluation of the Farm Woodland Premium Scheme.* MLURI, Aberdeen.

Merryweather, J. (2001). Meet the Glomales – the ecology of mycorrhiza. *British Wildlife*, 13, 86-93.

Nisbet, T (2003). Consultee communication.

Nottingham University Consultants Ltd (2003). *Countryside Quality Counts: Tracking Change in the English Countryside.* Volume 1: Approaches to Indicator Development. Unpublished report to the Countryside Agency, Defra, English Heritage and English Nature.

PACEC (2000). *English Forestry Contribution to Rural Economies*. Report to the Forestry Commission. PACEC, Cambridge.

Packham, J. R., Cohn, E. V. J., Millett, P. and Trueman, I. C. (1995). Introduction of plants and manipulation of field layer vegetation. In, *Ferris-Kaan (1995), pp 129-148.*

Pearce, D. W. (2003). The social cost of carbon and its policy implications. *Oxford Review of Economic Policy* (in press).

Peterken, G. F. (2002). *Reversing the habitat fragmentation of British woodlands*. WWF-UK, Godalming.

Peterken, G. F. and Francis, J. (1999). Open spaces as habitats for vascular ground flora species in the woods of central Lincolnshire, U.K. *Biological Conservation*, 91, 55-72.

Peterken, G. F. and Game, M. (1981). Historical factors affecting the distribution of Merculialis perennis in central Lincolnshire. *Journal of Ecology*, 69, 781-796.

Peterken, G. F. and Game, M. (1984). Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. *Journal of Ecology*, 72, 155-182.

Selman, P (2003). *Capital Modernisation Fund: Measuring Delivery of Economic, Social and Environmental Outputs*. University of Gloucestershire. Draft report to the Forestry Commission.

Snowdon, P. (2003). Consultee communication.

Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science,* 224, 420-421.

University of Cambridge, CJC Consulting and Segal Quince Wicksteed (2002). *ERDP Evidence Assessment*. Report to Defra. Department of Land Economy, University of Cambridge.

Woodruffe-Peacock, E. A. (1918). A fox-covert study. *Journal of Ecology*, 6, 110-125.

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

Woodland Trust (2003). Consultee communication.