FORESTRY COMMISSION
OCCASIONAL PAPER 33

Forestry Expansion – a study of technical, economic and ecological factors

Introduction, Summary and Conclusions

Professor I. Cunningham
Chairman, Macaulay Land Use Research Institute

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INTRODUCTION

What should be the scale, location and nature of forestry expansion in Britain? Very many factors – ecological, economic, social, technical, with local, national and international dimensions – bear on the answer to this topical question. The list of only the most obvious considerations is impressive: the needs of agriculture; the desire for open land for walking and shooting; wildlife habitats in forests and on land that might be afforested; the conservation of valued ecosystems; landscape protection, conservation and change, for better or worse; future domestic demand for wood products; the prospects for supplies of wood from British and foreign forests and its price; the effects of economic change on the viability of rural communities; technological developments in the wood processing industries; the silviculture, costs and productivity of different types of forest in different locations; the effects of air pollution on forests and of forests in the distribution of deposited pollutants; the effects of forests on the supply and quality of water as compared with existing land uses; the preservation of archaeological remains and public access to them; the consequences of increasing concentrations of greenhouse gases for forest productivity and species choice, and the value of forests as long term stores of carbon; and more. To examine these influences, demands and constraints, the Forestry Commission invited experts to write papers giving up-to-date assessments of how knowledge in their field of expertise bears on the question of forestry expansion. The group of authors working under my chairmanship have sought to identify general trends and developments which will continue to be relevant in the foreseeable future. Taken together, the papers deal with all the main aspects of interest to those concerned about forestry expansion.

The purposes of this study are thus to draw together up-to-date assessments of the main factors bearing on decisions about the broad direction of forestry expansion; to use this to inform discussions of the location and type of forestry that would best meet the demands

of society for wood products, jobs, recreation, amenity, wildlife conservation, carbon storage and the other services supplied by forests, at minimum cost in resources and without damage to other land use interests; and to see what conclusions follow for new planting over the next decade or so. I hope that the papers will be useful to those concerned with forestry.

This summary is an attempt to pick out the main threads, accepting the blurring and imprecision that brevity imposes. It begins with the story so far; then briefly summarises the papers dealing with the international environmental and economic influences on British forestry; considers the growth in domestic demand and supply for wood, and for the other services supplied by forests and woodlands; take account of the needs and interests of other land uses; and finally, briefly summarise the results of an economic assessment by Professor Pearce that incorporates as many as possible of the costs and benefits of forestry quantitatively. The concluding section draws together what can be said about the scale, location and type of investment in forestry that seems most promising.

BRITISH FORESTRY IN 1990

Forests are the natural vegetation of the whole of mainland Britain, save for the high mountain tops and permanent bogs. Early man found the country densely wooded. But this primeval forest was cleared so comprehensively for agriculture that, by 1900, only 5% of the country remained wooded. Sporadic efforts to conserve and reforest in Britain, occasionally with Governmental encouragement, had achieved very little by the First World War, in contrast to our European neighbours where effective public policies for forestry were introduced from the seventeenth century onwards, beginning with that model of a mercantile government, the Republic of Venice and its colonies. France, Germany, Italy, Austria, and the Scandinavian countries followed and developed their forestry, while Britain relied on the vast natural forest resources of the Empire.

The turning point in Britain's forest history came with the report in 1917 of the Acland Committee. Since then, successive Governments have pursued an expansionist policy for forestry, carried out by a forest service responsible for establishing and managing publicly-owned forests, giving advice and support to private forestry, and carrying out research, development and training.

The main purpose of the programmes of afforestation and regeneration was the creation of a resource to supply the domestic market, particularly in time of crisis when imports might be restricted. Domestic demand is predominantly for softwoods. The overriding priority given to safeguarding fertile land for food production effectively confined the new forests to marginal land, mainly remote areas in the hills and uplands and some lowland sites with poor soils. To thrive on these relatively infertile soils and exposed sites, the species planted have to be hardy as well as productive. Conifers best meet these requirements, and, fortunately, produce the softwood timber that is in demand. Only one native conifer species, Scots pine, produces a marketable timber but it does not flourish in the wetter west. Introduced species of spruce, larch, pine and fir, from Europe and from north-west America have proved very productive here.

The result of this sustained support for forestry expansion is a forest estate of 2.3 million ha, 10% of the land surface. More than half has been planted or re-planted since the Second World War, and is still immature. The forests supply wood to sawmills, and factories producing board products and pulp for paper making. These go to make an enormous variety of end products. Production has been increasing, from 3.4 million m^3 in 1955 to 6.5 million m^3 in 1989, and will continue to increase until about 2020-30, when it will approach 20 million m^3 a year. Domestic consumption has also grown, from 30 million m^3 to about 50 million m^3 a year in the same period. Imports, valued at some £7000 million a year, make the UK the second largest importer (after Japan) of wood, which comes into the country predominantly as wood products.

The expansion of the forest area, the increase in wood production, and the creation of some new processing businesses have provided stable employment in forestry. The 1989 employment survey recorded 40 000 man-years of employment in forestry and forest industries. Most of the workers live in rural areas.

Although the principal aims of forest policy have been the creation of a new and renewable resource to supply wood for processing into useful products, and providing employment in rural areas, there has been an increasing interest in the other services supplied by forests. The Commission's forest parks and other woodlands cater for outdoor recreation; its estate receives some 50 million visits a year. Privately owned forests and woodland are much used for sporting. Landscape protection and enhancement of despoiled environments have become objectives of forestry policy. There has been a start with creating community forests, aimed particularly at providing recreation opportunities and improving urban landscapes. Most recently, we have come to understand and appreciate the value of forests as stores of carbon, counteracting the increasing concentration of $C0_2$ in the atmosphere.

Nature conservation and the creation of new habitats for wildlife have constrained, modified and stimulated proposals for new planting. Conservation of natural woodland ecosystems, and their restoration, is encouraged through the Native Pinewood Grant Scheme and the higher grants for broadleaved woodlands. Indicative strategies are being introduced in Scotland to protect and enhance land use values, including landscape, nature conservation, archaeological sites and water supplies, to integrate effectively with agriculture. Environmental assessment has been added to the procedures for examining new planting proposals when they may have a significant effect on the environment.

Thus the aims of, and constraints on, forestry policy have become more complicated. At the same time, there has been a major shift in the direction of agricultural policy. The struggle to restrain the growth of agricultural over-production suggests that more and better land should be made available for tree planting. The European Commission has taken up this idea. There is thus a wider range of objectives, an expanding range of opportunities, and a more complex set of constraints, to be taken account of in assessing the costs and benefits of different types of forest expansion.

INTERNATIONAL ENVIRONMENTAL IMPACTS: ACID RAIN AND THE GREENHOUSE EFFECT

Forests affect the composition of the atmosphere, and forests are affected by changes in atmospheric composition that occur internationally. The two main influences are atmospheric pollutants that produce 'acid rain' (including other types of pollutant deposition), and increases in amounts of CO_2 and other greenhouse gases which may affect tree growth both directly and indirectly by changing the climate.

Greenhouse gases and climate change

The greenhouse gases – CO_2, methane, nitrous oxide and ozone – are produced mainly by combustion of fossil fuels, livestock farming, and a variety of natural and anthropogenic sources. The concentration of these gases is increasing, bringing with it a high probability of the climate becoming warmer at an unprecedented rate in the twenty-first century. Emissions of greenhouse gases world-wide are set to go on rising for at least a decade, with CO_2 levels rising from 350 p.p.m. at present to about 550 p.p.m. by AD 2050. There is much uncertainty about the regional and local impact of changes in the world's weather systems, brought about by an enhanced greenhouse effect, but the best guess of the climatologists is that Britain will become warmer, particularly during the autumn and winter, and possibly wetter.

These changes in CO_2 concentration, temperature and precipitation will generally stimulate tree growth in Britain, leading to increased productivity in our forests. To get maximum advantage it may be necessary to use provenances drawn from warmer locations, and there will be little time in forestry terms to adapt. But all our main species – oak, spruce, pine, beech, larch, birch, Douglas fir, sycamore – can grow in the climate expected by the middle of the next century. They should grow appreciably faster, provided there are not more, or more severe, droughts, gales, unseasonal extreme temperatures and increased vapour pressure deficits (i.e. drier air).

While in Britain the effects of climate change on forests may not be damaging, the global consequences for forestry, agriculture, human settlements and natural ecosystems are very worrying. Governments are beginning to work on the measures needed to combat global warming. Forests can help slow down the build-up of CO_2 in the atmosphere and thereby delay global warming. Growing trees remove CO_2 from the atmosphere and store the carbon in the form of wood for decades. The carbon is eventually released when the wood decays or is burned. Some end uses of wood lock carbon up for even longer periods, a hundred years or more.

New forests, as they mature, store progressively greater amounts of carbon. For example, one million hectares of new forests would store each year about 3% of total UK emissions of CO_2. It is clear from this that tree planting in the UK cannot be any more than a contribution to the solution of the problems caused by greenhouse gases. But tree planting could be part of an internationally-concerted package of measures to deal with these problems. World-wide there is much scope for afforestation, as well as conservation of existing forests. As stores of carbon, trees can be considered to earn a 'carbon credit', equal in value to the damage avoided by reducing CO_2 concentrations, or alternatively to the cost of reducing CO_2 emissions by other means, such as substituting non-carbon

fuels for coal, oil and gas. Such a carbon credit would be the obverse of a carbon tax on emissions. The value of fixing carbon is incorporated in the cost benefit analysis of Occasional Paper 47.

Acid rain

The second environmental problem of international dimensions is 'acid rain' a term loosely used to include all the air pollutants derived from the combustion of fossil fuels. The most important gases released directly by the combustion of coal, oil or natural gas include sulphur dioxide, nitric oxide, nitrogen dioxide and hydrochloric acid. These pollutants can be carried in the atmosphere for long distances and across national boundaries.

It is well established that trees are damaged by very high concentrations of pollutants, for example close to power stations. Apart from these local effects, British forests seem to have largely escaped serious damage from acid rain and other airborne pollutants. Air quality in Britain has improved markedly over the past decade. Although there are few rural measurements of gaseous air pollutants, data for sulphur dioxide show a consistent decrease in annual average air concentrations. Wet deposition of pollutants has also changed in the last decade with significant decreases in concentrations of acidity and non-marine sulphate over much of Scotland and northern England. The threat of damage should, at worst, not increase if power station emissions are reduced as planned improvements in air quality are implemented.

Forests can influence the pathways of pollutant deposition. The aerodynamically rough surface of the forest can increase the deposition of reactive gases and cloud deposits. In this way, trees perform a useful service in cleaning polluted air; this is an uncompensated benefit. However, it can turn into a disadvantage if the trapped pollutants are redirected into water courses, a problem considered in Occasional Paper 42, and summarised below.

THE LONG TERM GLOBAL DEMAND FOR AND SUPPLY OF WOOD

As the UK depends on imports for such a large part of its wood and wood products, decisions about expansion must be influenced by views about the way in which global demand and supply will evolve. The world's harvest of wood is enormous – over 3 billion m^3 a year. About half the output is used for fuelwood. Meeting the fuelwood needs of the rapidly growing populations of the Third World is one of the most serious, and intractable, international resource problems. It concerns this study only indirectly, however, as an influence on total supplies, since our imports are of industrial wood products, which comprise the other half of total production.

The coniferous forests of north America, northern Europe and the land formerly covered by the USSR are the main source of industrial wood production. The tropical forests supply about a fifth of total output while a small but increasing share is produced in the countries of the south temperate zone, mainly Chile and New Zealand, from plantations of fast growing softwoods.

About one-third of the output is traded, predominantly in the form of processed products. Trade is concentrated within flows from Canada to the USA, from the north European countries to the rest of Europe, and within Europe. Canada, Scandinavia, the USA and south-east Asia are the largest exporters.

Attempts to project future events over such lengthy periods (50 years and more), as are necessary in forestry planning, are extremely precarious. Demand for the products of forestry depends largely on the evolution of economic activity, which itself cannot be predicted with any degree of confidence for other than short periods ahead. Technological change, which can shift demand up or down, is even more difficult to forecast. None the less, it is necessary to take a view because action to influence wood output has such a long lead time. The paper has drawn on surveys by FAO and ECE, the World Bank, international research organisations, research institutes and universities in the USA, and Europe and country studies in the USA, the USSR, Japan and a number of other countries.

There is broad agreement that demand for industrial wood will continue to grow, with a range of views about the rate of increase. However, although there is uncertainty about rates of growth in consumption or demand beyond the end of the century, a number of features of the future can be discerned with reasonable confidence. The first is that there is no evidence to suggest that there will be fundamental changes in the place of the main wood products in the economy. None is likely to be displaced from its principal end uses, nor are there likely to be major breakthroughs which would radically alter the patterns of use. Secondly, with so much of consumption occurring in the mature markets of the industrialised regions, growth and change is likely to be moderate; with much of such growth, as does occur, likely to happen in the developing regions. Thirdly, the continuing shift from solid to reconstituted products, towards greater input flexibility in processing technology, and towards increasing the efficiency with which raw materials are used, and re-used, will all continue to reduce the need for roundwood for a given end use and to extend the range of available wood biomass that can be used.

About half of the world's forests lie in the north temperate zone; and these presently supply more than four-fifths of the world's output of industrial wood. These forests have been broadly stable for a considerable period. Though there have been significant fluctuations in the use of land at the interface between forestry and agriculture these have roughly balanced out. Loss of forest land to urban and infrastructure developments, and increasing allocations to non-timber uses such as protection and recreation, have been reducing the timber production potential in some areas. On the other hand, increased investment in planted forest and in silvicultural interventions, and the growing availability of relatively productive land withdrawn from agricultural use, have been increasing timber production potential elsewhere. Throughout the north temperate zone net increment exceeds removals and the volume of growing stock has been increasing. Growing stock and increment are also expanding, rapidly, in the planted forests of the south temperate zone.

The reverse is the case, however, in the tropical regions. The area of forest is being rapidly reduced through clearance and transfer to agricultural uses, and there is little investment taking place in increasing productivity on remaining forest areas or in creating planted forests.

During the future period being considered here, there will be a major shift in global production from old growth – the primeval forests – to planted and managed forests. Old growth resources, which have been important sources of production to date, notably those on the west coast of north America and in the tropics, will be worked out, where they have not been set aside for conservation purposes. Planted resources in the south and west of the United States, western Europe, Japan, Oceania and the southern parts of Latin America will be brought into production, together with second growth resources such as the hardwoods of the northern United States.

The recent production forecasts for all the main temperate producing regions – the USA, Canada, Scandinavia, Europe, Japan and the land formerly covered by the USSR – are for increased output of industrial wood. More will also come from Chile, New Zealand and Australia. The situation in tropical regions is much less clear, but production is unlikely to expand significantly. In brief, the evidence suggests that, if demand continues to grow at rates consistent with historical growth in consumption, supplies of wood are likely to expand without appreciable real increases in prices. Moreover, it suggests that, even if demand were to grow relatively rapidly, requiring more substantial increases in prices of roundwood in order to stimulate sufficient supplies of wood, prices of processed products – which is the form in which the United Kingdom imports its wood – would rise very little, if at all.

This strong supply situation is the result of past investment in wood production. Growth at the same pace beyond the 50-year period cannot be assumed unless there is a continued inflow of capital into managed resources. It is against this background that we must consider UK wood demand and supply.

UK DEMAND FOR AND SUPPLY OF WOOD AND WOOD PRODUCTS

The main end uses of wood in the UK are in construction, packaging, furniture, fencing, paper and newsprint. All these end uses have grown since the war. The roundwood required to supply the UK market is now equivalent to some 50 million m^3 a year.

Domestic supply has also increased, from 3.5 million m^3 to 6.5 million m^3 in 1989. The harvest from the forest goes to sawmills to be converted into sawnwood, to pulpmills for production of paper of many different qualities, including newsprint, and to board factories which produce reconstituted wood products. The residues and bark are also used. Some of these are intermediate products that are further processed before being supplied to the final user.

DEVELOPMENT OF BRITISH WOOD PROCESSING INDUSTRIES

There are now four large integrated paper mills in Britain, three largely dependent upon spruce and one using hardwoods. The restructuring and expansion in the 1980s resulted in eight board mills. There are some 500 commercial sawmills in the UK. The trend towards large automated mills with kiln-drying facilities seems likely to continue. The

board mills and sawmills are closely linked. The particle board mills depend on the sawmills for half or more of their raw material and the sawmillers are relieved of the need for much expensive re-sawing to win saleable product from slabwood. A recent study estimated the value of the output from these industries in 1986 at around £1 billion.

The UK is 13% self-sufficient in wood products. Demand has grown faster than domestic supply and the volumes of wood products imported have increased. The main suppliers are Finland, Sweden, Canada and the land formerly covered by the USSR.

The change in demand for wood in the future will depend upon developments in the end uses, changes in the price of substitutes and technological advances in the efficiency with which wood is converted. Growth in GDP is the ultimate engine driving changes in wood demand. The forecast data shown derive from statistical analysis of all the principal wood products in Adrian Whiteman's paper. It is assumed that prices in real terms will not change appreciably from current levels. The higher estimate assumes GDP growth of $2^1/_2$% a year; the lower, that GDP growth will progressively slow down to zero in 2040. The forecast range of demand in 2050 is 70-90 million m^3. Table 1 shows the forecast growth of consumption over the period alongside the potential production from the existing forests.

Table 1 UK wood production and consumption

		Million cubic metres	
	Potential production*	*Forecast low*	*Consumption high*
1990	7	50	50
2000	11	54	54
2010	15	59	61
2025	19	66	74
2050	12	70	91

*Potential production from the forests existing in 1990.

The growth in domestic supply has been predicted from data on the extent, age and productivity of the existing growing stock, making assumptions about the harvesting policies that owners will adopt.

Production from the present forest estate could increase to nearly 20 million m^3 a year in the late 20s of the next century before falling back to 12 million m^3 by the mid-century, reflecting the age structure of the forests. The demand and supply forecasts thus predict that, while domestic production will increase markedly, consumption will rise as fast. It follows that imports will not be reduced and could increase after 2030, depending on the rate of planting after 1990.

Wood processing industries have expanded in line with the increases in domestic supplies of wood. Given the very large UK market, the potential for growth in wood production presents an opportunity for a large sustained expansion of the wood processing industry over several decades. However, as other countries do not export unprocessed wood, if domestic wood output were to fall back after 2030, processing industries would have to contract. It is unlikely that sufficient investments in increased capacity would be made in the face of the prospect of an eventual reduction in supplies of wood from UK forests. The wood would either have to be exported unprocessed at low prices, or the harvest delayed by deferring the felling. In either case there would be a lost opportunity for industrial growth and a loss in value of the wood.

One advantage of forest expansion is that of filling the wood production 'trough' after 2030. If the country wished to sustain production at 20 million m^3 a year, it would be necessary to establish about 400 000 ha of new forests over the next 10 to 20 years. This would avoid the problem of deferring production or exporting the wood unprocessed.

THE DEMAND FOR FORESTS FOR RECREATION

New forests could also increase the opportunities for outdoor recreation. Countryside recreation has grown rapidly in the past; more recent trends and future projections suggest a slower but still positive rate of change. Current trends are for more rapid growth in more specialised pursuits. Forests provide a broad range of opportunities for such uses, particularly because of their ability to absorb large numbers of people and to screen activities both physically and perceptually. The local countryside around towns is of most value. The National Survey of Countryside Recreation showed that over 33% of trips have a round trip distance of less than 10 miles, and 50% a distance of less than 20 miles.

It is useful to distinguish commercial recreation enterprises from free recreation. Certain types of recreational use, for example, fishing, stalking, camp sites and holiday cabins are priced according to market valuations, and the revenue accruing provides a measure of the benefit to consumers. For such commercial recreation activity, revenues exceed costs, so that, for example, the provision of Forestry Commission holiday cabins yields rates of return in excess of 8% in real terms. There are similar facilities in the private sector. Thus there is an economic case for increasing such facilities in established forests.

Most forest recreation, however, is free. The Forestry Commission's forests receive about 50 million visitors a year. Since this recreation is not priced through the market, indirect approaches have to be used to assess its value in monetary terms. A recent study estimated visitors' 'willingness to pay' at an average of £2 per visit to Forestry Commission woodlands. The research shows broadly that the number of visitors (per unit area) and the total value of those visits is highest in the English lowlands and lowest in the Welsh and Scottish uplands. This is perhaps obvious, but the differences are striking; for example, the values are around £1 (per hectare per year) in the remotest areas, £10-50 in intermediate areas, but around £200 (and more in exceptional cases) in accessible lowland areas.

The conclusion is that, except for upland forests distant from people, unpriced recreational benefits can be a very valuable 'product' of the forests. In favoured locations, they can be even more important than the wood production. However, recreational benefits in new forests may only become substantial after the trees have grown sufficiently to provide a forest environment, unless there is already some woodland nearby. Some new planting may displace existing recreational use which would also have to be taken into account. The most beneficial forest expansion for recreation is therefore likely to be planting of small woodlands close to towns and cities, on sites not much used for recreation, and where possible as extensions of existing woodland. This is broadly what community forests aim to achieve.

There is not a great deal of hard evidence on peoples' preferences for different types of forest. But the results of recent research suggest that diversity of structure and species, with open spaces and easy access, are preferred.

FORESTS AS WILDLIFE HABITAT

New forests can also create new and valuable habitats for wildlife. But the land that is planted may already have high value in its current state. The growing interest in wildlife is reflected in the increasing membership of nature conservation organisations that use their members' subscriptions directly to manage land as well as in lobbying for increased official protection. Governments have increased spending on nature conservation and have extended and elaborated the system of reserves and protective designations. National Nature Reserves and Sites of Special Scientific Interest now protect some 8% of Britain and there are other safeguarded sites in the care of the Royal Society for the Protection of Birds (RSPB), county naturalists' trusts and others. Public agencies dealing with land and water now have duties to conserve nature.

While there is no body of data from economic research on wildlife habitat to parallel the evaluation of the value of outdoor recreation, there is no doubt that many people wish to have the opportunity to experience and learn about wildlife, are concerned that wild animals and plants should flourish, and that we should pass on to future generations a rich and diverse stock of wild plants and animals that includes all those which naturally belong in Britain.

The general concern for wildlife has been articulated by professional conservationists into a set of criteria for assessing nature conservation values of woodland and other ecosystems. The three most important criteria are 'naturalness', diversity and rarity. They serve as a guide to what to conserve and what to aim for in establishing new woodland.

Highest value is generally assigned to habitats nearest their natural state, and least to those most severely disturbed by human activity and dominated by introduced species. Changes in the naturalness of an area caused by changes in land use are of great concern to conservationists. It is not only the naturalness of the new forest which is important, but also the loss of naturalness resulting from the replacement of the existing habitats. A major problem in assessing naturalness arises from the fact that almost all land in Britain has been affected by human activities, directly or indirectly.

When considering ecosystems, diversity refers to species. Value is generally considered to be high when the total number and relative abundance of species approaches those which would occur naturally (in the absence of human disturbance). At the larger scales (landscape, regional, national, international), highest value is given to those areas which contain the greatest diversity of appropriate habitats.

Rarity, like diversity, can be considered at different scales – there are rare species, rare communities and rare ecosystems. Generally nature conservationists consider rarity at all these levels as being a relevant measure of value, because rarity is one important aspect of natural diversity.

Conservationists' worries about the effects of afforestation in Britain concerns those areas which, while relatively common here, are rare internationally. The plant and animal communities of raised and blanket bogs and heather moorland are especially important in this regard. Concern is heightened by the sensitivity of these habitats to changing land use.

Generally speaking, options for tree species choice increase with site fertility. Until recently the only land available for large-scale afforestation was in the uplands and on infertile lowland sites, such as the acid heaths in the east of England and coastal sand dunes. Now that most land not protected by statute is potentially available for afforestation, including fertile agricultural land in the lowlands, a new range of tree species options opens up, including most native broadleaves. Silvicultural options also increase. Forests with continuous canopy cover can be considered as an alternative to forests which are clearfelled. With the increased range of forestry options come a wider range of opportunities for wildlife habitat creation. Even in the uplands, as afforestation moves 'down the hill' to intermediate altitudes and better soils, the possibilities will increase.

Enhancing natural diversity and providing habitats for rare species are the best general guides to creation of the type of woodlands best for wildlife. On that score, more native woodlands would be the ideal. Unfortunately, it is not easy to re-create complete native woodland ecosystems and it takes a very long time to build up the full range of component species. A start has been made with the least difficult prospect – extending native Scots pine woodland on undisturbed sites in the Highlands. It will be more difficult to extend complex, multi-species lowland woods on to cultivated land because highly fertile arable soils tend to favour weed species rather than woodland plants. Also, many of the characteristic field-layer plants have very limited powers of dispersal and colonisation.

A major potential advantage for wildlife conservation from planting new native forests in areas where woodlands have become fragmented is the linking together of formerly isolated woodland communities. Larger woods tend to contain more species than smaller woods of the same kind because their populations are generally bigger and species in danger of local extinction are likely to be less vulnerable. Bringing formerly isolated populations together may also increase the genetic pools of crossbreeding species and hence increase their capacity to respond to environmental change.

After native woodlands the next best forest types for wildlife are broadleaved/conifer mixtures. These have the potential for higher wildlife conservation values than non-native broadleaves or conifers alone, because they are more structurally diverse and so provide a greater range of niches. They may develop more species diversity than new native woodlands, but may be considered less desirable nevertheless, because they are less natural.

Mixed woodlands are a feature of some parts of Britain, notably Perthshire, the Lake District and Snowdonia. They are common in hilly areas at low to intermediate altitude, which provide variable site conditions. Conifers are planted on the poorer, more exposed sites and broadleaves in the more sheltered areas with deeper, more fertile soils. More of this sort of afforestation is desirable if marginal land of this type becomes increasingly available. These mixed woods can have high wildlife conservation values, especially if the broadleaves are predominantly native and appropriate management practices are adopted.

For other types of woodland, while it is generally true that afforestation almost always increases habitat diversity in Britain, because forest cover is so sparse, this does not necessarily make forestry acceptable to nature conservationists. The deciding factor is whether the increased diversity is achieved by replacing more highly valued semi-natural communities, or is a complement to them. This will depend upon the nature of the site and the design of the forest.

FORESTRY AND THE CONSERVATION AND ENHANCEMENT OF LANDSCAPE

It is common ground between people with a concern for the countryside that in very many circumstances woodlands and forests are an asset in the landscape. The question to be resolved is thus, the scale, composition and structure of forest that will be appropriate in different landscapes, including a view on the circumstances when no forest is appropriate, irrespective of its attributes. In considering this question it is helpful to start with common perceptions of trees in existing landscapes.

The most straightforward case is that of woodlands and forests composed of species native to that site, particularly where visual evidence of the hand of man is missing or concealed. This type of woodland is now only present in Britain to the extent of 1 or 2% of the land surface. Too much of it is in poor condition; even so, wherever it occurs it is highly regarded – whether this is in the pinewoods of Strathspey, the oakwoods of the Lake District or the ashwoods of the Dales. These woodlands emphasise landform, add to diversity and assist in creating landscape unity.

Many types of woodland and forest which are not composed of species which are native to the site are also highly regarded as components in treasured landscapes. The spectrum is wide. At the one end are woodlands which appear to be natural, though they were originally planted, such as pines on Surrey heaths, old oak plantations in the Forest of Dean or managed beechwood in the Chilterns. At the other end are forests which are manifestly not natural, but which appear comfortable in the landscape by virtue of age, familiarity, structure, irregularity or tradition. A few examples can be chosen from many.

The policy woodlands established by the mansion house on most Scottish estates during last century; the forests planted by the Forestry Commission on better land at Haldon, Quantocks, Coed-y-Brenin, Gwydyr, Grizedale, Aberfoyle, Inverliever, Strathyre, Monaughty, Drumtochty and many others; forests established by water boards early this century such as Burrator, Lake Vyrnwy or Thirlmere; woods of sycamore established around upland farmhouses. There is as yet little research which tells us clearly about what people like. Such as there is, supports the intuitive perception that the important attributes are those of size, variety and accessibility.

Given these acknowledged values of trees in many existing landscapes and the relative paucity of wooded land in Britain it would seem to follow that there is significant scope for landscape enhancement through tree planting. While this is true, there are a number of limitations which must first be acknowledged.

The first is that people do not like dramatic change in any but the most damaged landscapes. It is fully acceptable to obliterate industrial dereliction swiftly. Elsewhere even the most benign change must be relatively slow if it is to be acceptable.

The second is that although Britain may once have been well wooded and forests can be established almost anywhere on the mainland, many existing landscapes are cherished precisely for their openness. It may be that they were made open by man's activities, and are kept open principally by grazing and burning. None the less, the sense of place now depends upon the dominance of features other than trees, whether this is southern heathland, heather moorland, or the upland and mountain landscapes of Dartmoor, the Pennines or the Scottish Highlands. The clearly articulated requirement of contemporary society is that these places remain more or less in their present condition and that policies and instruments be framed to keep them so. Many have been designated as National Parks, National Scenic Areas or Areas of Outstanding Natural Beauty. Others have yet to be recognised formally. It would be helpful if the process of choice became more conspicuous and robust.

The third limitation is that each landscape is different so that the quantity, type and location of acceptable new treescapes must be determined not at national but at regional or local level. Landscape assessment must be developed towards as objective a system as possible.

Safeguarding and, where appropriate, expanding semi-natural woodlands and forests is a key element in the conservation of heritage landscapes. In the larger landscapes of Britain particularly in the uplands, expansion must be on a significant scale if it is to be capable of an adequate impact. Elsewhere precision of location is of more consequence than scale. The clearest targets are the expansion of native pinewoods and Highland birchwoods and the better management of broadleaved woodland everywhere to retain their crucial role in well loved landscapes.

The discipline of landscape architecture must be brought most meticulously to bear on the most sensitive landscapes whether defined by designation or experience, to ensure that new planting is enhancing not detracting from the quality of what is there. But skill is also required in the wider countryside to ensure that an appropriate balance is struck and a matrix of different land uses arrived at, which will be appropriate to the land forms

and contribute to the appearance of diversity. There are major opportunities in lowland landscapes especially in the agricultural prairies of east England, to restore a sense of enclosure by careful siting of new woodland close to transport routes. This process of landscape planning can also identify sites that require enhancement with major tree planting, such as urban fringe areas or landscapes degraded by industrial abuse and dereliction. There has been some movement in this direction within local authorities in England, but a more consistent and codified approach would probably be helpful.

Attention needs to be given to the internal design of all new planting to seek and take opportunities to enhance wildlife recreational and aesthetic value. The level will vary with the opportunity but all new planting must seek to be interesting. In a well designed forest all internal space should have significance whether for roads, wildlife, burns or archaeological sites. Linear features should form veins which ramify throughout the woodland activity as passageways for people and wildlife. These veins should also link with open ground beyond the limits of the trees and with unplanted glades, lawns, flushes, ponds or outcrops within.

Indicative forestry strategies are being developed by regional councils in Scotland in co-operation with the Scottish Office, the Forestry Commission, the forestry industry and statutory agencies. These are intended to provide a framework that will identify preferred areas for extensive new planting while recognising the various environmental sensitivities elsewhere which will help to determine whether any new planting is acceptable and if so what type and scale.

Indicative strategies are a 'top down' approach to identify areas where well designed forests would enhance the landscape. In certain areas a 'bottom up' approach will be valid and complementary. This approach is to be most encouraged where communities see that their environment will be improved by extensive tree planting. Examples are around the old industrial towns and cities of the English Midlands and North East, South Wales and Central Scotland. Here the intent will be to use all woodlands as part of a mosaic of a new countryside to serve the aesthetic and leisure needs of an increasingly urban population as well as providing a green envelope within which 'clean' industry can grow.

Changing what is currently unattractive urban fringe in this way is a major challenge which will not be accomplished without the co-operation and enthusiasm of all the relevant agencies and communities. The idea of a 'forest for every town' is popular. Such community forests could have many different outputs including employment in forestry conservation and leisure. Above all, it is emphasised that they must be true community forests shaped by the local people for themselves and their children into the future.

THE IMPACTS ON WATER QUALITY AND QUANTITY

Forestry influences water yield and quality. Its main effect on yield is through higher rates of evaporation and transpiration compared with grassland. In general, this is not a problem because the UK uses only a very small portion of the total precipitation. However, the bulk of the precipitation falls in the uplands of the north and west while the main demand is in the populous lowland regions of the south and east. Water

supplies are in general more than adequate in Scotland, whereas the growing demand in England may require development of increased capacity. The presence of forestry could, on reservoir catchments where increasing water demand is already close to supply capacity, bring forward the need for development of new supplies. In the uplands it is also necessary to take account of effects on the run off to hydro-electric plants where it could affect electricity production.

Controlling quality requires attention to the chemistry, dissolved oxygen, smell, taste, colour, sediment and temperature of water for public water supply, for fisheries, for recreation and to meet the special requirements of industry. Quality is closely controlled by legislation. While different aspects are of concern to the water industry in different parts of Britain, the greatest concerns in the uplands are colour, sediment, aluminium, acidity and phosphate. Nitrate, phosphate, sewage and farm waste are of most concern for lowland surface waters; and nitrate, organic solvents and pesticides in lowland ground waters.

Forestry expansion is of interest to the water industry as it can influence a number of these aspects of water quality. The potential problems concern acidification; erosion as a result of site preparation and road construction; fertilisers and pesticides; and the effect of harvesting on sediment load.

Relative to indigenous pasture forestry is a more intensive form of land use in the uplands. Planting will lead to an increase in erosion but adherence to the Forestry Commission's guidelines should keep this to acceptable levels. Fertiliser and pesticide applications are not on a scale to cause problems, again provided that the existing guidelines are followed.

Acidification, however, is a potential problem on sensitive sites. Streams draining forestry areas may be more acidic and may contain more aluminium than streams draining moorland or grassland. This effect is confined to land where acid soils overlie rocks containing few readily weathered minerals, in areas with significant levels of atmospheric pollution. Thus, although atmospheric pollution, not forestry, is the primary cause, sensitive sites need to be identified and planting controlled. In the short term, to reverse any effects of increasing acidification, cost-effective liming strategies may need to be developed. In the medium to long term emission abatement should reduce the need for such amelioration measures.

In the margins where uplands and lowlands meet, forestry as a land use is of a similar intensity to the agriculture of this zone. The agriculture is mainly livestock oriented but with relatively high stock densities, areas of pasture improvement and limited growth of arable crops. Planting in these areas does not generally require extensive cultivation or drainage networks. Screef planting is adequate on the freely drained soils to suppress weed competition. The risks of increased erosion as a result of planting are therefore small. The soils generally have a higher base saturation than the uplands; and the risk of mobilisation of acidity and aluminium into surface waters is less than on the more acid upland soils. The total amounts of fertiliser applied to forests are lower than those used in pasture improvement in this zone because they are applied less frequently. The contamination of ground-water is not a significant risk because the zone is not underlain by major aquifers as the majority of the rocks are impermeable.

In the lowlands, forestry is a much less intense form of land management than the bulk of lowland agriculture. A switch from intensive agriculture to forestry would have a generally beneficial impact on water quality. However, the impact on water yield could be equally important.

The broad overview can mask important local impacts. Small local direct supply sources (lakes and reservoirs) for remote communities may be highly sensitive to reductions in water yield and quality. Hydro-electric power catchments would be sensitive to reductions in water yield but less so to reductions in quality except for sediment load. The assessment of the impact of further planting should therefore be site specific and related to the catchment or aquifer recharge area affected.

SPORTING RECREATIONAL USE OF LAND

Country sports – fishing, hunting, shooting and stalking – are important to their many millions of participants. They also make a useful contribution to the rural economy, which is particularly significant in the remoter areas, by generating income and jobs.

A recent Scottish study shows that the demand for sporting shooting facilities appears to be buoyant and on many estates is increasing in importance as a source of revenue. Apart from forestry, there are few viable alternative uses of land currently devoted to sporting shooting. Despite this there is excess capacity, and returns are modest and variable; none the less, demand for sporting recreation is expected to increase and this will tend to raise the cost of land for forestry.

The implications for forestry expansion seem to be that new planting programmes close to population centres or within easy reach of airports and other centres of population are most likely to be competitive with sporting demands for land. Land which is currently devoted to grouse shooting is in scarce supply and any extension of forestry into such ground would incur a high opportunity cost which would probably be reflected in the market prices were this land to be available. On deer stalking land it is quite possible for an estate to plant a substantial proportion of its land, provided the sites are carefully selected not to interfere with the requirements of stalking.

Land area requirements for lowland sporting activities tend to be less extensive than for upland varieties of the sport, and can more easily accommodate extensive additional planting.

To a degree forestry and sporting shooting are complementary. Typically, sporting use will be combined with agriculture or forestry. Complementary development of agriculture, forestry and sporting recreation may be necessary to maintain a minimum level of viability, particularly in a period of declining agriculture returns. It is clear for certain types of sporting recreation that woodland cover, if not extensive forest, enhances sporting potential. A significant proportion of estates carry out continuous woodland planting and management to realise this potential.

Fishing is also a valuable contribution to the rural economy. Any decline in water quality would be a cause for concern by angling interests. This has consequences for the assessment of planting proposals in the uplands, as noted above and discussed in Occasional Paper 43. In lowland areas, forestry is more benign in its impacts on water quality than other land uses including agriculture. Lowland forestry would therefore have clearer benefits for lowland fishing, particularly near centres of population where demand is greatest.

THE AGRICULTURAL DEMAND FOR LAND: ITS AVAILABILITY AND COST FOR FORESTRY

An increase in the area of forestry in the UK would require a reduction in land used for agriculture. We must therefore consider the consequences of agricultural change on the availability and cost of land for forestry. The objective is to estimate the social opportunity cost of transferring land from agriculture to different uses, including forestry, and analyse how this is likely to change in the future.

There was long a presumption that farmland required protection to reduce the loss to other uses, such as urban development, roads and forestry. It is striking, however, that the total area of land in agricultural use has been stable over the last 20 years, at just under 19 million ha. There has been a small increase in the cereal and arable crop acreage, and an associated decline in the area of temporary grass which are typically included in an arable rotation to both provide a break from continuous cropping and also to provide highly intensive grazing for livestock, especially dairy cattle. At the other end of the intensive-extensive spectrum, there has been some transfer of rough grazings out of agriculture to forestry and to improved grass. However, when seen in the perspective of the total land area, these changes have been marginal.

Concern over the loss of farmland has given way in the last few years to worries about surplus production. Estimates from various studies suggest that 2-4 million ha will become surplus to farm production requirements by the year 2000. Compared with the loss of under 0.3 million ha over the last 10 years, these estimates envisage dramatic changes in the countryside. However, they need to be interpreted with care, as is shown by a more fundamental analysis of the factors influencing the agricultural demand for land.

There is of course surplus production of agricultural products, the result of the Common Agricultural Policy (CAP) supporting prices above world market prices and national policies that have stimulated output. A recent assessment of the effects of the CAP suggests that the costs to the consumer taxpayer are not only large, but far in excess of the benefits to farmers – hence the search for reforms which would reduce the costs while achieving the major objective of supporting farmers' incomes.

This is not easy. The dynamism of the agricultural industry, and the rapid technological and structural change that it produces, has the result that farmers are able to produce increasing amounts of food and fibre, with increased productivity of all their resources

and consequent reductions in cost. In a competitive and unsupported market, this process would result in even lower prices to farmers and consumers alike. But it would also cause considerable hardship for the more marginal farmer and result in some farms being forced out of business as their more competitive neighbours expand.

However, attempts to halt this process by supporting market prices so that the weaker farmer can stay in business are bound to fail. Such policies don't repeal the forces of competition in the industry, they merely push those forces in new directions. Increases in profitability for all farmers increases the demand for land and fixed plant and equipment and pushes their prices up. Prices set by large input supply companies also tend to increase. The end result is that farm costs increase as output prices are increased. Farm incomes, as the difference between returns and costs, remain under pressure.

Over the whole post-war period, real gross output and gross input for the industry have shown very weak upward trends while gross product (gross output minus gross input) has shown a stronger downward trend and that for farm business income (net farm income plus land rents) showing an even stronger downward trend. Over the period 1971-1988, since entry to the European Community and the CAP, all four trends are more strongly downwards, with that for farm business income the strongest trend.

All of this has happened in spite of a general increase in the level of public support to the industry, which almost tripled in real terms between 1972 and 1984 when the additional costs borne by the users and consumers of farm output is taken into account. Furthermore, at the market level, production continues to increase as the industry becomes ever more productive. The increased supply, occurring at increasingly uncompetitive prices, cannot find markets without subsidies and the cost to the public purse grows seemingly without limit.

The intractability of the problem has stimulated a search for new crops and products, so far with little success. The Agriculture Economic Development Committee provides a useful and comprehensive survey, based on previous work. This report concludes that novel products could account for only up to 200 000 ha possibly as an addition to, rather than a replacement of, projected tillage areas. The expectation is therefore that agricultural returns will continue to fall in real terms (i.e. not keep pace with inflation) over the next few years, as efforts are made to contain the costs to society while productivity continues to increase.

However, this does not mean that significant areas of farmed land are likely to become surplus in the sense of being left idle and therefore available almost rent free for other uses such as forestry. As farming incomes fall, land prices will also drop, with the result that farm amalgamations will be favoured, leading to less intensive farming. But the land will still be in demand for agriculture, and still command a price.

Current and expected future price support have been capitalised into the price of farmland. Estimates presented in Occasional Paper 45 suggest that, on the assumption that market support were eliminated entirely, the fall in land prices could be about 45% in England and Wales, and rather less in Scotland. This implies that the social value of the land is some 45% below market prices. However, it does not allow for social

preferences for retaining land in agriculture for amenity reasons, which would in these cases raise the opportunity cost. This influence evidently depends on the sites in question.

If the present methods of support, including the CAP remain in force, then land with highest cost production would be released for other purposes such as forestry. This points to some lowland grassland in the Midlands and north of England being attracted out of agriculture. However, such land would be likely to be released in small parcels rather than in large scale tracts. In Scotland it is likely that new planting would tend to shift away from poorer lands in the north and west towards higher quality hill land and lowland of limited agricultural potential. Overall, the withdrawal of up to 1 million ha of land from agriculture over the next 20 years or so should not cause major problems for UK agricultural production. Nevertheless, the more land is taken out of agriculture, the higher the price that will have to be paid to persuade land to leave the industry. By the same token, so long as the current agricultural support policies remain in place, higher prices will have to be paid for land to obtain it for tree planting. As noted in Occasional Paper 34, agriculture departments are no longer seeking to protect all better quality land from new planting. In Scotland, a relaxation of the criteria for releasing agricultural land was announced in 1989 opening up new opportunities for planting on better quality land.

ECONOMIC ASSESSMENT OF COSTS AND BENEFITS

As the preceding sections make clear, forestry is a multiple output activity. New forests produce a number of joint outputs and services. These outputs are usually thought of as benefits; however, depending on the location and design of the forest, they can be negative if they reduce the provision of a service compared to the land use displaced, thereby creating a cost.

The main effects of new forests identified in the study are on:

- wood production;
- opportunities for recreation;
- landscape values;
- watershed protection and soil erosion;
- water supply, both quantity and quality;
- deposition of airborne pollutants;
- carbon storage;
- national economic security;
- stability of rural communities.

A full assessment should take account of all those effects, whether positive or negative. Ideally they should all be expressed quantitatively in a common monetary unit to allow the calculation of social rates of return. Allowance should also be made for the distorting effect of subsidies or market rigidities on the prices of inputs, such as, land and labour.

Occasional Paper 46 gives an assessment of the commercial returns from wood production only. It examines a range of forest types, including community forests, conifer forests in the uplands and lowlands, forests of native species in the uplands and lowlands and mixed forests in the upland lowland margins. The analysis is based on current costs and prices. The rates of return, expressed in real terms (i.e. net of inflation) range from 1% a year and less for native broadleaves to 2-3% for community forests, 3% for semi-natural pinewoods in the Highlands and 3-5% for conifer forests in the uplands and lowlands.

Occasional Paper 47 extends the commercial assessment to include estimates of recreational values and the value of carbon storage. It includes a small allowance for the effect of increased wood production on national economic security. The other impacts cannot at present be quantified in terms of money, but the paper gives a qualitative assessment of their relevance to the different forest types. It also analyses the effect on rates of return of different assumptions about the social value of land and labour, drawn from Occasional Papers 44 and 45.

The results of this fuller analysis of the costs and benefits are to increase all the rates of return but with a much larger impact on lowland forests. Community forests achieve returns in the ranges 5-7%. For native broadleaves in the lowlands, returns of 4 -5% are achievable where the amenity value of the land in its existing use is not high; and for lowland conifers over 6%. Conifer forests in the uplands can also achieve return over 6% where there are some additional recreational benefits and job creation is valued, provided that the land is not of high conservation or landscape value in its existing use. In similar circumstances, semi-natural pinewoods achieve over 4%. Mixed conifer/broadleaved forests in the lowland/upland margins offer rates of return of up to 8% where they are established on land that does not have high amenity value and can add to the provision for recreation.

Thus, although only some of the benefits and costs of forestry expansion can be quantified in monetary terms the results of the cost benefit analysis are illuminating. It remains true that much that is of importance cannot with current economic techniques be given a monetary value. Landscape, nature conservation, air pollution, water quality and quantity and community values are evidently of great interest and must be taken into account, even though they are not included in the cost-benefit calculations. We have allowed for them in the conclusions below where we suggest some of the most promising locations and types of forestry to develop.

CONCLUSIONS

1. The most important direct benefits to aim for in an expansion of forestry are:

   – increased wood production, to permit a sustained expansion of wood processing in the UK over the next 50 years;

   – greater provision for outdoor recreation and sporting;

- support for remote rural communities through job creation and widening the base of local economies;

- improvements to degraded landscapes and derelict environments and reinforcements of the woodland components of other landscapes;

- an expansion of scarce wildlife habitats; and

- a contribution to international efforts to reduce environmental damage through cross boundary pollution, notably global warming.

2. Different types of new forestry offer different packages of benefits. For some purposes, such as, for example, reinforcing a native forest ecosystem by extending it, one use will be dominant, and will determine the silviculture. Generally, however, the study suggests that forests located and designed to serve multiple uses will usually supply greater benefits in total than single-purpose forests, even after allowing for trade-offs between, for example, wood production and landscaping, or conservation and recreation.

3. To achieve expansion without environmental damage, attention has to be paid to the effects on water quality and quantity, wildlife habitat, landscape, archaeology and, generally, the dislike for rapid change. The environmental constraints will tend to be greater in the uplands than in the lowlands. In all cases, however, the impact will depend on the specific attributes of the site and the nature and design of the forest. Each proposal for new planting therefore requires individual assessment.

4. There would be many advantages from more planting 'down the hill' and in lowland areas. Forestry on more fertile ground could produce higher yields and the timber would be closer to markets than in the uplands. Locating forests close to people could provide recreation benefits. The choice of species and silvicultural options available would be much greater. Planting on intensively-farmed land could produce conservation benefits through creation of new wildlife habitats. Some intensively-farmed and treeless landscapes could be enhanced. There would be gains in water quality relative to the alternative land use, intensive agriculture, which would be displaced. On the other hand, new forestry planting in lowland areas would generally have to be on a smaller scale than in the uplands and will tend to be more costly.

5. Enough land can be attracted out of agriculture to permit an expansion of forestry of half a million to a million hectares. In view of the dislike for rapid change, the timescale is a matter of judgement. Provided that careful attention is paid to location and design, it seems to us that it should be possible to establish these forests over a period of 50 years, and possibly more quickly. They would help to sustain the expansion of the wood processing industry up to the middle of the next century, while yielding significant savings on production of agricultural surpluses.

6. High social rates of return are possible for community and other forests designed specifically for recreation and environmental enhancement. They are most effective if located close to towns and cities, with ample open space, car parking and walks. An

example is Delamere. They need not be very large to supply high recreational benefits and can comprise any species provided there is significant variety. Planted on damaged land close to towns or on derelict industrial sites they enhance the landscape.

7. The cost-benefit analysis shows that the combination of high wood production and recreational values offers the opportunity for high rates of return, particularly where the amenity value of the land in its current use is modest. This applies to mixed forests in the lowland/upland margins, which comprise the most productive conifers – Douglas fir and spruce – with a substantial proportion of broadleaves which grow better at the lower elevations. Examples include Coed-y-Brenin, Gwydyr, Craigvinean, Monaughty. They have very high productivity and rapid carbon storage. The relatively more sheltered sites and deeper soils allow for greater diversity of species and structure, which can give them a high landscape value, and a wide range of habitats for wildlife. Being less remote they have more potential for recreation.

8. Quite high social rates of return are achievable with accessible conifer forests in the uplands, which are composed predominantly of spruce or pine, with larch and native broadleaves to add diversity. Examples include Clashindarroch, North York Moors, Trossachs. These forests have value for timber production, carbon storage and sustaining rural economies. Where large, they can be a valuable habitat for species that need freedom from disturbance, such as goshawks, pine martens and red squirrels. Where they are not too remote they have significant recreation value. Where they are more remote they are useful for minority interests, such as cross country ski-ing and orienteering, and they are the only available sites for car rallies. The best options would therefore be on sites where spruce and pine grow well, where the land does not have high conservation value in its current use, and where there is seen to be value in measures to sustain rural economies. Generally, these objectives are best achieved on the better hill land.

9. Conifer forests in the lowlands may also offer high rates of return. These forests comprise mainly Corsican and Scots pine which grow better in the drier and sunnier eastern counties. Examples include Thetford, Tentsmuir and the forests of the Weald. Originally planted mainly for wood production, they now provide for recreation, store carbon, and have become valued parts of the landscape and important wildlife habitats by adding diversity to intensively-farmed areas. The cost-benefit analysis suggests that the best returns are from pine forests that are accessible for recreation established on land that does not have high amenity value in its current use.

10. The cost-benefit analysis cannot deal adequately with tree planting aimed mainly at wildlife conservation and landscape enhancement because these benefits are not at present quantifiable in terms of money. But the ecological and landscape assessments suggests that there would be considerable conservation value in new native forests to restore woodland ecosystems. Native pinewoods in the Scottish highlands, and native broadleaved woodlands in the uplands and lowlands would add to a greatly diminished wildlife habitat and could enhance poorly-wooded landscapes. Economic research to assess these values would help improve decision taking on the location and type of forestry expansion.

'FORESTRY EXPANSION: A STUDY OF TECHNICAL, ECONOMIC AND ECOLOGICAL FACTORS'

This is one of a series of papers which form part of a study to consider the scale, location and nature of forestry expansion in Britain.

The Forestry Commission invited fourteen specialist authors, including economists, foresters, ecologists and biological scientists to write about current knowledge and to assess the main factors bearing on decisions about the future direction of forestry expansion. It is intended that the papers will form the basis for future discussions of the location and type of forestry that will best meet the demands of society for wood products, jobs, recreation, amenity, wildlife conservation, carbon storage and the other uses and public benefits supplied by the country's forests.

Published by the Forestry Commission on 19th July, 1991.

The full list of papers is as follows:

Occasional Paper No	Title	Author
33	Introduction	Professor Ian Cunningham, Macaulay Land Use Research Institute
34	British Forestry in 1990	Hugh Miller, University of Aberdeen
35	International Environmental Impacts: Acid Rain and the Greenhouse Effect	Melvyn Cannell and John Cape, Institute of Terrestrial Ecology
36	The Long Term Global Demand for and Supply of Wood	Mike Arnold, Oxford Forestry Institute
37	UK Demand for and Supply of Wood and Wood Products	Adrian Whiteman, Forestry Commission
38	Development of the British Wood Processing Industries	Iain McNicoll and Peter McGregor, University of Strathclyde and Bill Mutch, Consultant
39	The Demand for Forests for Recreation	John Benson and Ken Willis, University of Newcastle
40	Forests as Wildlife Habitat	John Good, Ian Newton, John Miles, Rob Marrs and John Nicholas Greatorex-Davies, Institute of Terrestrial Ecology
41	Forestry and the Conservation and Enhancement of Landscape	Duncan Campbell and Roddie Fairley, Countryside Commission for Scotland
42	The Impacts on Water Quality and Quantity	Mike Hornung and John Adamson, Institute of Terrestrial Ecology
43	Sporting Recreational Use of Land	James McGilvray and Roger Perman, University of Strathclyde
44	The Agricultural Demand for Land: Its Availability and Cost for Forestry	David Harvey, University of Newcastle
45	Forestry in the Rural Economy	John Strak and Chris Mackel, Consultants
46	New Planting Methods, Costs and Returns	Jim Dewar, Forestry Commission
47	Assessing the Returns to the Economy and to Society from Investments in Forestry	David Pearce, University College London

The summary document is free; each of the 14 papers is available at £2.00 (including postage) and the full set is priced at £25.00 (including postage) from: Publications, Forestry Commission, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH, Tel: 0420 22255 .