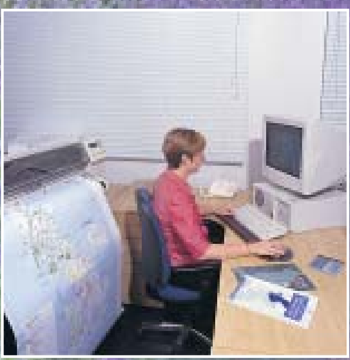
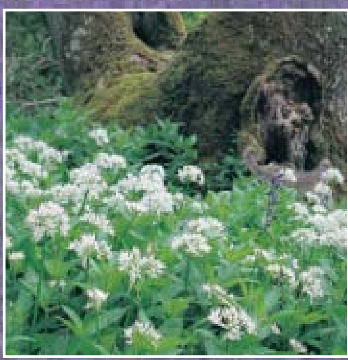
Forest Research

Annual **Report** and **Accounts** 2000-2001





Forest Research

An agency of the Forestry Commission

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Spring 2001

Forest Research Annual Report and Accounts 2000-2001

Together with the Comptroller and Auditor General's Report on the Accounts

Presented to Parliament in pursuance of Section 45 of the Forestry Act 1967 and Section 5 of the Exchequer and Audit Departments Act 1921

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Contents

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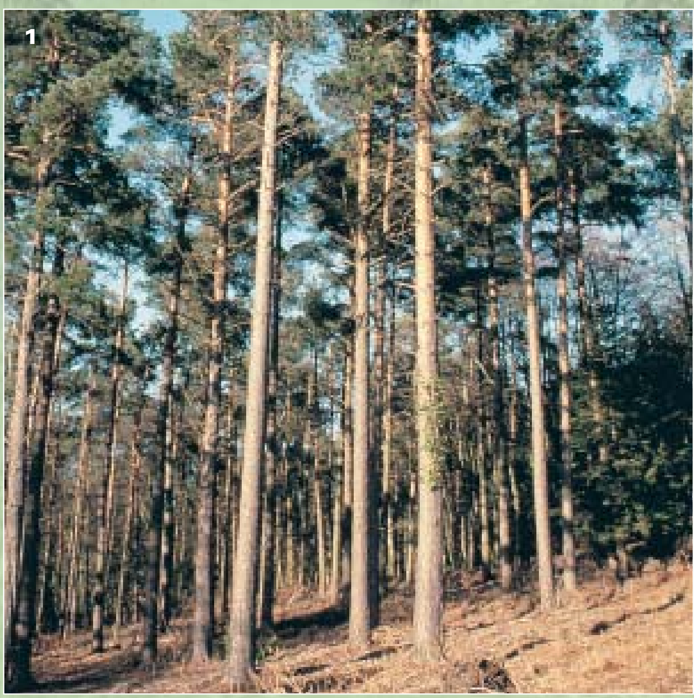
About Forest Research

Forest Research (FR) is an agency of the Forestry Commission and is the principal organisation in the UK engaged in forestry and tree related research. The Agency was launched on 1 April 1997.



1 Scots pine at Exeter

2 Ash keys

3 Orange tip butterfly on bugle

4 Amenity tree health survey at Deene Estate, Northants

Aims and objectives

Aims

To provide research, development, surveys and related services to the forest industry and to provide authoritative advice in support of the development and implementation of the Government's forestry policies.

Objectives

- To meet customers' needs and respond to changing customer demands.
- To satisfy current standards for the quality of research.
- To increase competitiveness and efficiency and demonstrate value for money.
- To recover the full economic costs of the Agency from charges to customers.

Customers

Most of our work is funded by the Forestry Commission with the Policy and Practice Division of the FC acting as purchaser of research and other services in support of forestry in Britain, including the particular needs of England, Scotland and Wales. Forest Enterprise, the agency responsible for managing the FC estate, purchases research, development and surveys specifically related to this estate. Other customers include the Ministry of Agriculture, Fisheries and Food[a], the Department of Trade and Industry, the Department of the Environment, Transport and the Regions[b], the European Union, commercial organisations, private individuals, land owners and charities. All our customers are free to purchase their research from Forest Research or from other sources.

Activities

FR's research covers a broad range of topics from genetic improvement of trees, through tree seed, tree establishment, stand management and threats to tree health. The species covered include all the main native trees as well as the commercially important introduced conifer species. An increasing proportion of the research effort is directed at increasing the environmental and social benefits of trees, including biodiversity and recreation, and ensuring compliance with international agreements on the sustainable management of forests. The Agency also carries out method studies, product evaluations, crop inventory, surveys and monitoring.

Resources

The Agency has two main research stations, Alice Holt Lodge in Hampshire and the Northern Research Station on the Bush Estate south of Edinburgh. The main office of Technical Development Branch is located at Ae in Dumfriesshire with subsidiary offices in the English Midlands and Wales. The Agency also has 10 field stations from which an extensive network of field trials, sample plots and monitoring sites is assessed. A list of addresses and telephone numbers is given on the inside back cover. The Agency employs 260 staff, not including visiting scientists and sandwich students. The Agency has published a Corporate Plan for the period 2001-2004. Copies are available from the Library at Alice Holt Lodge.

Editorial update Since the June 2001 General Election, Government Department name changes have occurred:

[a] Department of Environment, Food and Rural Affairs (DEFRA).

[b] Department for Transport, Local Government and Regions (DTLR).

Chief Executive's Introduction

I am pleased to present the Agency's Annual Report and Accounts for the year ended March 2001.

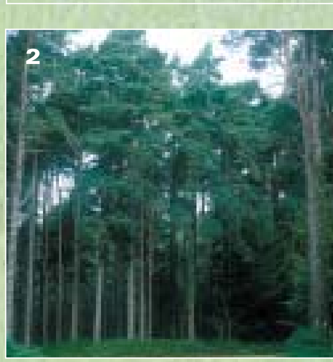
The Agency has again had a successful year achieving all its targets despite continuing reductions in income from our main customer, the FC's Policy and Practice Division. Income from non-FC sources also declined as a result of several EU projects coming to an end, delays in obtaining authorisation to start new EU projects and reduced activity on the major short rotation coppice project jointly funded by MAFF, DTI and the FC. Foot and mouth disease affected some field work in the last few weeks of the financial year. The Agency was able to reduce costs in line with the reduction in income through non-replacement of staff on casual and fixed term appointments. Despite the need to make reductions in staff numbers we were able to make several new appointments in response to changing demands.

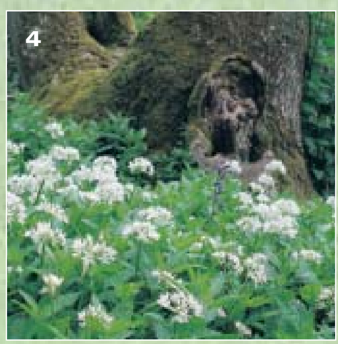
1 Enjoying a walk in Delamere Forest, Cheshire

2 Scots pine in the New Forest

3 Jim Dewar, Chief Executive

4 Oak with wild garlic in ancient woodland





Research highlights

Our research aims to protect Britain's trees and woodlands from pests, disease and other threats; to increase the contribution trees and woodlands make to improving quality of life including environmental and social benefits; and to increase the competitiveness of British grown forest products and their contribution to wealth creation. The following highlights describe progress on a selection of projects and illustrate the range of our activities.

Pest and disease management

Entomology Branch has taken the lead in developing a new approach to pest management (Integrated Forest Management, IFM) which includes a wide range of disciplines to achieve sustainable, long-term reductions in the use of pesticides in forestry. Initially IFM research is focusing on the biology of the pine weevil *Hylobius abietis* and its interaction with restocking as a forest management process. The role of plant quality is being assessed in relation to the ability of transplants to tolerate different levels of attack. The population dynamics of *H. abietis* are being examined in order to develop predictive models of the relationships between population size and damage to transplants and to determine in advance the level of population reduction required to give acceptable plant protection.

Although the main elements of management of restocking pests is now concentrated within the IFM programme, tools for direct intervention are still required when population levels of *H. abietis* are predicted to exceed the damage threshold. For example, insect parasitic nematodes are being used to reduce populations of *H. abietis* breeding in the stumps of conifer crops. This project includes development of systems for rearing large quantities of nematodes (in partnership with CABI), methods for application to stumps and assessment of efficacy in field use. A total of 66 ha was treated with nematodes during 2000 and a reduction of up to 68% in *H. abietis* populations was achieved.

Permethrin, the currently approved insecticide used to protect transplants, will be phased out by 2003. This has led to an urgent programme to assess the efficacy of alternative active ingredients. Two pyrethroid insecticides, alpha-cypermethrin and lambda cyhalothrin, offer promise and are being investigated further to provide the data necessary for registration through the Pesticides Safety Directorate.

We have started a new phase of the programme to assess the impact of green spruce aphid, *Elatobium abietinum*, on growth of spruce. Studies are now concentrating on pole stage trees, using permanent scaffold towers to make accurate counts of aphid populations and tree growth parameters such as needle biomass, shoot lengths, tree height and tree diameter. By using insecticide fogging to keep some trees free from aphid attack, it will be possible to compare directly the effects of presence or absence of aphids. The experimental plots have been located at different altitudes to provide links to climatic variables, thus allowing data to be assessed against climate change predictions.

Methyl bromide is widely used as a pre-shipment or remedial treatment to kill pest organisms in wood or wood products moved internationally. Under the Montreal Protocol, this ozone-depleting gas will be phased out over the next decade. This programme, partially sponsored by the EU in collaboration with the Central Science Laboratory (CSL), Applied Plant Research Institute in the Netherlands and Enterprise Ireland (IE), is looking at alternatives to methyl bromide for quarantine treatment. We are concentrating on developing reliable methods for heat treatment of bark using natural composting processes. Unlike full composting, which takes weeks or months to complete, the use of the process for quarantine purposes is concerned with time scales as short as one week. Results from trials carried out during the past year, indicate that it is possible to reach temperatures in excess of 60°C in 2–5 days but this is not sustained throughout a compost heap.

Methods are being developed to improve the ability to reach lethal temperatures without the need for turning the composting bark. Other measures being investigated in collaboration with CSL include alternative active ingredients for fumigation and development of temperature indicating systems for use within heat treatment chambers.

Forest Research has played a leading role in gaining approval, as a commodity substance, of disodium octaborate tetrahydrate (DOT) for stump treatment against Fomes root and butt rot. The change from urea to DOT will result in large reductions in pesticide usage within the FC, because much lower doses of DOT provide effective treatment compared with urea. The process has also stimulated a review of the quality of the application systems fitted to harvesters. Various components have been identified where significant improvements can be engineered which would improve the quality of application and at the same time reduce pesticide wastage. In addition, the assessment of risk posed by Fomes *(see Forest Research Annual Report and Accounts 1999–2000)* has led to a reappraisal and rationalisation of the areas of forest where treatment is required.

Forest health

Since 1987 changes in the condition of five forest tree species have been monitored by annual assessment of a network of permanent observation plots distributed throughout the UK. In 2000, a total of 8376 trees was assessed comprising five species: Sitka spruce, Norway spruce, Scots pine, beech and oak. A marked deterioration in the condition of common beech was largely attributable, as in previous cases of decline in 1990 and 1995, to heavy mast production. Levels of damage from insects (particularly *Rhynchaenus fagi*) and fungi on beech were similar to those recorded in 1999. Changes in the condition of both Norway spruce and Sitka spruce were minor, the latter having yet to recover fully from severe defoliation by *E. abietinum* in 1997. A slight improvement in Scots pine reflected the low incidence of attacks by both the pine shoot beetle *Tomicus piniperda* and the defoliating fungus *Lophodermium seditiosum* in 2000. The condition of oak also improved, with damage by insects such as *Operophtera brunnata* and *Erranis defoliaria* being frequent but less severe than in recent years.

Pathogens: a fresh focus on Phytophthora

As part of an EU project, Forest Research has been investigating the cause of oak decline which is locally severe. Several different *Phytophthora* species were found associated with roots of oaks including one previously unknown in the UK. Pathogenicity tests showed some of the Phytophthoras were highly pathogenic to the fine roots or bark of native oak trees and these are probably playing a significant role in the die-back of oak under certain soil conditions. This rising profile of Phytophthoras as tree pathogens has been highlighted recently by the discovery of another new, aggressive *Phytophthora* causing sudden death of oaks in California. The potential threat this pathogen could pose to oaks in the UK has been analysed in a Pest Risk Analysis, and FR's Mycologist (Clive Brasier) recognised it as being highly similar, if not identical, to a *Phytophthora* recently found on rhododendron in parts of Europe.

Environmental monitoring

A demonstration project applying modelling at a physiological level to the Intensive Forest Health Monitoring Network has been completed. The study has been augmented by the measurement of net ecosystem carbon flux, litter-fall analysis, and understorey leaf area and biomass determinations to provide carbon inventory datasets for the validation of the process model, ForestFlux.

The assessment and development of best management practice for the protection of the freshwater environment continues to be an important area of work. One major output was a review of all of the available guidance on pollution prevention in UK forestry. This has now been published by the Environment Agency.

Lowland forests have generally been viewed as protecting groundwater quality from major agricultural pollutants such as nitrate and pesticides. However, recent measurements of drainage water quality beneath a Corsican pine stand in Clipstone Forest, Nottinghamshire have suggested that this may not always be the case. Further studies are under way to investigate high nitrate levels recorded in the upper soil at this site.

Trees and archaeology

The cultural heritage of Britain is a finite resource and we have undertaken research into the conservation of sites of archaeological importance. This work will allow more site-specific guidance on site management and advice on the potential implications of woodland establishment for archaeological remains.

Biodiversity assessment

Findings from the Biodiversity Assessment programme were presented to a major seminar of policymakers and forest managers in November 2000. The results will be made available to a wider audience in a Technical Paper, currently in preparation and due for publishing in 2002. The assessment programme has provided a sound baseline and revealed substantial biodiversity in Britain's planted forests. For example, a number of rare fungi, normally associated with semi-natural pinewoods, have been found to have colonised Sitka spruce stands. The findings have confirmed the value of several practical methods for improving biodiversity, and further analyses of the data are expected to provide reliable indicators of biodiversity.

We jointly organised two major conferences - on the Restoration of Forested Landscapes and on Deer and Biodiversity. Papers from the former are being prepared for publication as an FC Technical Paper, while those from the latter will be published as a special issue of the journal *Forestry.*

Silviculture and biodiversity: the Scots pine study

A 3-year EU funded project on 'The silviculture and biodiversity of Scots pine forests in Europe' which involved 21 participants from 11 European states was concluded. Scots pine forests are widely distributed throughout the EU, making up over 20% of the commercial forest area. During the last century, the overriding objective of silvicultural practice in this forest type was timber production which resulted in shorter rotations and more uniform and single species stands. This led to a loss in biodiversity, particularly where stands of old trees with abundant deadwood were brought under this management system.

Recent changes in forest policy in the various member states are leading to more 'natural' management systems with longer rotations, more mixed stands and greater use of natural regeneration. Despite these changes in forest structure, there was no evidence of serious effects in recent times upon genetic diversity in Scots pine, largely because of the safeguards provided by EU regulations on Forest Reproductive Materials. Reviews of both invertebrate and vegetation species associated with Scots pine forests suggested that there were no bioindicators that could be used operationally as surrogate measures of biodiversity at a Europe-wide scale. However, recently developed measures of stand structure and tree species composition could be used for this purpose. Such measures can be quantified and linked to tree growth models and so provide methods of evaluating alternative stand management strategies and their potential impact upon biodiversity.

Direct seeding

Direct seeding is an alternative silvicultural system in which tree seed is sown directly into the site intended for woodland creation. It has a number of potential advantages over conventional tree planting for new broadleaved woodlands. Through higher stocking rates it allows selection for better quality timber, gives a more rapid establishment of a woodland environment, utilises farm scale techniques and machinery, is cheaper in some circumstances and may offer a means of reducing herbicide inputs. Woodland stands resulting from direct seeding tend to have a variety of spacings and randomly occurring open space, similar to that advocated for new native woodlands. Disadvantages include unpredictability of germination, and a limited number of site species combinations. Experimentation has highlighted the importance of good weed control, protection and seed pretreatment. Detailed silvicultural prescriptions and recommendations will be published later this year. Investigations are continuing into fate and depredation of tree seed, quantification of possible reductions in herbicide use, the potential use of the technique for linking up existing areas of ancient semi-natural woodland and the use of direct seeding for restocking.

Alternatives to clearfelling

Work on alternatives to clearfelling (ATC) has led to a new FC Information Note on *Transforming even-aged conifer stands to continuous cover management,* and large scale ATC trial sites have been established on the FE estate.

Substantial effort during the year was given to supporting new initiatives introducing continuous cover forestry (CCF) to conifer plantation forests in various parts of Britain. An outline framework for classifying sites for their suitability for CCF was developed in conjunction with a User Group of Forest Enterprise and private sector managers. This guidance gives particular emphasis to potential stand vulnerability to windthrow, possible vegetation competition to regeneration and species suitability for the site based upon Ecological Site Classification (ESC). This is to be published as a FC Information Note. Other studies have been undertaken to investigate appropriate monitoring systems for stands being managed under CCF and support was given to training events on CCF in Wales, Scotland and England.

Social forestry

A seminar on Social Forestry was held at Alice Holt in December 2000. This brought together staff from across the FC, academics and landowners to discuss issues of current importance in relation to people and woodlands. Presentations set out the position and needs of FE, FC and FR and were followed by workshop discussions covering topics such as Social Sustainability, Stakeholder Analysis and Quality of Life. A major conference has been organised for June 2001 at Cardiff University on Social Science Research into Woodlands and the Natural Environment.

Forest design planning

A major initiative during the year was the development of a prototype decision framework for public involvement in forest design planning. This was the result of collaborative research with Dr Mark Twery of the Northeastern Research Station of the USDA Forest Service, whose three month stay in Britain was part funded by the Scottish Forestry Trust. The overall aim of the work was to provide forest managers with guidance to help them select appropriate tools for involving the public in their forest planning process. The framework involves three primary elements: a system to allow managers to assess which stakeholders should be involved; a flowchart to help managers to determine when the stakeholders should be involved; and a description of the appropriate tools to use according to the level of stakeholder involvement. The decision framework has received a favourable response when presented at training events for staff of Forest Enterprise and other countryside bodies. We aim to develop this framework further in the coming year and see it as one way of ensuring consistency of effort from staff involved in public consultation on forest design and of enhancing the likelihood of successful outcomes.

Log straightness surveys

Further surveys of Sitka spruce log straightness have been carried out in northern England and northern and western Scotland. The results agree

with those from south Scotland which we reported last year, namely that trees in stands planted in recent decades and at higher elevation are less straight than those planted in earlier decades or at lower elevations. Since log straightness is an important measure of quality influencing conversion rates at the sawmills, the implications are of importance for the timber processing sector. Work is now in hand to elucidate the causal reasons for this change.

Interactive yield models

A version of the Sitka spruce interactive yield models for forecasting timber production in Sitka spruce stands has been released for evaluation by selected users from industry, research and commercial organisations. The advantages of the new model are a comprehensive mathematical description of Sitka spruce growth, the ability to respond dynamically to a wide range of alternative silvicultural prescriptions, the capacity to forecast development and yield in stands managed on long term retentions and the capability to provide predictions of volume out-turn in terms of specified product assortments. The response from reviewers has been positive and commercial release of the software package is planned.

Recent collaboration between Mensuration Branch, Silviculture (North) Branch and a visiting senior researcher from New Zealand, Mr Leith Knowles, has provided the opportunity to evaluate a decision support system for Douglas fir stand management. The original system was developed in New Zealand over the past nine years from data gathered from more than 1000 sample plots, mainly drawn from replicated silvicultural trials. It includes modules dealing with effects of site, silviculture and genetics on stand growth, log quality and sawn timber out-turn. Results so far are promising and the overall approach may prove to be an effective way of providing improved models for even-aged stands of Douglas fir in the UK.

National Inventory of Woodland and Trees

The National Inventory of Woodland and Trees (NIWT) has two sections – the survey of woodlands of 2 hectares or more and the survey of small woodland and trees covering woodlands of less than 2 hectares, groups of trees, belts of trees and individual trees. The digital map of woodland of 2 hectares and over for GB has been updated to a common reference date of 31/03/00, and the fieldwork for the survey of woodland of 2 hectares and over in GB was completed early in May 2000. Results for the final two Scottish Regions of the survey of woodland of 2 hectares and over have now been published. Analysis of the primary data from both surveys (> and < 2 hectares) was completed for all counties and regions in England and Wales. Summaries for Scotland, England and Wales, and county and region reports for England and Wales, will include the results of both surveys, and will be published over the next year. The results show the extent to which woodland area has increased over the last 20 years.

NIWT results showing woodland cover compared with the previous inventory.

Woodland cover (%)		
Country	**Census of Woodlands and Trees Reference date 1980**	**National Inventory of Woodland and Trees Reference date 2000**
Scotland	11.8	16.5
England	7.3	8.6
Wales	11.6	14.0
Great Britain	9.2	11.8

New private sector forecasts of softwood availability were produced for Wales and England using the latest data from the NIWT. The results were combined with Forest Enterprise forecasts, plus the previously prepared Scottish forecast, and an overall forecast for Great Britain was presented to the FC's Advisory Panel and subsequently published. The results show softwood availability in GB is set to increase by 50% over the next 20 years to just over 15M m^3 per annum.

Advisory Committee on Forest Research

The Advisory Committee provides guidance to the Agency on the quality and direction of its research. The Committee met on two occasions and appointed two Visiting Groups of scientists to review the work of the Statisticians and of Woodland Ecology Branch.

The Visiting Group to the Statisticians was chaired by Professor Joe Perry from Rothamsted Experimental Station (BBSRC). The group found the quality of the statistical resource to be appropriate and acceptable, but was concerned over the sustainability of this level of achievement. They thus made a number of recommendations over the way that statistical services are provided and charged for and on the professional development of the statisticians. The majority of the recommendations are now being implemented.

The Visiting Group to Woodland Ecology Branch was chaired by Professor Brian Staines (retired Head of ITE Banchory). The group found 5 out of 7 programmes of research in the Branch to be comparable with the best international or UK standards with none of them being of an unacceptable standard. Specific comments were made on the need to allow time for writing up of research in peer-reviewed journals, the need for guidance to staff on publication requirements, the need to resource GIS work in the Branch, the lack of a professional ornithologist in the Branch and the advantages of getting sabbatical and similar non-FC staff to work in the Branch. Comments specific to individual programmes were also made and these will be of value to FC fundholders in commissioning research and to FR staff in future management of the Branch.

We are grateful to the members of the Advisory Committee and of the Visiting Groups for their valuable advice.

Finance

Income through the service level agreement with Policy and Practice Division declined by 2% to £9.8 million. Income from other parts of the FC including Forest Enterprise increased by 15% to over £1.4 million. Income from non-FC sources declined by 22%. Total expenditure declined by 2.5%. The target operating surplus of £519k was exceeded by £61k.

Total spending on capital was £587k which is over twice the rate of recent years. Major investment took place in IT equipment, refurbishment of laboratories, replacement of boilers and, in collaboration with CEH, gene sequencing equipment. Such investment is vital if Forest Research is to continue to carry out high quality, cost effective research.

Visitors

Both the Environment Subcommittee of the FC Advisory Panel and the FE Management Board met at Alice Holt during the course of the year. Many workshops were held either at the research stations or on forest sites. These included a one-day seminar on the new research programme on Social Forestry, and research updates for members of the Timber Growers Association and the Institute of Chartered Foresters. Seminar series with guest and Forestry Commission speakers were also hosted at Alice Holt and NRS. As part of the FC's programme of Technology Transfer, Technical Development Branch held several well-attended workshops at Aberfeldy and Inverness, in partnership with The Royal Scottish Forestry Society and Highland Birchwoods.

During the year we were pleased to have Dr Mark Twery of the USDA Forest Service, Leith Knowles of Forest Research (New Zealand) and Dr Thomas Jung of the Institute of Forest Botany (Munich) working with us as visiting scientists, as well as a large number of individual visitors and UK groups (MSc courses etc). The working meetings of a number of EU shared-cost projects were hosted and visitors from some 16 countries were welcomed to the research stations.

Targets and Achievements

Performance measure		1997/98	1998/99	1999/00	2000/01	
Customer satisfaction	Target Achieved	85% 90%	92% 94%	95% 96%	96% 97%	Target met
Peer-reviewed papers	Target Achieved	29 33	35 40	38 43	43 48	Target met
Unit cost/ research day 96/97 = 100	Target Achieved	98 98	96 94	94 94	94 94	Target met
Unit cost of support services	Target Achieved	- -	- 100	98 98	96 96	Target met
Cost recovery	Target Achieved	100% 101%	100% 103%	100% 100%	100% 101%	Target met

People

Total staff numbers employed by the Agency at year end excluding sandwich students and visiting scientists was 263 full-time equivalents, a reduction of 19 on last year.

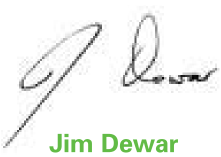
I am pleased to record the award of an MBE in the Queen's Birthday Honours to Yvonne Samuel who had recently retired from the Official Seed Testing Station at Alice Holt. Professor Barry Gardiner of Silviculture (North) Branch was appointed Associate Professor in the Department of Wood and Forest Science at the Université Laval, Quebec. Dr Helen McKay and Dr Alvin Milner won the ICF Silvicultural Prize for their paper on 'Species and Seasonal Variability in the Sensitivity of Seedling Conifer Roots to Drying and Rough Handling'.

Dr John Gibbs OBE retired after more than 30 years service with the Forestry Commission, including 18 years as Head of Pathology Branch, during which time he worked on a wide range of tree pathogens including Dutch elm disease, *Phytophthora* diseases of alder and Fomes *(Heterobasidion annosum)*. Dr Derek Redfern also retired from Pathology Branch after more than 30 years service during which time he worked on tree cankers, Fomes and blue stain pathogens. He was also a mainstay of the Disease Diagnosis and Advisory Service in the north and led the UK Forest Condition Survey. After more than 30 years with the Commission, Dr John Parker retired in Spring 2001. For 13 years he worked in Pathology Branch, mainly on beech bark disease, then for 10 years as Technical Publications Officer responsible for a large and varied output of publications, and from 1992 as Head of Communications Branch.

In common with the rest of the Forestry Commission, Forest Research unified its labour force dropping the distinction between industrial and non-industrial staff. This change, as well as giving more opportunities for staff, is leading to savings through greater flexibility in the deployment of staff. Following unification the Forestry Commission, including Forest Research, was recognised as an Investor in People.

New appointments to the Agency included Dr Kirsten Foot who is working on land reclamation, Dr Jason Hubert to work on timber quality, Dr Elizabeth O'Brien to study the social impacts and benefits of forestry and Dr Roger Trout to work on protection of trees against mammals. We also appointed Mrs Alison Melvin as our Business Development Manager.

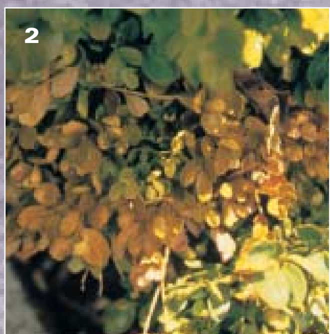
The success of the Agency in providing advice to policymakers, in equipping forest managers with improved methods and technical services and meeting key targets could not have been achieved without the skills, enthusiasm and commitment of the staff of the Agency.



Jim Dewar
Chief Executive, Forest Research

Pests and Diseases

by Hugh Evans and Joan Webber



1 Exotic longhorn beetle: adult of *Batocera*

2 Foliage affected by box blight fungal disease

3 Oospore of alder Phytophthora (Dutch variant)

4 Larva of browntail moth showing barbed hairs

Introduction

Awareness of the threats posed by both native and, especially, exotic pests and diseases is a core requirement. Entomology and Pathology Branches devote considerable efforts to improving Pest Risk Assessment (PRA) methods and are frequently in touch with other scientists and Plant Protection Organisations worldwide. During the past year a new panel of the European and Mediterranean Plant Protection Organisation (EPPO) has been evaluating the risks posed by pests from the former Soviet Union. Meetings in Helsinki (Finland), Perm (Russia) and Paris (France) have concentrated on determining the pests and diseases of most significance. The panel is now carrying out full PRAs on the list of organisms identified by experts from the Soviet Union. This approach has the benefit of including expertise from both the importing (the PRA area) and exporting countries. Consensus on the listing of prospective pests and on the risks that they pose will benefit exporting and importing countries alike.

In relation to PRA technology, scientists from both Branches have been active in assessing risks and in developing new methods for evaluation of the threats posed by organisms of plant health significance in international trade. One such high profile example is the risk posed by a new fungal pathogen, *Phytophthora ramorum*, which is causing widespread and sudden death of oaks in California, USA (see www.suddenoakdeath.org), but has also been found sporadically in parts of Europe causing a disease of rhododendrons. Clive Brasier has been involved in advising on the problem in both Europe and the USA. More generally, Hugh Evans was co-organiser with the USDA Forest Service of an international symposium on the threats posed by movements of pests internationally, at the IUFRO World Congress in Malaysia. The symposium title, Biological Invasions of Forest Insect Pests - Agents of Global Change, and the 12 papers presented by speakers from eight countries, reflected the threats posed by rapid and increasing international trade in all commodities that involve, in some form, wood or wood products. In a similar vein, Forest Research has been active in a new venture on plant health in which internationally renowned authors provide key papers for an on-line workshop designed to initiate debate on the threats posed by international movements of pests and diseases. Hugh Evans has acted as co-ordinator of a session on the biology of quarantine pests and diseases and a joint paper by Joan Webber and Clive Brasier provides insight into the threats posed by sapstain and vascular pathogens. Uniquely, the papers from this symposium will be accessible on the internet and there will be opportunities for both experts and lay participants to contribute to the debate on this important plant health topic. Undoubtedly, knowledge will be increased but at the same time new questions will be posed that require further efforts by researchers in Forest Research and elsewhere.

Threats from abroad

Horse chestnut leafminer, *Cameraria ohridella*

The appearance in Europe of the leafmining moth, *Cameraria ohridella* (Lepidoptera: Gracillariidae), on horse chestnut, *Aesculus hippocastanum*, is a cause of considerable concern, especially since it appears to cause both leaf damage and loss of growth in attacked trees. The precise geographical origin of *C. ohridella* has not been established but since the first reports of its appearance in Macedonia in 1985, it has spread rapidly across Europe. It has been suggested that this expansion of range is linked to human transportation, particularly accidental movement of infested leaves on vehicles. There have been no reported sightings of this insect in the UK but it is known to be present in western Europe including Belgium, The Netherlands and France.

The larvae of *C. ohridella* develop within the leaves, feeding between the upper and lower epidermises. The resulting serpentine mines, which are at first translucent, may reach 4 cm in length (Plate 1). On heavily infested trees with multiple attacks on the

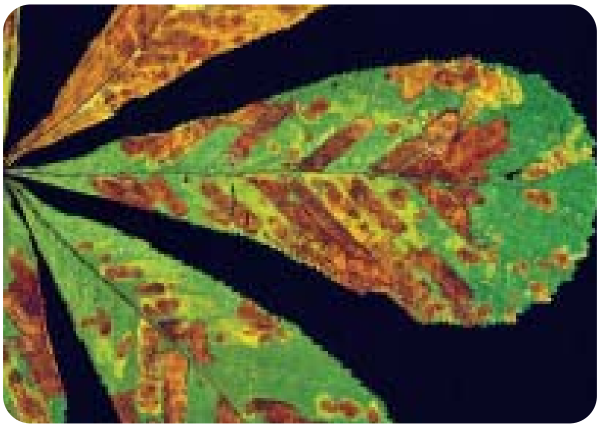


PLATE 1

Leaf of horse chestnut showing damage by horse chestnut leaf miner. (J. Metzger, LWF)

same leaf, the mines often merge together leading to browning and drying of the leaves, which eventually curl upwards and inwards at the edges and fall prematurely. Early leaf-fall can affect 70–100% of the leaves on a single tree. At first glance, *C. ohridella* mines could be confused with the red-brown blotches caused by the fungus *Guignardia aesculi* (Plate 2).

PLATE 2

Damage caused by (a) *Guignardia aesculi* and (b) *Cameraria ohridella* on horse chestnut. (Th. Lohrer)

Life cycle of *Cameraria ohridella*

Depending on weather conditions and climate, up to five overlapping generations per year have been reported, especially in hotter and drier conditions. In Western Europe, up to three generations per year seems to be the average. Adults appear in April and are up to 5 mm long with metallic-brown wings having transverse white stripes with black edges (Plate 3). Eggs are laid along the lateral veins on the upper side of the leaflet; between 200 and 300 per leaflet and 700 per compound leaf have been counted. Eggs hatch in 2–3 weeks.

PLATE 3

Adult of horse chestnut leaf miner. (P.Roose)

Larvae pass through five instars and complete their development in about 4 weeks (Plate 4). They feed inside the leaf tissue, leaving only the upper and lower epidermises intact. The final, pupal, stages develop in a silken cocoon in the mine, and generally complete development in about 2 weeks, but this stage can last for 6–7 months in the over-wintering generation. The over-wintering pupae are found among the fallen leaves and are known to be extremely frost tolerant, surviving temperatures as low as –23 °C in Hungary. Throughout the summer it is possible to find all developmental stages present in attacked leaves.

PLATE 4

Mine caused by larva of horse chestnut leaf miner. (J. Freise)

Spread of infestation and type of damage

Once established in an area, population densities can increase rapidly although the natural rate of spread in an undisturbed population is slow. However, passive carriage on vehicles from infested areas has been shown to be a highly effective and speedy method of dispersal.

The threat

In the UK most tree species have associated leaf miners. While infestations of these can be disfiguring, even severe attacks are not regarded as affecting the overall health of the host tree in a significant way. However, *C. ohridella* may prove to be of greater consequence to the health of *Aesculus hippocastanum* (and also *Acer platanoides and A. pseudoplatanus*, the other known hosts of *C. ohridella*) due to a combination of the following factors:

- Multiple, overlapping generations can result in rapid infestation of leaves and both the primary and the second flush may fall prematurely.
- Pupae appear to be extremely frost tolerant. This can lead to increasing populations from year to year even when winters are severe.
- Numbers can build up rapidly following establishment in a new location, e.g. the heavy damage in Brussels during 2000, even though the moth was not noted in the previous year.
- Rapid long distance dispersal arising from passive transportation on vehicles can lead to new infestations at locations remote from known centres of attack.
- The pest does extremely well in hot dry conditions when the tree may be already suffering drought stress. *C. ohridella* can, therefore, be a contributory factor in further tree decline.
- Spread via vehicles tends to favour establishment in urban areas where growing conditions are less than ideal and trees are less able to withstand the effects of additional stresses.
- Horse chestnut and the other known hosts are significant amenity trees in urban and suburban areas so that both visual damage and loss of growth are more serious than in rural locations.

Trees heavily attacked by *C. ohridella* are not reported to die, but reduced growth of young trees has been noted. Continuing repeated defoliation, especially when it occurs early in the growing season, may lead to an overall gradual decline in tree vigour. The long-term effects are not yet known.

Control options

Biological control: Approximately 15 species of natural enemy (mainly parasitic wasps) have been identified within the known distribution area of this pest. However levels of parasitism and predation within established populations appear to be low (1–8%).

Chemical insecticides: Various chemical agents have been tried but it seems unlikely that these can be used successfully or routinely in urban situations.

In areas where there has been removal and destruction of dead leaves in the autumn and winter (in cities for example) there has been reduced damage locally. However in the long term this could also decrease the numbers of natural control agents that over-winter in the leaves.

Quarantine measures

It is not practical to prevent spread using phytosanitary measures because of the known propensity for passive dispersal of infested leaves on vehicles. Transportation to Britain is therefore highly likely and it is important to be aware of the possible establishment of the moth. The Forestry Commission is increasing its vigilance to try to detect possible infestations as early as possible so that the biology and potential impact of the moth can be evaluated and the possible need for appropriate control measures determined. This information will be available as an Exotic Pest Alert and in electronic form on the Forestry Commission website (www.forestry.gov.uk) (Tilbury and Evans, in press).

Conclusions

It is unlikely that *C. ohridella* would be able to complete more than one or two generations even in a warm dry summer in the UK. However if this pest shows more climatic tolerance than observed to date, particularly combined with any increase in the frequency of hot dry summers, it may pose a greater threat than predicted on the basis of current knowledge.

Longhorn beetles, Coleoptera: Cerambycidae

Exotic cerambycids are imported frequently into Britain and some, including *Trinophylum cribratum* from India and *Nathriius brevipennis* from southern Europe, have become established here, although neither of these species causes any significant damage. Cerambycids are conveyed easily in timber mainly because larval stages live deep within the wood and can have a prolonged period of growth in sawn timber or in wooden packaging, eventually emerging as new adults in the destination country. Interceptions are regularly made on a variety of commodities from around the world.

The Asian longhorn beetle, *Anoplophora glabripennis*, is frequently associated with packaging wood from China (Evans and Gibbs, 1999). It causes considerable damage, both in its native range and in the USA, where it is present in street trees in New York and Chicago. Despite the introduction of EU legislation in 1999 governing the standard of solid wood packaging material entering Britain, live larvae and adult beetles continue to be intercepted, although in far fewer numbers than before the legislation. It remains a cause of considerable concern to us in Britain.

Those involved in trading in non-wood commodities, where wood is used only as packaging, may be less aware of plant health controls than wood importers and considerable effort has gone into increasing the level of awareness among all importers. This has resulted in the reporting of an increasing number of species of cerambycids, as well as other wood boring beetles, in addition to the Asian longhorn beetle. Included are species of *Monochamus*, which are prohibited on account of being known vectors of the potentially lethal pinewood nematode (PWN), *Bursaphelenchus xylophilus*. Notable among these is *M. alternatus*, a native of China and Japan, where it is the principal vector of PWN.

No exotic pest cerambycid species have been found outside harbours, timber yards or other premises where imported timber or wood products have been stored. This may be explained by factors affecting the likelihood of a species establishing, such as climate, lack of suitable breeding material or insufficient individuals to establish a pioneer population. However it is possible that a small population with a restricted distribution might be overlooked as was the case with the bark beetle *Dendroctonus micans* which appeared to have been present in the country for about 10 years before it was spotted.

Pinewood nematode

Pinewood nematode, *Bursaphelenchus xylophilus*, is a microscopic nematode worm that is native to North America where it lives mainly on dying or dead trees and rarely affects healthy living trees. The nematode is carried from tree to tree by longhorn beetles in the genus *Monochamus* (see the section on longhorn beetles). When trees are susceptible and average temperatures are high (July/August isotherm > 24–26 °C), nematodes introduced into the crowns of trees may enter the water conducting vessels, breed and, by increases in numbers and production of a toxin, eventually kill the tree. Tree death can be rapid and give rise to characteristic wilting in which needles redden within a few weeks of nematode introduction.

PWN has established in a number of new locations world-wide where extensive tree mortality has been observed. It is now a serious pest in Japan, China, Korea, Taiwan and in 1999 was also found in Portugal (Gibbs and Evans, 2000). One of the strategies adopted by the EU, in response to the outbreak in Portugal, was to ask Member States to carry out surveys to determine whether the nematode is present in their territories and also to assess whether either the nematode or its vector is being carried to the EU on imported wood.

A standardised method for carrying out the surveys was developed by the EU. In the UK, 118 conifer samples were taken and checked for the presence of *B. xylophilus* infestation. Sampling was concentrated on the identification of 'high-risk' sites, primarily those associated with points of wood import (harbours) known to take material from countries having PWN.

- *Sampling of direct imports at the point of landing*
  - Packing wood in the form of crates, pallets, packing cases, dunnage etc.
  - Imported timber bundles.
- *Sampling at premises where imported wood is handled or stored*
  - Sawmills and wood processing mills.
  - Warehouses and depots in the case of packing wood transported in sealed containers.
- *Forest and individual trees*

These were in locations adjacent to points of wood import, handling or storage of wood using the following criteria:

- Forest trees within a 5 km radius of points of wood import, handling or storage of wood. If there are no forest blocks within 5 km this should be increased to 25 km.
- Other sources of potential host trees, i.e. small woodlands, isolated trees, parkland trees around points of wood import, handling or storage of wood.

- *Selection of conifer species*

In Britain, Scots pine, *Pinus sylvestris,* is the only commercially grown species known to be highly susceptible to PWN. Surveys were therefore concentrated on Scots pine but other conifer species were included at some sites. A map summarising sampling locations is shown in Figure 1. In addition to these sites, three samples were received from Guernsey, two from growing trees and the third from packaging wood from Japan. *B. xylophilus* was not extracted from any of these samples. Live nematodes were extracted from 65% of the samples. In no instance was *B. xylophilus* found to be present.

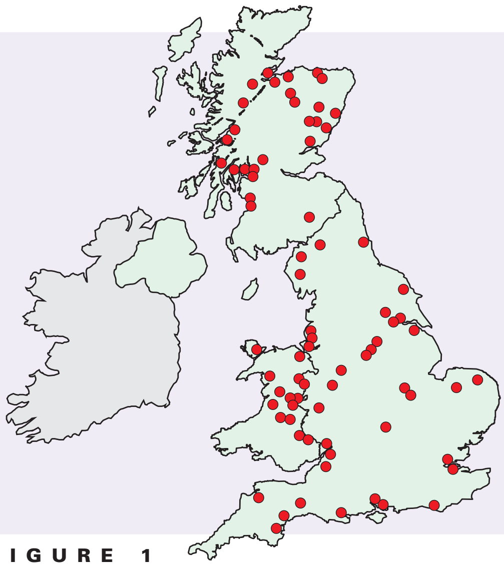


FIGURE 1

Map showing sampling locations for EU pinewood nematode survey.

In both its native range in North America and in countries where it has become established, *B. xylophilus* is vectored (carried from tree to tree) by longhorn beetles in the genus *Monochamus*. Although nematodes have occasionally been found on other beetle genera in several beetle families, there is no evidence that they were effective vectors of the nematode. The risk of transmission from wood to trees without the presence of the *Monochamus* vectors is extremely small.

There are no native *Monochamus* species in the UK, therefore the risks of establishment are relatively low because both the vector and the nematode would have to be imported and successfully transfer to British trees. However, as indicated in the section on longhorn beetles in this report, interceptions of *Monochamus* species have been noted on a number of occasions and thus present a significant risk.

Established pest and disease problems

Great spruce bark beetle, *Dendroctonus micans*

The discovery of *D. micans* in Kent in the 1990s, and the subsequent programme of sanitation felling and release of the specific predator *Rhizophagus grandis,* has considerably increased the survey effort on this damaging bark beetle and has led to new assessments of management strategies.

Annual peripheral zone surveys on the eastern edges of the known infested area in Wales, the bordering counties of England and in Lancashire have provided information to confirm that natural spread occurs at an average rate of between 2 and 5 km per annum. These data have been used to carry out a financial appraisal of the current strategy, which comprises surveys on the periphery of the infested area, restriction of timber movement from the *Dendroctonus micans* Control Area (DMCA) into the uninfested *D. micans* Protected Zone, sanitation felling of any new infestations found and release of *R. grandis* (O'Neill and Evans, 1999). The appraisal confirmed that the current strategy was cost-effective at *D. micans*-induced tree mortality rates of 0.5% or greater and an annual natural beetle spread rate of 2 km or greater. However, during 2000, new infestations were discovered in both Westonbirt and Bedgebury Arboreta. Combined with the continuing outward spread of the known infested areas in the DMCA and Kent (Figure 2), this has led to a reappraisal of management options which includes consideration of changes to the DMCA boundary and also the form and frequency of surveys. In the meantime, intense management of the isolated infestations in Kent continues. This includes 100% surveys of all spruce, felling of infested trees, removal of bark to kill any *D. micans* present and release of *R. grandis* into all infested woodlands.

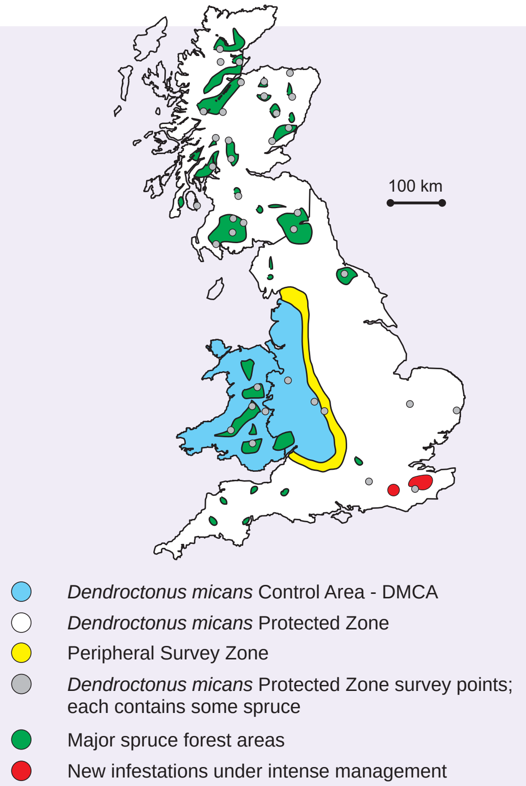


FIGURE 2

Map showing *Dendroctonus micans* control and survey areas in UK mainland.

Browntail moth

The browntail moth, *Euproctis chrysorrhoea*, is a member of the lepidopteran family Lymantriidae, which contains some of the most destructive moth pests world-wide. It was first reported as a pest species in Britain in 1720 by the naturalist Albin and since then numbers have fluctuated irregularly. Browntail moth is widely distributed in central and southern Europe but appears to be more a coastal and river-associated species in northern Europe. In Britain, populations occur in scattered localities predominantly in the south and east, but its range fluctuates from year to year and it can occur as far north as Yorkshire.

Browntail moth caterpillars (page 12) feed on leaves of many hardwood trees and shrubs and, at high population levels, may completely defoliate the host. Commonly infested trees and shrubs include hawthorn, blackthorn, ash, bramble, cherry, willow and privet. However, the principal concern arises because of the human reaction, often severe, to contact with the caterpillar hairs. These hairs are barbed and hollow and contain chemicals that can give rise to allergic reactions in both humans and animals. Direct contact, especially with the larger larvae, produces the most extreme reactions because large numbers of hairs break off. In addition, the hairs are small enough to drift on the wind, thus affecting others not in direct contact with the larvae. Reactions include skin rashes and irritation, conjunctivitis and asthma attacks. Hairs can embed themselves in clothing leading to further sources of irritation. Repeated exposure can give rise to hypersensitivity and the necessity for hospital treatment.

There was a slight increase in the number of reports of problems from browntail moth during the summer months, which is consistent with the known fluctuations in numbers associated with this insect. However, direct control could prove to be more problematical in the future as there are now very few insecticides with specific approval for use against the caterpillars available to the professional, and those still remaining are most effective against young larvae. This could create difficulties because the problem is often not recognised until the larvae are well grown and thus less susceptible to the spray. The use of the bacterial insecticide *Bacillus thuringiensis* is still an option but this is also most effective when applied to young larvae, which must ingest the bacterial toxin to be killed. The alternative, non-chemical, strategy for dealing with these caterpillars involves cutting out and destroying the webbing nests in which young caterpillars aggregate to spend the winter months. The lack of larval activity means that far fewer hairs are released than when the caterpillars are active in the autumn and spring, although protective clothing is still required. The method is labour intensive and requires adequate survey to locate all the nests, and can only be of value in an area where the caterpillars have been previously identified.

Phytophthora disease of alder

This disease continues to cause concern, with new records in Scotland. An estimated 580 000 trees are now affected, comprising more than 12% of the alder population. There is also increasing evidence that the pathogen can be disseminated via young alder plants which have become infected in the nursery, either by watering with contaminated river water or through the importation of infected saplings. Many nurseries do not grow their own alders from seed but buy them in as young plants from other European countries and grow them on before resale. If such stock is then planted out to woodland and riverside sites, new infection foci may be established. This could account for the rapid dissemination of the alder Phytophthora to many parts of Europe. Evidence linking the disease with nurseries comes not only from the UK, but also from Germany, Italy and Sweden.

Since the disease was first identified in 1993 (Gibbs *et al*., 1994) our understanding of the status of the alder pathogen has changed markedly. Its hybrid origin has now been established beyond doubt – the parent species being *Phytophthora cambivora* and a fungus close to *P. fragariae* (Brasier *et al*., 1999). However, the new pathogen is not a homogeneous unit but exists as a swarm of distinct hybrid types: a widely distributed 'standard type' with two sets of chromosomes – one from each parent – and several so-called 'variants' which have a more restricted distribution. The variants are morphologically and behaviourally distinct and may have been generated from the genetic breakdown of the standard type, or be the products of back-crosses or further hybridisation events. Frequently they are significantly less pathogenic to alder than the standard alder Phytophthora (Figure 3) and evolution of all the hybrid types appears to be a continuing process. It is striking that the hybrid pathogen is very damaging to alder and can cause significant levels of bark necrosis in just a few weeks, but the putative parent species cause little or no damage to alder although they are aggressive pathogens of other woody hosts.

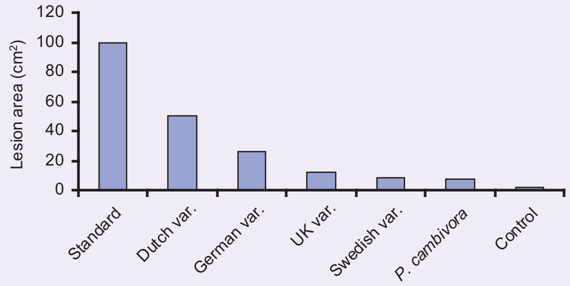


FIGURE 3

Lesions provided by different forms of alder Phytophthoras and *P. cambivora*, inoculated into freshly felled alder logs and measured after 6 weeks to quantify pathogenic potential.

Weather-related and periodic damage

Spring 2000 was very wet throughout the UK; rainfall was over three times greater than normal during April in England and this, combined with periods of cool weather, encouraged the development of a number of leaf and shoot diseases. The most prominent included willow scab *Pollaccia saliciperda* (Plate 5) and cherry leaf spot caused by *Blumeriella jaapii* (Plates 6 and 7).

PLATE 5

Willow scab caused by *Pollaccia saliciperda* on willow species *Salix alba vitellina*. (Forest Research Photo Library 41213)

PLATE 6

Cherry leaf spot on *Prunus avium*. (Forest Research Photo Library 41210)

PLATE 7

Detail of cherry leaf spot caused by *Blumeriella jaapii*. (Forest Research Photo Library 40667)

In some cases, willow scab was so severe on *Salix fragilis* that virtually no live foliage remained, raising the possibility of widespread dieback and even death of affected trees.

In England, the summer months continued to be wet and cool. Such conditions favour the development of *Phytophthora* diseases and these were widely reported, most notably on yew and silver fir, *P. cinnamomi*. There were also more cases of bleeding canker, *P. cactorum*, continuing the pattern of last year when this pathogen caused unusually severe damage to horse chestnut.

In contrast, July in Scotland was very dry with temperatures reaching 27 °C and these conditions exacerbated a problem of fertiliser scorch on a Fraser Christmas tree plantation. Browning of the current year's needles was noted within two weeks of the application of a granular fertiliser, and lack of rainfall combined with high temperatures enhanced the desiccating effect of the fertiliser residue which remained on the foliage.

A severe gale in the north and west of Scotland on 13 June caused physical damage to many trees in these areas; both conifer and broadleaf trees were affected. Wilted and dead shoots were visible on the current year's growth of some Sitka spruce and *Abies* species, while on other trees the damage was directional. Strong winds at the end of 2000 in England also caused a significant number of trees on roadsides and banks to blow over, but despite the exceptionally wet autumn and heavy rainfall in the following spring with accompanying floods, there have been few damage reports. However, the snowfall which affected central Scotland in February 2001 was heavy enough to cause snow break on some trees.

Green leaf weevils

A large number of enquiries were received during the spring and early summer from anxious callers requiring advice regarding the defoliation of recently established broadleaved trees. The insects responsible were a group of leaf-feeding weevils (Coleoptera: Curculionidae) belonging to the genus *Phyllobius*. A number of different species were involved, the most common being *Phyllobius pyri*, which can be found on a variety of tree species. Other species included *P. argentatus* and *P. roboretanus*, the latter being more frequently associated with damage to oaks. Although damage is most often seen on broadleaved tree species, conifers can also be attacked. The group has been given the common name of 'green leaf weevils' on account of the brilliant green or bronze-green colour of the adult beetles.

When the adults are present in high numbers they can completely defoliate young trees which seem especially vulnerable when they emerge from the tops of treeshelters. The damage occurs between April and July, after which time the adult weevils disappear quite suddenly and damage ceases. The young trees usually recover, although growth can be checked, and they are able to produce a second flush of leaves which are not attacked. Repeated annual attacks can lead to a loss of vigour and may result in bushy, multi-stemmed tops developing in some trees.

New or unusual records

Box blight

Box blight, *Volutella buxi,* has been known in England since the mid-19th century but reports of the disease are rare. During the year it was found in Scotland infecting *Buxus* in a newly planted millennium garden. Previously the disease has only been noted from scattered localities in England and once before in Scotland.

Dieback in birch and poplar

There has also been an increasing number of reports which relate to the failure of trees planted under the Woodland Grant Scheme, particularly in Scotland and northern England. Many of the failures occur during the establishment phase and in some cases the problem may not be primarily pathological but caused by a number of factors. Failure of birch is frequently associated with leaf spots and stem lesions or defoliation by rust, although this is unlikely to be the cause of extensive branch dieback that was reported. At another site severe dieback and death occurred on 7-year old poplar clones Beaupré and Boelare on a farm woodland scheme. This occurred possibly as a result of severe defoliation in the previous year followed by damage by unseasonal frosts in 2000.

Red band needle blight

Red band needle blight, caused by the fungus *Mycosphaerella pini* (syn. *Scirrhia pini*), led to widespread damage to Corsican pine in Thetford Forest Park and at least two private woods in southern England. This potentially serious disease (also known as Dothistroma needle blight) is listed in EC plant health legislation and was last recorded in the UK in 1989, but this is probably the most significant outbreak in England for 40 years. There has been a notable increase in the severity and distribution of the disease in France over the past few years (Villebonne and Maugard, 1999) and the outbreaks in England may herald a similar increase in intensity. The disease seems principally to affect stands between 15 and 30 years of age and can be particularly severe in dense, unthinned stands. Symptoms usually appear in autumn and become more conspicuous through the winter (Plate 8a and b). Pathology Branch has set up an FC internet page to alert growers of Corsican pine to the disease.

(a)

(b)

PLATE 8

Red band needle blight on Corsican pine showing (a) the reddish-brown necrosis of the foliage and (b) banding on individual needles. Note also the necrosis towards the needle tips. (a: John Gibbs; b: Forest Research Photo Library 39129)

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Biodiversity in Planted Forests

by Jonathan Humphrey, Richard Ferris, Martin Jukes and Andrew Peace

1 Overmature Sitka spruce: a natural reserve to encourage structural diversity and deadwood habitats

2 Long-tailed tit nesting in gorse within a forest ride

3 Chickweed wintergreen, a characteristic herb of northern forests

4 Hoverflies feeding on leopard's bane

Introduction

The majority of planted forests in Great Britain were established in the 20th century, usually on previously open ground with no recent history of forest cover (Hodge *et al.*, 1998), but occasionally through conversion of ancient semi-natural woodland (Spencer and Kirby, 1992). Introduced conifer species such as Sitka spruce *(Picea sitchensis)* and Corsican pine *(Pinus contorta* var. *maritima)* make up a large proportion (66%) of the planted area. Opinions differ as to the potential value of these 'new forests' for biodiversity. Attention has often been drawn to deleterious effects on the flora and fauna of the habitats which forestry replaces or modifies (e.g. Ratcliffe and Thompson, 1989), but there have also been a number of studies which have highlighted the positive value of planted forests for wildlife (e.g. Petty *et al.*, 1995). However, these studies have been mostly site specific, and there have been no comparative studies of plantations of different crop species in contrasting bioclimatic zones, or on a range of varied site types. Similarly, there have been few attempts to compare the biodiversity of planted forests with that of native or semi-natural woodlands. With continuing pressures on forest managers to improve the biodiversity of planted forests, e.g. the Forest Certification process (Anon., 2000), baseline information is urgently needed to provide a quantitative framework for understanding the levels and types of biodiversity currently found in plantations, and to inform the development of biodiversity enhancement strategies.

An additional problem is that the comprehensive assessment of biodiversity is an extremely difficult task. It is rarely cost-effective or practical to conduct a complete census of all taxa within a forest stand, let alone an entire catchment or forest landscape. Therefore, the identity of biodiversity 'indicators' or surrogate measures of biodiversity has become a research priority in recent years (Ferris and Humphrey, 1999). Examples of potential indicators include: deadwood, vertical stand structure, and the occurrence of particular tree species such as birch (*Betula spp.*). However, the link between such indicators and wider biodiversity has not been substantiated to the same degree in British forests as in other countries.

In this article we present results from a 5-year programme of research aimed at:

1. Obtaining baseline information on the types/levels of biodiversity in planted forests.
2. Evaluating the contribution of planted forests to the conservation of native flora and fauna through comparisons with semi-natural woodlands.
3. Identifying potential biodiversity indicators by relating the diversity of range of measured taxa to soil, climate, vegetation and stand structure variables.

Summary data are presented for all taxa analysed to date. Initial results from this programme were presented in *Forest Research Annual Report 1997–1998* (Ferris-Kaan *et al.*, 1998). Ground vegetation, fungi, lichen, bryophyte and selected invertebrate datasets are considered in more detail, and potential indicators of diversity within these groups are discussed. A number of management options for improving habitat quality are identified. A full analysis of the datasets for these and other species groups are presented in a forthcoming Technical Paper based on the proceedings of a symposium held at Harrogate in November 2000 (Ferris and Humphrey, in press).

Study sites

Assessment sites were selected from within the 'lowland', 'foothill' and 'upland' bioclimatic zones of the Ecological Site Classification system (ESC; Pyatt and Suárez, 1997). The zones are defined by annual precipitation totals (lowlands < 800 mm; foothills 800–1500 mm; uplands >1500 mm). Study sites were established in the main crop and semi-natural woodland types within each zone (Figure 1). At the majority of sites, a chronosequence of four 1 ha (100 m x 100 m) permanent sample plots was established in forest stands encompassing different growth stages based on the normal economic rotation (1: pre-thicket, 2: mid-rotation, 3: mature, 4: overmature). Wherever possible, individual chronosequences were established on sites with similar soils, climate and site history.

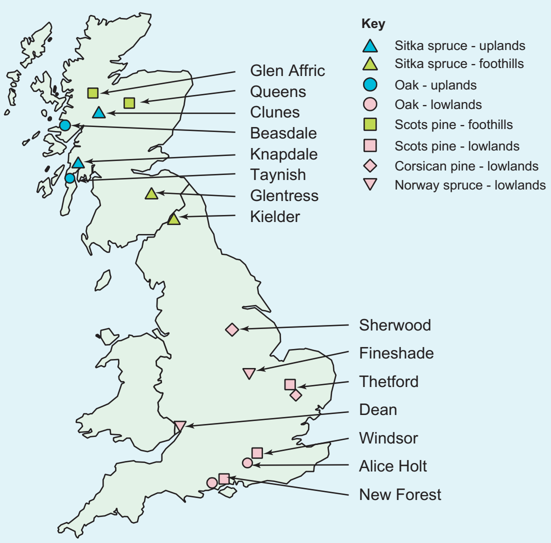

FIGURE 1

Location of biodiversity assessment plots; 52 plots were sampled in total over a 4-year period.

Assessment methods

Plots were selected to minimise heterogeneity in stand structure, species composition, topography and hydrology. A standardised system of assessment was established to maximise potential comparisons between measured attributes and to minimise disturbance during sampling. The plots were permanently marked. Assessments were carried out over a 3–4 year period and covered: structural aspects of biodiversity, such as vertical foliage cover and deadwood; taxa important in ecosystem functioning (e.g. fungi); a range of different groups making up the 'compositional' aspect of biodiversity (e.g. invertebrates).

Practicality and cost also influenced the selection of species groups to assess. Invertebrates were sampled from deadwood and three separate vertical strata (canopy, sub-canopy, ground). Canopy dwelling species were sampled using a canopy insecticide fogging technique (Jukes *et al.*, in press), sub-canopy species by malaise traps (Humphrey *et al.*, 1999), and ground species by pitfall traps (Jukes *et al.*, 2001). The frequency and abundance of vascular plants and fungi were sampled in eight sub-plots within each 1 ha plot (Ferris and Humphrey, in press). Species frequency and abundance estimates were made for lichens and bryophytes growing on individual pieces of deadwood (Humphrey *et al.*, in press). Volume and decay status of fallen deadwood (logs), standing deadwood (snags) and stumps were recorded within each plot. Songbird monitoring was undertaken by point counts and territory mapping (Ferris and Humphrey, in press). Data analysis methods for the various groups are described in full in the publications cited above.

Overview of results

Over 2000 species have been recorded to date (Table 1) with nearly half of these being invertebrates. A surprisingly high number of species were recorded in the planted stands, with lowland Scots pine and Norway spruce stands being the most species-rich of all the crop types. Stands in northern Britain (foothills and upland) had generally less diverse invertebrate and songbird communities than those in the south, but richer lichen and bryophyte communities. It had been expected that the native woodland stands would be considerably more species-rich than the plantations, but this was only the case for some groups such as vascular plants and lichens. These results are due in part to under-sampling of some groups in the native stands (e.g. birds, Table 1), and to a lower number of stands surveyed (e.g. 4 upland oak stands compared to 8 upland Sitka spruce stands). However, the positive value of plantations for groups such as the beetles and hoverflies is substantiated by other studies in

Table 1 Total number of invertebrate, fungi, lichen, bryophyte, vascular plant and songbird species recorded in each forest/climate zone type. Ninety-four coleoptera species (from a total of 474 species records excluding carabids) were recorded in more than one of the three vertical strata (canopy, sub-canopy, ground).

	Lowland				Foothill		Upland		Total species	Red Data species
	Corsican pine	Scots pine	Norway spruce	Oak	Scots pine	Sitka spruce	Sitka spruce	Oak		
Canopy invertebrates										
Coleoptera[a]	71	81	86	66	53	66	47	31	225	2
Sub-canopy invertebrates										
Cicadomorpha[b]	55	68	72	–	35	22	33	–	133	0
Syrphids[c]	27	43	37	15	25	22	29	22	59	4
Coleoptera[d]	76	109	114	80	61	52	52	62	228	4
Ground invertebrates										
Coleoptera (excluding carabids)[e]	36	54	52	25	30	29	35	19	116	1
Carabids[f]	30	21	29	16	18	23	17	18	53	1
Deadwood invertebrates[g]	23	24	21	8	20	14	23	2	64	3
Fungi	94	249	170	181	210	88	232	127	677	29
Lichens	11	29	14	51	100	23	46	102	202	2
Bryophytes	25	35	32	37	31	39	54	60	111	0
Vascular plants	28	34	47	55	27	29	40	60	143	0
Songbirds	18	25	27	–	17	16	15	–	40	0
Totals	494	772	701	534	627	423	623	503	2051	46

[a] Beetles – 37 families; [b] cicalids – 5 families; [c] hoverflies; [d] beetles – 30 families; [e] beetles – 26 families; [f] ground beetles. [g] The deadwood invertebrates category comprises data from a number of insect groups, many of which remain to be analysed. It is anticipated that more species will emerge from the deadwood collected from the oak stands.
– no data available.

planted forests (Humphrey *et al.*, 1998). A scattering of Red Data list species were recorded across the majority of species groups, but the most striking result was for the fungi where 29 Red Data list species were recorded, suggesting that plantations provide a particularly valuable habitat for rare fungi. Fungi, however, have been under-recorded in the past compared to other groups, particularly in plantations, so many of these species may be less rare than previously thought.

Ground vegetation

Although ground vegetation diversity was closely related to soil nutrient levels there was also an effect of stand age on vegetation community composition, with the vegetation in most crop types becoming progressively more wooded in character through the stand cycle (increase in woodland similarity coefficient – Table 2). This process is a function of stand age (enough time has elapsed to allow slow-colonising woodland plants to become established in the stand), but may also be related to site history, i.e. whether the stand was established on a site previously occupied by ancient semi-natural woodland. Nevertheless, the plantation coefficients are still lower than those of the semi-natural woodland 'control' plots (oak and overmature foothills Scots pine), and only time will tell whether the wooded character of the vegetation of the overmature planted stands will continue to develop.

Table 2 Changes in the woodland vegetation similarity coefficient in relation to stand stage and crop type. The woodland vegetation similarity coefficient gives a measure of how closely the sampled vegetation is matched to a National Vegetation Classification (NVC; Rodwell, 1991) semi-natural woodland community type relative to a non-woodland vegetation community.

Woodland vegetation similarity coefficient (%)	Pre-thicket	Mid-rotation	Mature	Overmature
Lowland Corsican pine	43.2	32.8	27.4	58.2
Lowland Scots pine	21.9	34.6	34.9	32
Foothills Scots pine	41.3	58.2	69.1	70.8
Lowland Norway spruce	56.6	41.9	51	–
Foothills Sitka spruce	33.3	17.5	25.5	36.8
Upland Sitka spruce	44.7	33.9	49.9	58.6
Lowland oak	–	88.9	60.7	–
Upland oak	–	75.4	79.2	–

– Stand stage not available.

Invertebrates

Carabid (ground beetle) species-richness and community composition were strongly influenced by latitude and canopy structure, and to a lesser extent by soil organic matter and vegetation diversity. Species diversity was greatest in the more open plots, either pre-thicket or overmature, declining with canopy closure. There was a significant increase in the proportion of forest specialist species as the stands matured, with the overmature stands having the highest values (Figure 2).

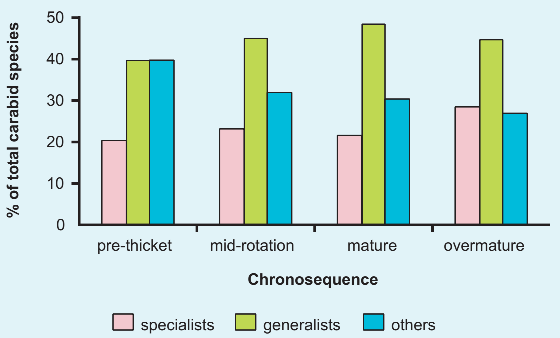

FIGURE 2

The increasing proportion of carabid forest specialists with plantation age, together with a corresponding decline in non-forest species.

Canopy Coleoptera (beetles) were categorised into the functional groups saproxyles, herbivores, predators and others. The main influences on community composition were tree species and latitude. Saproxylic species showed an increase in abundance with plantation age, but no relationship with fallen deadwood volume was found, possibly due to the narrow sampling window (only one sample per year for 2 years in each plot). Predators were the most abundant group in many plots, particularly spruce, where the predators associated with the green spruce aphid, *Elatobium abietinum*, were dominant. Higher structural diversity in Scots pine stands resulted in a more diverse canopy Coleoptera community, though this relationship was not found in other tree species. A positive relationship between leaf area index and herbivore species richness in pine suggests that as stands are thinned, the loss of canopy cover has a direct effect on the species-richness of canopy Coleoptera.

Large numbers of invertebrates, mainly Diptera (flies) and parasitic Hymenoptera (wasps) were collected from the malaise traps. Hoverflies (Syrphidae), tree hoppers (Cicadomorpha) and beetles (Coleoptera) were identified to species level. Analysis of these data is still in progress, but the key points which have emerged are:

- Hopper and hoverfly species-richness and diversity decreases as mean tree basal area increases.
- Beetle diversity is not related to mean basal area.
- Pre-thicket plots have the highest hopper and hoverfly diversity.
- Sitka spruce canopies support the lowest diversity for all three insect groups.

Fungi

The fungi were broken down into four functional groups: mycorrhizals, parasites, litter saprotrophs and wood saprotrophs. The results shown in Figure 3a are for mycorrhizals (223 species in total) and wood saprotrophs (180 species). Upland Sitka spruce plots had the highest mycorrhizal species counts relating to denser canopy cover. This finding contrasts with those of other studies which have suggested that the fungal flora of conifer stands is often less diverse than that of broadleaved stands (Villeneuve *et al.*, 1989). It is possible that the denser stand conditions associated with spruce are conducive to the development of mycorrhizal communities by affording freedom from competing ground vegetation and providing a higher tree root density for mycorrhizal associations.

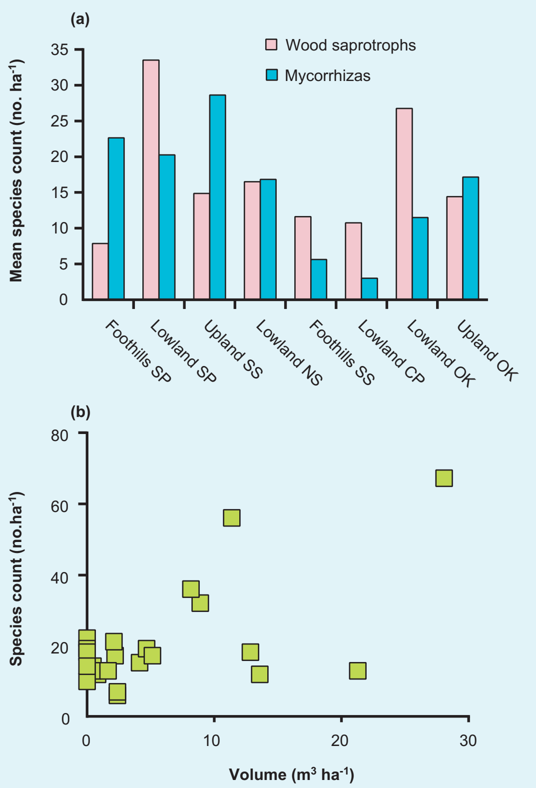

FIGURE 3

(a) Mycorrhizal and wood saprotroph species-richness in relation to crop type. SP: Scots pine, SS: Sitka spruce, NS: Norway spruce, CP: Corsican pine, OK: oak.

(b) Relationship between wood saprotroph species counts and volume of fallen deadwood (lowland sites only).

In the lowland plots, mycorrhizal species-richness was positively correlated with the number of potential host tree species ($P < 0.05$). This confirms recent analyses indicating that many tree species in Britain are associated with distinctive ectomycorrhizal fungi which, in some cases, may be host-specific (Newton and Haigh, 1998). Wood saprotroph richness was strongly correlated ($P < 0.05$) with increases in fallen deadwood (log) volume (Figure 3b), with the lowland Scots pine and oak plots having the highest species numbers and log volumes.

Bryophytes and lichens

There was little distinction between the bryophyte flora of planted stands and semi-natural woodland (Table 1). Bryophyte species-richness was more closely related to crop type than climate, with spruce stands being richer than pine stands, regardless of climate zone. This observation has not previously been recorded in Britain, but is consistent with Fennoscandian literature, where spruce is generally considered a more favourable habitat for bryophytes than pine (Esseen *et al.*, 1997). Bryophytes were less affected by shading, and most spruce stands had a reasonable complement of species in all stand stages. The best stands appear to be those with high values for upper canopy cover (i.e. mature and overmature stand stages). It is possible that these stands offer a better combination of high humidity, adequate light levels and constancy of micro-climate.

Lichen species-richness was much higher in the upland and foothills stands than in the lowland stands (Table 1), substantiating existing views that oceanic conditions (and low pollution levels) in the north and west of Britain provide much better conditions for lichen growth (Rose, 1993). The semi-natural pinewood and oak stands had richer lichen communities than the planted stands, relating to the occurrence of habitat features such as old trees, shaded rocks and cliffs, and a long-continuity of woodland conditions (Plate 1).

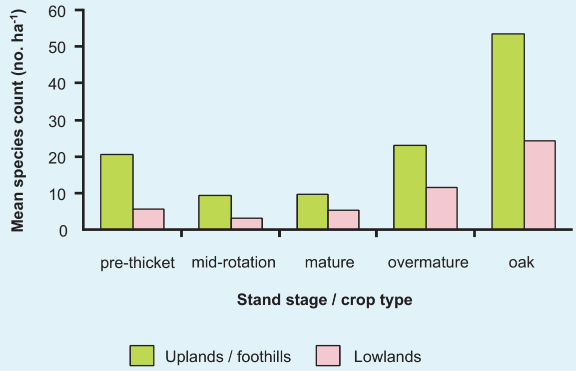

FIGURE 4

Lichen species-richness in relation to stand stage; oak is included for comparative purposes.

PLATE 1

Ancient semi-natural Scots pine wood showing old trees and standing deadwood. (Simon Davey)

PLATE 2

Typical group of pinewood lichens including *Cladonia botrytes* (B) on deadwood; *Vaccinium* berry added for scale. (Simon Davey)

Low light levels are considered to be highly detrimental to lichen growth (Rose, 1993). This explains why stand structure had such a significant effect on lichen species-richness, mid-rotation and mature stages having lower species counts than the pre-thicket and overmature stands (Figure 4). The pre-thicket stands are particularly important in the foothills Scots pine plots where stumps support *Cladonia* species. A scarce and important species within the group is *C. botrytes* shown in Plate 2. Bryophyte species-richness was higher on logs and stumps, while snags were more important for lichens (Figure 5). Observations from overseas (Kruys *et al.*, 1999) tend to support these findings. Larger and more highly decayed material appears to provide a better substrate for lower plant development (Ferris and Humphrey, in press). Snags in native pinewoods provide a key habitat for the rare 'pin-head' lichen group (species of the genera *Calicales* and *Chaenotheca*).

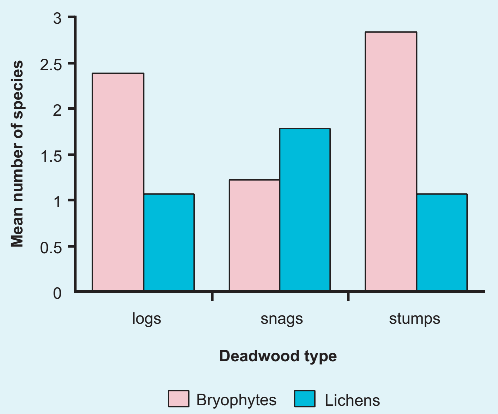

FIGURE 5

Lichen and bryophyte species-richness on different types of deadwood.

PLATE 3

Deadwood is an important substrate for lower plants and fungi especially within natural reserves. (Simon Davey)

Conclusions and implications for management

The project has been successful in meeting its main objective of establishing a baseline dataset of the biodiversity of plantations across Britain. The most significant finding was that stands of non-native conifer species appear to provide suitable habitat for a wide range of native flora and fauna and should be viewed as making a positive contribution to biodiversity conservation in the UK. There were considerable differences in value of different stand ages and crop types for different species groups with no single type providing 'optimal' conditions for biodiversity. Pre-thicket plots and restocks provide habitat for a variety of species-groups common to non-wooded habitats (e.g. heathland). However, the overmature stands, both in native and planted forests, are important for species requiring continuity of wooded conditions and deadwood. Therefore, three contrasting, but not mutually exclusive, management strategies could be considered for plantations:

1. Maintenance of the patch-clearfelling system to ensure provision of early-successional habitat.
2. Extending rotations beyond normal economic felling age and establishing 'natural' (non-intervention) reserves.
3. Managing some stands under continuous cover regimes (sensu Mason *et al.*, 1999).

The latter two strategies would help to maintain and develop mature woodland conditions, including production of old trees, accumulation of deadwood (Plate 3) and diversification of the tree flora.

While wind risk is a significant factor to consider when deciding where to locate continuous cover stands (Mason *et al.*, 1999), site history is also of key importance, as there is a suggestion from the data that plantations established on ancient semi-natural woodland sites (PAWS, e.g. some lowland Norway spruce and upland Sitka spruce stands) have a much higher diversity of woodland fungi, bryophytes and vascular plants than their counter-parts established on previously open ground. Restoring PAWS back to native woodland may not always be of benefit to biodiversity in the short to medium term, particularly if the restoration is done very rapidly. This is especially the case for mycorrhizals where extensive felling of host trees can disrupt mycelial connectivity and reduce the extent of recolonisation after restocking or natural regeneration (Flynn *et al*., 1998). Even smaller-scale felling can be disruptive (Flynn *et al*., 1998), and it may be more desirable therefore to identify some PAWS known to have a high number of characteristic species as potential 'natural reserves'.

PLATE 4

Old beech stump. Fresh and well-decayed large logs and stumps provide a range of habitat types. (Entomology Branch, Forest Research)

Based on the results presented above it is clear that measures of stand structure and deadwood have considerable potential as biodiversity indicators in planted forests. For example, the number of host tree species could be used as an indicator of mycorrhizal diversity. The positive correlations recorded between deadwood volumes, and species-richness of wood saprotroph fungi, lichens and bryophytes is also notable. A mix of fresh and well-decayed large diameter logs and stumps should provide a range of habitat types (Plate 4) with volumes in the range of about 40 m^3 ha^{-1} providing for the greatest lower plant and fungal diversity (Ferris and Humphrey, in press).

The biodiversity indicators and management strategies proposed in this article are still tentative and further work is planned in the near future to validate these proposals and analyse additional datasets, looking particularly at the issue of site history.

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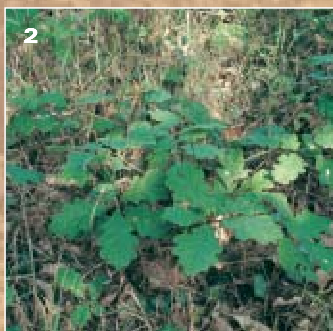
Uneven-aged Silviculture in Britain

by Gary Kerr



1 Douglas fir at Longleat Estate, Wiltshire

2 Natural regeneration of oak

3 A female flower and ripe male flowers on Douglas fir

4 Beech at Ebworth Estate, Gloucestershire

Introduction

Uneven-aged silviculture has had a limited role in British forestry but this is changing as a result of demands for greater diversity, avoidance of clearfelling and increased use of natural regeneration (Forestry Commission, 1998; McIntosh, 2000; UKWAS, 2000). The use of uneven-aged silviculture requires silvicultural knowledge and observation of stand dynamic processes, but most forest managers lack the experience and confidence to put it into practice and there is limited guidance to assist them (Paterson, 1958; Reade, 1990). This article describes the results of studies on three different uneven-aged stands, gives some guidance on how uneven-aged silviculture could be used in Britain, and suggests areas for further research.

For the purposes of this account an uneven-aged woodland is one in which there are three or more age classes. Uneven-aged silviculture is therefore a sequence of stand interventions designed to perpetuate these three or more age classes; generally this will produce conditions of continuous cover.

Methods: sample stands

Three stands were selected with an uneven-aged structure. The first, at Plashetts Wood in East Sussex, has an even-aged oak canopy and dense mixed-age understorey of sycamore which developed due to the protection from browsing offered by pheasant rearing pens (Plate 1a and b). The second is a mixed stand of grand fir, Douglas fir, sycamore and ash on a sandy soil overlying chalk at Snake Wood, Thetford Forest (Plate 2a and b). This was an even-aged conifer stand until the 1970s, when windblow of some trees in the canopy and prolific natural regeneration initiated the process of stand differentiation. The third stand is Sitka spruce and Norway spruce at Knightwood Inclosure in the New Forest. The history of the stand is unknown but the structure is diverse with a range of diameters at breast height (dbh) between 7 and 91 cm (Plate 3a and b).

(a)

(b)

PLATE 1

(a) and (b) Even-aged oak canopy with dense understorey of sycamore at Plashetts Wood, East Sussex. (Forest Research Photo Library a: 42446, b: 42450)

(a)

(b)

PLATE 2

(a) and (b) Mixed stand of grand fir, Douglas fir, sycamore and ash at Snake Wood, Thetford Forest. (Forest Research Photo Library a: 42458, b: 42461)

(a)

(b)

PLATE 3

(a) and (b) Diverse structure of a stand of Sitka spruce and Norway spruce at Knightwood Inclosure in the New Forest. (Forest Research Photo Library a: 42436, b: 42441)

Stands were assessed using a variety of methods to ensure that representative species and diameter information were obtained which could be expressed on an area basis. At Knightwood three height classes of trees were identified and the total height of a sample of large diameter trees in each height class were measured. The mean height for each of the three classes was used as a top height from which to estimate form height using Table 12 in Edwards (1983). Form height is important in uneven-aged silviculture because it allows volume to be estimated directly from diameter data (volume = basal area x form height).

Methods of uneven-aged management

Reverse-J diameter distribution

A reverse-J diameter distribution describes a pattern which has been observed in some uneven-aged woodlands when the frequency of tree size has been investigated (De Liocourt, 1898). A typical reverse-J diameter distribution is shown as the 'ideal structure' in Figure 1; additional information is given in Box 1. Generally the number of trees in successive diameter classes reduces by a constant, commonly referred to as q, which is the ratio between the number of trees in one diameter class to the number in the next larger class. The actual structure of a woodland is determined and then compared with an appropriate 'ideal' reverse-J diameter distribution. The difference between actual and ideal is then used to decide how many trees, and of which size, should be removed.

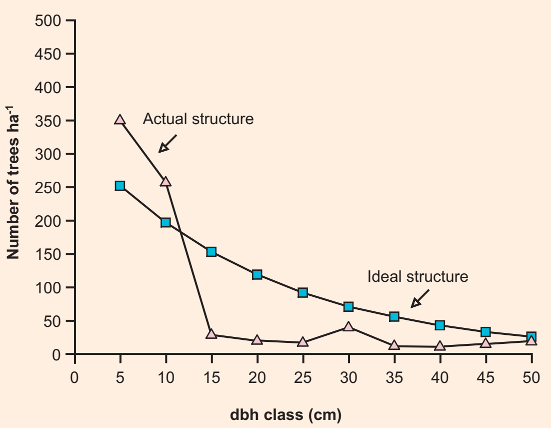


FIGURE 1

Results from comparison of the Snake Wood stand with an ideal reverse-J diameter distribution.

Box 1 Reverse-J diameter distribution

The reverse-J diameter distribution is a negative exponential function whose form can be described by the equation:

$$Y = ke^{-ax} \quad [1]$$

where Y = number of trees per unit area of a dbh class
x = mid-point of the dbh class
k and a are constants.

The constants k and a will vary with species and site. The constant k describes the stocking of saplings beyond browse height and a defines the relative frequencies of successive diameter classes. The constant a is related to q by the equation:

$$q = e^{aw} \quad [2]$$

where q = the ratio between the number of trees in one size class to the number of trees in the next larger class
w = the width of the dbh classes
a = constant (as above).

The ideal diameter distribution used in the example of Snake Wood had a = 0.05 and k = 396.3. Substituting these values in equation [1] generates the ideal diameter distribution in Figure 1 (hint: for the 5–9.9 cm class x = 7.5). The values of a and k relate to the ecological characteristics of the tree species or woodland type. For example, birch would be expected to have large values of a and k because it is a prolific seed producer and intolerant of shade, whereas beech may have a lower value of a compared with birch because it is tolerant of shade (Philip, 1994). However, in practice, the value of these constants is difficult to determine. The spreadsheet by Clarke (1995) is helpful in this respect because it allows ideal diameter distributions, and hence the values of a and k, to be determined from input of basal area, dbh of the largest tree and a value of q.

Clarke (1995) devised a spreadsheet which generates appropriate 'ideal' reverse-J diameter distributions. The spreadsheet requires the forest manager to input: (1) basal area, which for spruces and Douglas fir should be 25–35 m^2 ha^{-1} (Mason and Kerr, 2001); (2) diameter of the largest tree; this is usually set by the forest manager from a knowledge of timber markets; (3) the constant *q*, as described above. Using a modified version of this spreadsheet (Kerr, 2001) an 'ideal' diameter distribution was defined for Snake Wood using 32 m^2 ha^{-1}, maximum diameter of 50 cm and a *q* value of 1.3.

There has been little work defining reverse-J diameter distributions for woodlands in Britain and guides such as Yorke (1998) rely on data from central Europe. However, recent work (Kerr, in press) has determined a suite of reverse-J diameter distributions for coppice-with-standards woodlands in East Sussex. One of these diameter distributions has been used to examine how the stand at Plashetts Wood could be managed using uneven-aged silviculture.

Equilibrium growing stock

The question of defining equilibrium growing stock for uneven-aged woodlands has been well researched in Switzerland (Schütz, 1997). A stand which is in equilibrium is in a theoretical state where sustainable timber increment is generated from a size-class frequency distribution which remains broadly constant and where there is sufficient recruitment of young trees. At the stand level this equilibrium or 'target' structure is formulated for a given species composition and site in terms of the growing stock in m^3 ha^{-1} and the distribution of volume across broad dbh size categories. An equilibrium structure which has stood the test of time for European silver fir–Norway spruce–beech forests in Switzerland has a growing stock between 250 and 400 m^3 ha^{-1}, depending on site fertility, with 20% as trees 17.5–32.5 cm dbh, 30% as trees 32.5–52.5 cm dbh and 50% as trees >52.5 cm (Poore, 2001). To apply this to the stand of Sitka spruce at Knightwood it has been assumed that an equilibrium growing stock of 350 m^3 ha^{-1} is appropriate with a slight change to the size class categories of <30 cm dbh, between 30 and 50 cm dbh and ≥50 cm dbh.

Results

Snake Wood

Results from the comparison of the Snake Wood stand with the 'ideal' diameter distribution defined by Clarke's (1995) spreadsheet are shown in Figure 1. The actual stand basal area of 23.9 m^2 ha^{-1} (74% conifers, 26% broadleaves) is low for shade tolerant conifers (Mason and Kerr, 2001). In comparison to the ideal, the smaller trees (<15 cm dbh) are in surplus and all sizes above this are in deficit. This analysis suggests there is no immediate need for intervention but that within a 10-year period it may be necessary to reduce the number of smaller trees and possibly remove some large trees. Any decision to remove larger trees can only be taken after full consideration of the dynamics of the woodland. For example, if evidence suggested that tree seedlings are being heavily browsed and not developing into saplings, reducing the number of the most productive seed trees is unlikely to improve the chances of future natural regeneration. In this situation it would be best to be cautious about removing the seed trees until there was experience of developing at least one new cohort of regeneration. In the case of Snake Wood it would also be sensible to remove the grand fir first and keep the Douglas fir to increase the chances of regeneration of the more valuable species.

Plashetts Wood

Table 1 compares the structure of the stand at Plashetts Wood with a local reverse-J diameter distribution determined by Kerr (in press). This shows that there is a surplus of trees <15 cm dbh and >45 cm dbh. In Table 1, 15 cm diameter classes have been used because in the field it is difficult to differentiate between very small diameter

Table 1 Calculation of a marking guide for Plashetts Wood.

Diameter classes (cm)	Stand Trees ha⁻¹	Ideal structure Trees ha⁻¹	Difference Trees ha⁻¹	Trees to be removed (%)	Marking guide
<15	1326	671	655	49	1 in 2
15–29	125	230	<0	0	0
30–44	22	79	<0	0	0
45–59	48	27	21	44	3 in 7*
⩾60	21	12	9	43	3 in 7*
Totals	1542	1019	685		

* If natural regeneration of oak is required this should be delayed as these trees are the main seed source.

classes. Table 1 suggests a possible silvicultural treatment of removing half the trees < 15 cm dbh, these would be mainly sycamore, and up to 3 in 7 of the larger trees, mainly oak. However, as with Snake Wood, any decision to remove large trees can only be made after careful consideration of the effects on the woodland, particularly with oak which only produces large amounts of seed periodically. It is important to emphasise that the figures in Table 1 are a guide to management and not a prescription.

Knightwood

This woodland has a relatively high basal area (45.4 m^2 ha^{-1}) and volume (500 m^3 ha^{-1}), with a large proportion of the volume (64.3%) in trees ⩾ 50 cm dbh (Table 2). As an example, an appropriate equilibrium growing stock has been assumed to be 350 m^3 ha^{-1} divided 20:30:50 between the size classes. Comparison of this equilibrium growing stock with the actual structure of the woodland shows that the medium and small trees are close to that required but trees in the largest size class are in surplus (see darker shaded columns in Table 2). Observation of stand data showed that the area contained 37 trees ha^{-1} which are >70 cm dbh and if these were removed the target volume for the area would be achieved. If this is done in November to April, to coincide with Sitka spruce seed dispersal, this would also increase potential for establishing a new cohort of young seedlings in appropriately sized gaps.

Table 2 Comparison of Knightwood with an assumed equilibrium growing stock.

Diameter class (cm)	Trees ha⁻¹	Basal area (m² ha⁻¹)	Estimated form height	Volume (m³ ha⁻¹)	Equilibrium growing stock (m³ ha⁻¹)	Difference (m³ ha⁻¹)
7–29	518	12.3	6.80	83.6	70	13.6
30–49	62	8.4	11.25	94.5	105	n/a
50+	78	24.7	13.03	321.8	175	146.8
Total	658	45.4		500	350	

Discussion and conclusions

One of the main hurdles to the wider adoption of uneven-aged silviculture in Britain is to overcome the concern of forest managers that the systems are too fussy and require intensive assessments. In all three examples the main data requirement was for information on species and diameter and there is no reason why collection of this data, with appropriate sampling, should be prohibitively expensive. In each of the examples guidance was produced which must be interpreted within the stand, depending on species and the spatial and size distribution of trees. This does require silvicultural knowledge and observation of stand dynamic processes.

This article has demonstrated two methods for managing an uneven-aged woodland but has also raised many questions concerning the approaches adopted. For example, how appropriate is the reverse-J diameter distribution as a management tool in Britain? Kerr and O'Hara (2000) argue that the lack of experience with uneven-aged silviculture in Britain has led to a tendency to regard the reverse-J diameter distribution as the only way to manage uneven-aged stands. This is clearly not the case. However, it is relatively easy to understand and implement, and the work of Clarke (1995) and Kerr (2001) enables 'ideal' diameter distributions to be generated with a minimum of information. Further research is required to obtain a better understanding of what constitutes an 'ideal' diameter distribution for any particular set of circumstances, and guide forest managers on how to select appropriate values of the constant *q*.

One possible alternative to the reverse-J diameter distribution is the concept of equilibrium growing stock. However, the figures used as an equilibrium growing stock for Knightwood were a combination of information from Switzerland and estimates based on experience by the author. We currently have no information on equilibrium growing stock in terms of volume per hectare or the distribution of volumes between different components of the crop for any important forest tree in Britain. What is certain is that sites and species are very different between Britain and Switzerland, and within Britain, and there are inherent dangers in just copying a system developed elsewhere. Another area of uncertainty is the estimation of form height. All the information in Edwards (1983) originates from even-aged stands. Many conifer species in the more open upper canopy of an uneven-aged stand are capable of carrying more volume than is suggested by the form heights used in this study.

A subject not covered in this article but of great importance is to be more specific about where, and with which species combinations, success with uneven-aged silviculture is most likely. For example, is uneven-aged silviculture appropriate to an oak woodland on a surface water gley soil or to a stand of Sitka spruce and Norway spruce in the New Forest? Two estates which have had a pioneering role in adopting uneven-aged silviculture have been Longleat and Stourhead (Western) Estates in Wiltshire. Both estates have concentrated their efforts on soils derived from greensand which is favourable for natural regeneration compared with more base-rich sites or soils with heavier textures. In addition, both estates have a mixture of conifer and broadleaved species with differing degrees of shade tolerance. Success has been most marked with species which have seedlings which are moderate to very shade tolerant: Douglas fir, ash, beech, western hemlock, Norway spruce. This experience confirms that forest managers commencing uneven-aged silviculture, or transforming even-aged to uneven-aged woodland (Mason and Kerr, 2001), should concentrate on shade tolerant species on sites where natural regeneration is reasonably reliable.

This article has examined two methods for managing uneven-aged woodland but it is important to recognise there are many more (Brasnett, 1953; O'Hara, 1996; O'Hara and Valappil, 1999). Much time and effort can be expended in researching these different systems for different combinations

of species and sites. However, the immediate priority is to be able to provide simple advice and decision rules to forest managers which will allow them to achieve the objectives of uneven-aged silviculture at an acceptable cost. Our research aims to provide this advice and develop a greater understanding of the potential of uneven-aged silviculture in Britain.

Acknowledgements

I am grateful to Mark Yorke for access to his data on Knightwood, Giles Drake-Brockman (Forest Enterprise) for making available the data on Snake Wood and Bruce Rothnie (Forest Enterprise) for help in locating the stand in Knightwood Inclosure. Ralph Harmer, Anna Brown, Peter Freer-Smith and Jim Dewar made useful comments and suggestions on the text.

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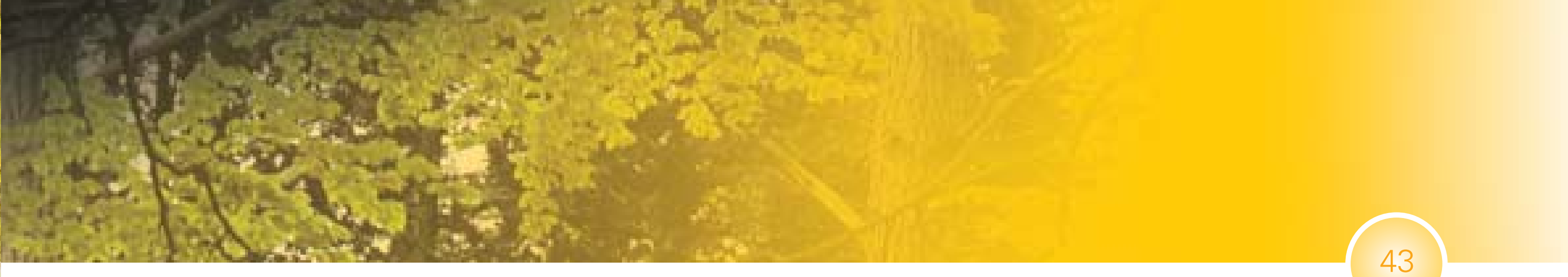
The Integrated Forest Management Programme

by David Wainhouse, Hugh Evans, Roger Moore,
Joan Webber, Katherine Thorpe and Joanna Staley

1 Adult pine weevils showing natural variation in size; pine needles included for scale

2 Nylon mesh cages used to enclose adult weevils during feeding experiments

3 Scots pine seedling with weevil feeding damage on stem



Introduction

One of the principal objectives of the Integrated Forest Management (IFM) programme is the co-ordination and development of research that has the ultimate goal of reducing the use of chemicals in forest management. Chemicals are used to achieve a number of different forest management objectives, although they are used much less extensively than in agriculture. Important uses include applying urea to stumps after felling to prevent establishment of the butt rot fungus *Heterobasidion*, application of herbicides to reduce weed competition in reafforestation sites, applying insecticide to conifer transplants to reduce the impact of feeding damage caused by the pine weevil, *Hylobius abietis*, and using rodenticides to limit the impact of grey squirrel populations in broadleaved forests (Table 1). In addition, fertilisers may also be used to aid tree establishment and promote rapid early growth.

Table 1 Current chemical use in GB forestry (Willoughby, 1999 and personal communication).

Chemical	Tonnes[a]
Urea	420
Herbicides	30
Insecticides	1
Rodenticides	1

[a] Approximate tonnes a.i. in 1994.

The convenience and efficacy of many of these chemicals has been clearly established and much research devoted to selecting appropriate chemicals, optimising timing and target specificity, and minimising risks to operators and the environment. Nevertheless, the development of alternative practices or complementary management techniques that are integrated to allow reduction in chemical use is now regarded as a key component of sustainable forest management (Anon., 1998) and, indeed, is a requirement of the Forest Certification or Woodland Assurance Schemes (Bede Howell, 1999). The development of such methods in forest management will depend to a greater or lesser extent on collaborative research between different disciplines, not only to avoid introduction of conflicting techniques but to ensure that the necessary breadth of expertise is focused on key problem areas. The project on the Integrated Pest Management (IPM) of the pine weevil, *Hylobius abietis*, illustrates this approach.

Integrated Pest Management of pine weevil

The pine weevil is so damaging to young conifer transplants that it is the only UK forest pest against which prophylactic applications of insecticides are used. Adult female weevils are attracted to areas of clearfelled conifers (Plate 1), partly by the odour of ∝-pinene and ethanol released from the cut surface of stumps. The females then lay eggs in the bark below the soil surface and, on hatching, the larvae pass through several growth stages before they pupate and eventually emerge as adults after a period of 1–2 years. The young plants used in restocking are vulnerable to attack by the emerging adults. Both the number of weevils emerging from stumps, as measured by emergence traps (Plate 2), and the timing of emergence in relation to replanting influence the amount of feeding damage on transplants and the period over which it occurs. The tree species present in the forest is one important factor determining the number of weevils emerging from stumps since there is considerable variation both between and within species in their suitability for larval development. In intensively managed forests, emergence of adults from lodgepole pine, *Pinus contorta,* averages 40 to 100 per stump whereas 15 to 30 is more common for Sitka spruce, *Picea sitchensis*. In the forest of Ae, the number of immature *Hylobius* in Sitka spruce varied from 0 to 178 per stump, confirming the wide variability in colonisation and breeding success. Emergence traps placed over these stumps also revealed that weevils emerged over a protracted time period. Most emergence occurred within 33 months of felling, but in some stumps, emergence occurred over a period of 52 months. More detailed examination of the development of larvae revealed some interesting findings that suggest limitations in the effective exploitation of stumps that could have significant effects on weevil abundance and population dynamics and which therefore may be of importance in the management of this pest.

PLATE 1

Stumps utilised for weevil breeding in a clearfell area. (D. Wainhouse)

PLATE 2

Weevil emergence trap placed over conifer stump. (R. Moore)

Effects of competition and stump quality on performance of weevil larvae

When weevil eggs or larvae are inoculated into logs of Douglas fir, Scots pine, Sitka spruce and hybid larch in laboratory experiments, larval survival varies considerably between species and is also influenced by the size of larvae inoculated (Figure 1). The size differences among larvae are related to differences in the size of eggs laid by weevils (Figure 2) which appear to be caused by variation both in the size of adult weevils themselves and in the species of transplant on which they have been feeding. These so-called maternal effects on offspring 'quality' and survival can arise where size or competitive ability of offspring are important in survival and development (Wainhouse *et al.*, 2001). This suggests that mortality of *Hylobius* larvae in stumps can be high, depending on the conifer species, degree of resistance in 'fresh' stumps and the extent of previous colonisation by weevil larvae. As well as *Hylobius* larvae, stumps can be colonised by other organisms such as *Hylastes* bark beetles, other saproxylic invertebrates and fungi that may be effective competitors. Their activity may further restrict the availability of bark during the larval development period which typically extends over 1–2 years (Plate 3).

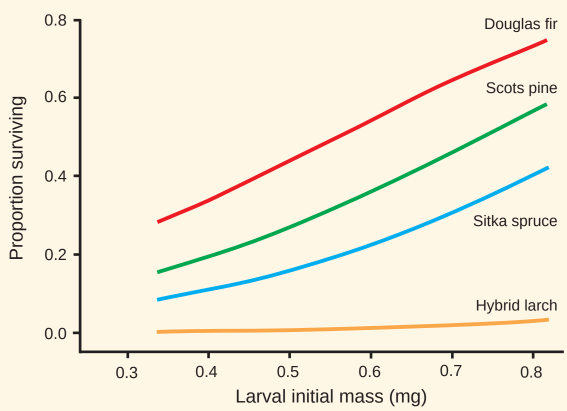


FIGURE 1

The effect of larval size on survival on different conifers.

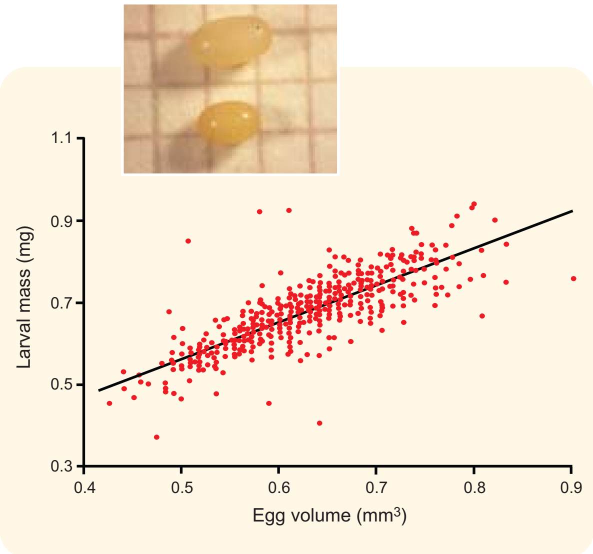


FIGURE 2

Relationship between larval and egg size. Inset illustrates variation in egg size (scale: grid = 1mm). (J.Staley)

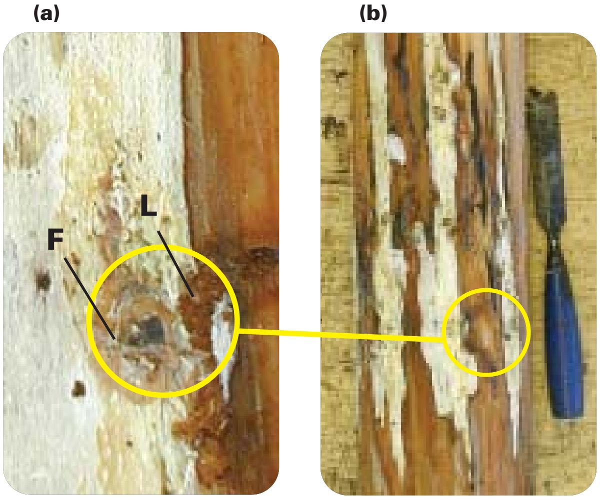


PLATE 4

(a) Enlarged section of log showing *Hylobius* larval gallery (L) avoiding fungal lesion (F). (b) Large pale coloured fungal lesions on log restrict lateral movement of *Hylobius* larvae. (K. Thorpe)

It is possible that some of the most effective strains of fungi already applied as stump treatments for the biological control of the root and butt rot pathogen *Heterobasidion* (Pratt, 1999) may be effective colonisers of bark, with the potential to limit the amount of bark resource available for exploitation by *Hylobius* larvae. Preliminary studies using a range of fungi inoculated into freshly felled logs show that *Hylobius* larvae actively avoid already established fungal lesions (Plate 4), suggesting that competitive exclusion may be a promising line of research with the potential to unify elements of the control of *Heterobasidion* and *Hylobius*.

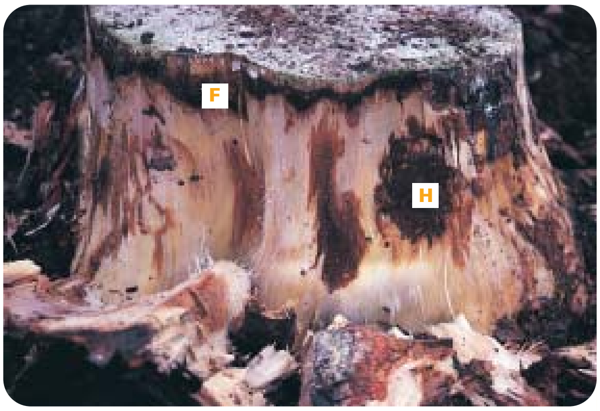


PLATE 3

Scots pine stump colonised by fungi (F) and *Hylastes* sp. (H) as well as *Hylobius* larvae. (D. Wainhouse)

Reducing populations of *Hylobius* emerging from stumps is only one element of an integrated approach to control. Even at relatively low densities, feeding by adult weevils can kill or severely damage transplants. The behaviour of weevils once they emerge from stumps, how long they remain on site and how effective they are at finding seedlings will be important determinants of the relationship between weevil population size and damage to seedlings, and is the subject of ongoing research. The damage that is inflicted on transplants is assumed to be part of maturation feeding without which female weevils would be unable to lay eggs. Although transplants are assumed to represent a high quality food, there are nevertheless large differences in the number of eggs laid by females when thay feed on different tree species (Figure 3). Such differences could affect population dynamics and management in forests dominated by different conifer species. Replanting forests with conifers that have the ability to resist or recover from weevil attack is an important element of IFM and is currently the subject of intensive research.

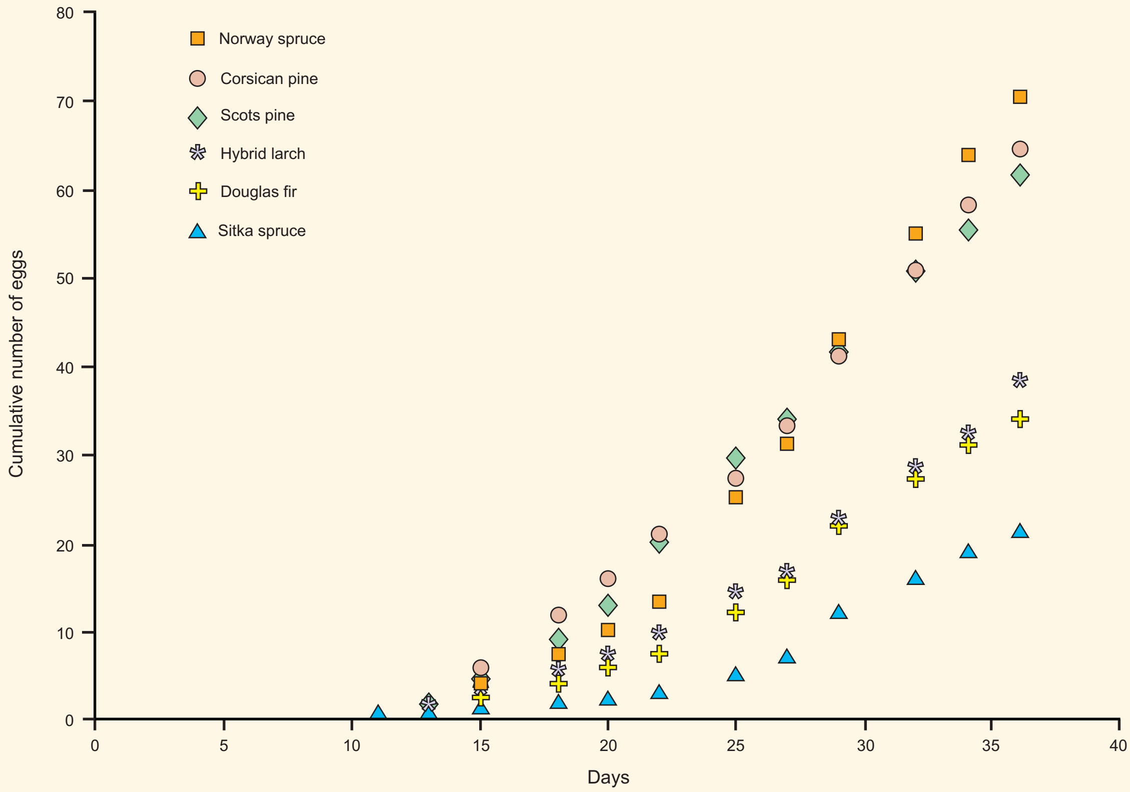


FIGURE 3

The fecundity of weevils when feeding on current year stem bark of different species of conifer transplant.

Some of the main factors likely to influence risk of damage to transplants and therefore of value in a decision support system have been discussed in a recently published information note (Heritage and Moore, 2001). An important consideration will be how the various factors interact to drive down *Hylobius* populations below the level that leads to plant damage. In the medium term, the results described here, together with data on population dynamics, weevil movement and the application of insect parasitic nematodes for the biological control of *Hylobius* larvae (Brixey, 1997), will be used to develop a practical IFM approach to management of this important pest.

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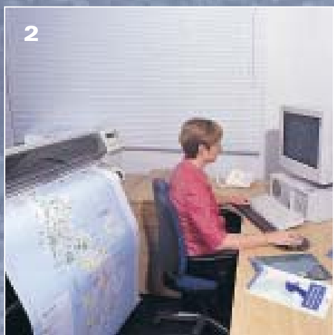
The National Inventory of Woodland and Trees - England

by Steve Smith

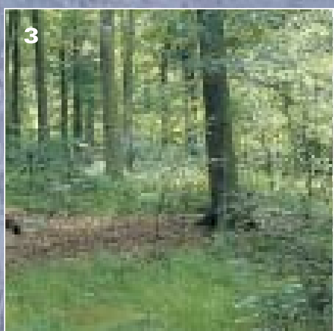


1 Mature conifer plantation

2 GIS Officer creating woodland map

3 Shrub, field and ground layers included in woodland assessment

4 Track through mixed woodland



Introduction

In prehistoric times England was largely covered with woodland. By the end of the first millenium much had already been cleared to satisfy the needs of an increasing population, with the Domesday records showing approximately 15% woodland cover across England. This trend continued, and by the end of the 19th century woodland had dropped to below 5%. Since then England's forest and woodland area has been expanding, and by the beginning of the 21st century there were over 1.1 million hectares, equivalent to 8.4% woodland cover. This, however, remains relatively low in international terms.

In the last 10 years UK forestry policy has had two main aims:

- the protection and sustainable management of existing woods and forests;
- the continued steady expansion of woodland area to provide more benefits for society and our environment.

Within this framework, the new forestry strategy for England (Anon., 1998) sets out priorities and programmes tailored to English circumstances. A key requirement for the formulation and monitoring of these priorities and programmes is to know the extent and condition of woodland and trees. The development and monitoring of policies for increasing the woodland area and for developing wood-using industries, for example, require data on aspects such as the extent, distribution, condition and ownership of woodland.

The British Boards of Agriculture carried out woodland surveys between 1871 and 1913. The Forestry Commission was then handed responsibility in 1919 and has been carrying out national woodland inventories for Britain on a regular basis since 1924. The penultimate survey has a base date of 1980. Despite updates, the information from the 1980 survey has become increasingly less reliable. For some while there has been a real need for accurate information for current issues such as the increase in harvesting volumes, monitoring the effects of recent woodland grant schemes, assessing woodland environmental habitats, and evaluation of the new focus on rural development and the social dimensions of sustainable forestry. The current National Inventory of Woodland and Trees (NIWT) was started with a pilot survey in Scotland in 1994. The survey progressively covered the rest of Britain, and the last field work was completed in England by May 2000. In contrast to the previous practice of periodic surveys, the inventory will be continually updated on a rolling basis thereafter with a cycle of approximately 10 years.

The new inventory consists of two sections:

- the survey of woodlands of 2 hectares (ha) or more.
- the survey of small woodland and trees covering woodlands less than 2 ha, groups of trees, belts of trees and individual trees.

Aims

The overall aim of the NIWT is to provide up to date information on the extent, size and composition of our woodlands. In particular the objective is to provide an accurate assessment of woodland area, and to estimate other characteristics such as forest type, species, age class, stocking, timber potential and woodland structure. The survey data will provide information for:

- decisions on land use and woodland expansion
- forecasting timber production
- targeting advice and grant aid
- assessing woodlands as a wildlife and conservation resource
- studies on biomass production and carbon storage
- monitoring the sustainability of forest management
- other more specialised woodland surveys.

A specific aim is the production of a digital map of all woodland over 2 ha, which is incorporated into a Geographic Information System (GIS) together with the sample data. This allows the sample data to be analysed by any geographically defined area. It also allows the data to be combined with other geographical datasets, e.g. the Woodland Grant Scheme (WGS) or the Ancient Woodland Inventory.

A series of County and Regional Inventory Reports will be published for England both in printed and digital format, with the latter available on the Forestry Commission internet site. Forest Research can also respond to requests for further analysis of the sample data.

PLATE 1

Landscape in Yorkshire showing the variety of forest and woodland types. (Forest Life Picture Library 1019041020)

Methodology

The 'Census of Woodland' in 1980 took information from the Forestry Commission's (FC) sub-compartment database and from Plans of Operation relating to Dedicated or Approved Woodland Schemes, and only surveyed the remaining private woodland. The NIWT, however, surveyed all woodland. There were several reasons for doing so: firstly, growing stock data is no longer available for grant schemes; secondly, much of the environmental data collected in the current inventory does not appear in other databases; and finally to be able to create a complete woodland map.

Between them the two surveys within the NIWT assess all woodlands, groups of trees, linear tree features and individual trees in the rural landscape (Plate 1), plus woodland of 2 ha and over in urban areas. The NIWT does not include an evaluation of hedgerows where there is no tree component, nor does it include smaller woodlands and trees in an urban setting.

Survey of woodland 2 ha and over

The digital map showing all woodland over 2 hectares (Figure 1) was created from 1:25 000 aerial photographs. Woodland is classified into broad forest types: Conifer, Broadleaved, Mixed, Coppice, Coppice with Standards, Shrub, Young trees, Ground prepared for new planting and Felled (Wright, 1998). New areas planted subsequent to the date of aerial photography were added by reference to WGS information and to Forest Enterprise (FE) sources. The finalised map therefore provided an up to date record of the extent of woodland. In the future this map will be updated annually, using the WGS and FE data, and revised periodically, roughly every 10 years.

Mapping was followed by a ground survey of roughly 1% of the woodland area. The digital map formed the basis for sampling woods for ground survey. Woodlands were stratified into three size categories with 1 ha plots then being used for ground sampling. A 1% sample of each size category was selected according to the following design:

Woods 2.0 ha – 100 ha:
every fifth woodland selected with plots at 5% intensity.

Woods 100 ha – 500 ha:
two woods in five selected with plots at 2.5% intensity.
Woods 500 ha and larger:
all woods selected with plots at 1% intensity.

A cluster sampling scheme was used as it was more cost effective: travelling time was reduced while ensuring that the sample plot selection remained unbiased. With the permission of owners, surveyors assessed the 1 ha plots. Data were entered onto hand-held computers which were programmed to hold data at six levels. The data structure was as follows:

Wood: locational information
Owner: address and management context
Cluster: first level of field data, e.g. management practice
Sample square: second level of field data, and vegetation/canopy structure assessment
Section: forest type, thinning history, underwood species
Element: species, area, planting year, timber potential, damage and health

Locational information, such as grid reference and local authority, is held at the wood level. Each sample woodland was given a unique number which clearly identifies the wood and enables data to be linked to the digital map. This allows the NIWT data to be used within a GIS. Details on ownership type and management context (i.e. farm, woodland estate, etc.) were entered. The surveyor made an assessment of the general management practice found within the cluster of plots, and then went on to assess each sample square.

The 1 ha sample square was divided into sections by forest type, species or age along similar lines to subcompartments within a stock map. Open areas within the square were identified as a separate section. The woodland sections were then divided into elements or components which generally identify different species or age classes. Locational information and links to the digital map were also created at this level. In England more than 12 000 one hectare sample plots were ground surveyed.

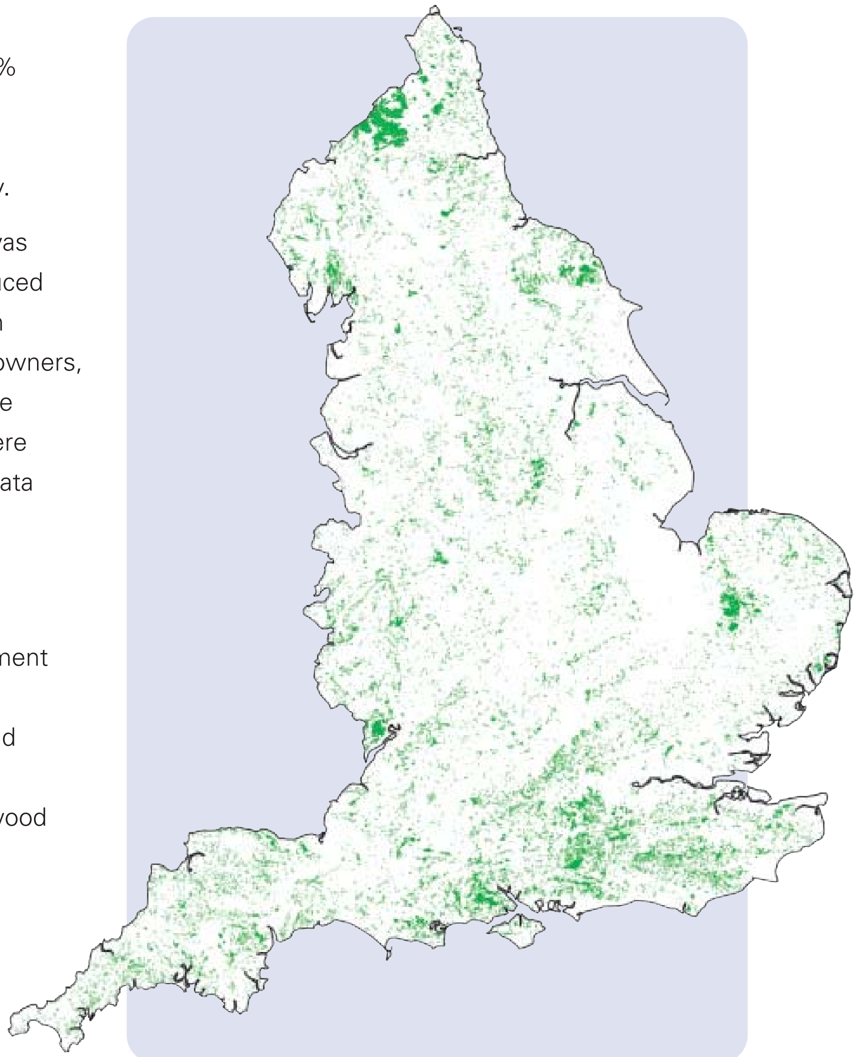


FIGURE 1

English woodland map: showing distribution of woodland of 2 ha and over.

There are a number of special features within the data collected that will help to widen our knowlege on the conservation and biodiversity aspects of our woodlands. For example, a structure assessment identifies the extent and species composition of upper, lower, shrub, field and ground layers (Plate 2), and a deadwood assessment estimates the proportion of deadwood over 15 cm diameter.

PLATE 2

The NIWT assesses woodland structure. (Forest Life Picture Library 1007378020).

Survey of small woodland and trees

For woodlands smaller than 2 ha, groups of trees and individual trees, a combination of aerial survey assessment and ground sampling was carried out. Aerial photographs were again used as the basis for this assessment.

A random sample of approximately 1% of land area was taken, with the basic sampling units being 1 km squares from the Ordnance Survey grid. The 1 km squares had to be stratified into coastal and inland types in order to ensure an adequate representation of coastal squares. Each 1 km square was then surveyed in two stages; initially aerial photographs were used to assess the whole square, which was then subdivided into 16 (250 x 250 m) squares, two of which were ground assessed. Similar types of field information to the main woodland survey were collected in this part of the survey. Over 1300 km^2 plots were assessed in England.

Results

The field survey work in England was carried out between 1996 and 2000, and an appropriate reference date is applied to each county. Results show that there were 1 097 000 ha of woodland over 0.1 ha, including an element of integral open space, in England. This represents a woodland cover of 8.4%. Table 1 gives the areas of woodland by main species/groups and woodland size.
For the most common species the precision of

Table 1 Areas of woodland in England by principal species/groups and woodland size.

Principal species/ groups	Woodland area ('000 ha)			Per cent of total area
	By woodland size			
	2.0 ha and over	0.1–<2.0 ha	Total area	
Pines	125.8	3.8	129.6	13
Spruces	79.4	1.0	80.4	8
Larches	44.4	1.7	46.1	5
Other/mixed conifers	80.2	3.8	84.1	8
Total conifers	329.8	10.4	340.2	34
Oak	147.8	10.8	158.7	16
Beech	60.6	3.5	64.0	7
Sycamore	45.0	3.8	48.8	5
Ash	96.3	8.6	104.9	11
Birch	68.5	1.1	69.6	7
Other broadleaves	89.6	21.0	110.6	11
Mixed broadleaves	77.5	13.4	90.9	9
Total broadleaves	585.3	62.2	647.6	66
Total all species	915.2	72.6	987.8	100

These are net areas of high forest, excluding coppice, felled areas and open space. Figures may not add due to rounding.

these results is very high, for example the standard error was 2% for the overall area of oak, and 2% for ash and Scots pine. However the precision of the results for the less common species was much lower.

The overall average figure of 8.4% woodland cover hides a large degree of variation within England. Humberside, for example, has less than 3% woodland cover, while Surrey has 22%. The most wooded region, the South-east, includes three more counties, Hampshire, East Sussex and West Sussex, with over 16% woodland cover.

The open space occurring within woodland, e.g. rides and clearings, has been assessed at 6.5%. The pattern was relatively consistent between FC and other woodlands at 6.0% and 7.1% respectively.

The survey of woodland of 2 ha and over included an assessment of ownership type. The Forestry Commission managed (owned or leased) 22% of woodland, with 78% being in other ownership. The 'other' ownership has been split into several categories (Figure 2).

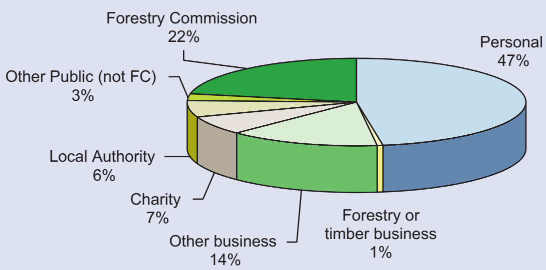


FIGURE 2

Ownership of woodland of 2 ha and over in England. 'Other Public (not FC)' includes, for example, Crown Estates, Ministry of Defence.

The results of the FC inventories are used as the basic input for the published Private Sector forecasts of softwood availability (Smith *et al.*, 2001), and produced jointly by the FC and the Timber Grower's Association (TGA). Figure 3 illustrates a recent forecast produced using the latest NIWT results.

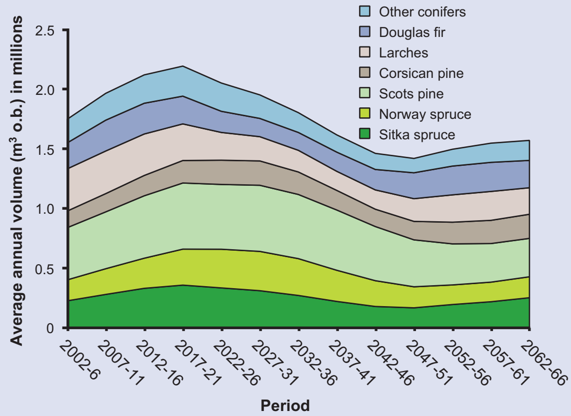


FIGURE 3

England: private sector forecast of softwood availability by species. o.b.: overbark

Comparison with previous surveys

An important role of the NIWT is to monitor changes from previous surveys. However, each survey has been designed in a slightly different way and adjustments need to be made to bring the results to a common base. Figure 4 shows how the woodland area in England has changed over the last century or so. It indicates that many of the First World War fellings were not replanted. The woodland area increased by over 17% since the last survey in 1980, which surpasses the increase of around 6% between 1965 and 1980 (Locke, 1987). While the detail should be treated with some caution, due to the methodological differences between surveys, the upward trend is clear with a near doubling of the woodland since the end of the 19th century.

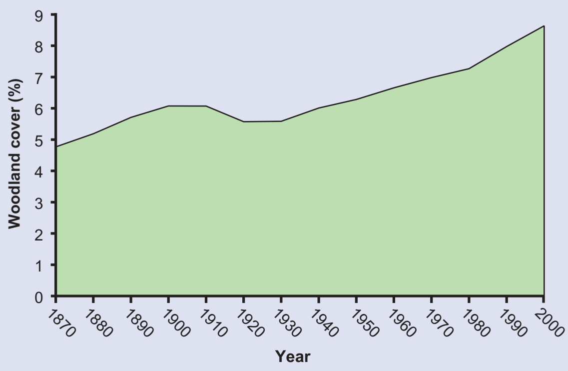


FIGURE 4

England: change in woodland cover 1870 – 2000.

Figure 5 illustrates the changes in woodland in more detail using the old county boundaries at three survey dates. The South-east has long been the most wooded region of England. The biggest differences occur in northern England. Northumberland, for example, has increased its woodland from less than 4% to over 15% since the late 1800s. At the other end of the scale the areas of woodland in Lincolnshire and Warwickshire have hardly changed.

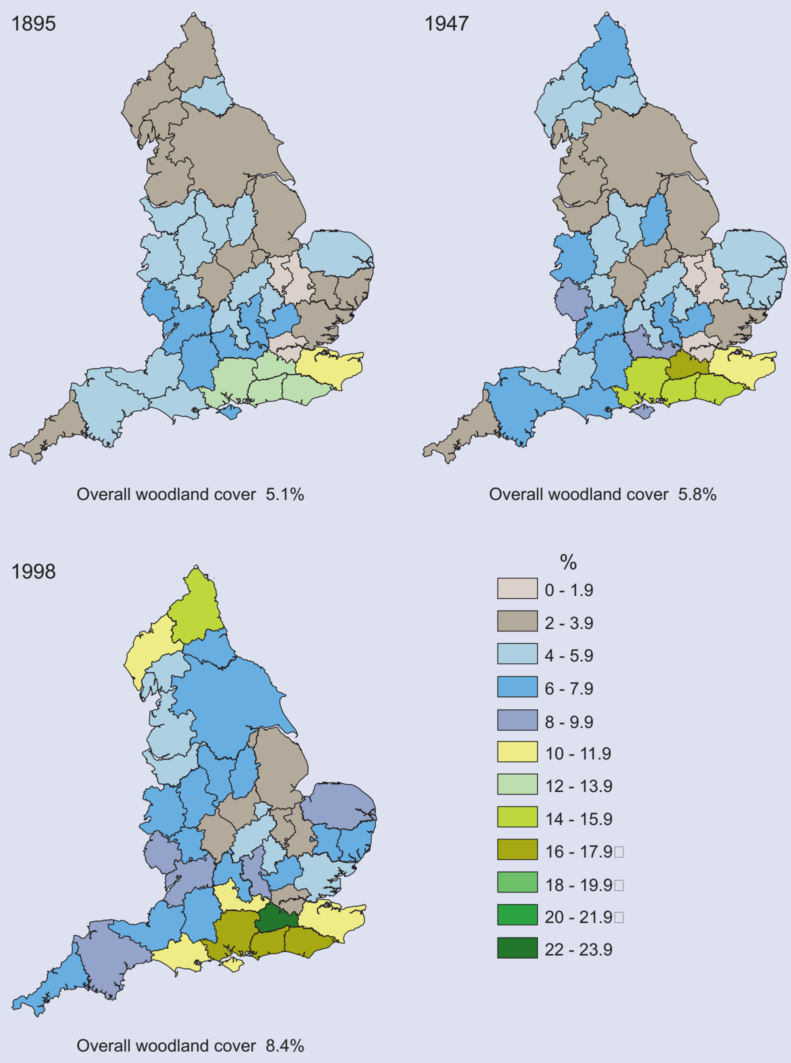


FIGURE 5

Woodland cover in England by county: 1895 / 1947 / 1998.

An analysis of woodland ownership at the last four surveys is given in Figure 6. Forestry Commission ownership as area of woodland and per cent of woodland peaked in 1980. Since 1980 the area of FC woodland has declined by 13%. Woodland in other ownerships declined slightly after 1947, but has been increasing steadily since 1965.

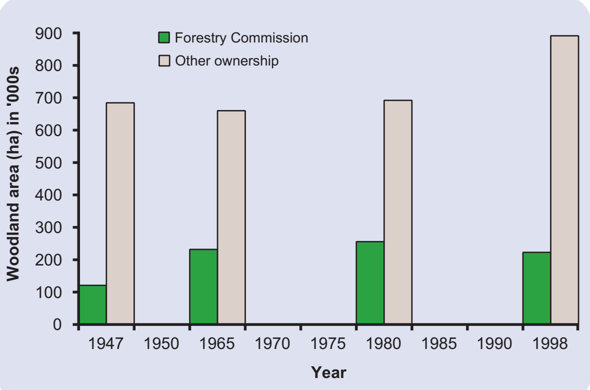


FIGURE 6

Change in woodland ownership in England since 1947.

In comparing the areas of the major species and groups between 1980 and 1998, the most notable feature is that almost across the board there are apparent increases in broadleaves and decreases in conifers (Figure 7). The only exception to the latter is the spruces, which showed a very slight increase, and the exception to the former was elm, which showed a 20% decrease. Overall conifers were down 7%, and broadleaves were up 36%. It is not possible to say how much of the increase is due to the more exacting survey techniques in the current NIWT, and how much to real woodland expansion.

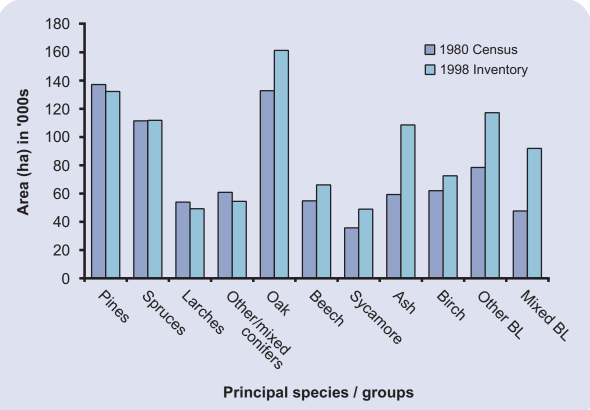


FIGURE 7

Comparison of major species/groups between 1980 Census and 1998 Inventory.

Future developments

With the digital capture of woodland areas the dataset has a key role in providing a baseline for the future, with substantial potential in monitoring the pattern of woodland change and condition within England. While the core results are being presented in the initial series of reports, there are aspects of the sample data which have not yet been fully analysed. There is also scope for further analysis of the digital map and the sample data, for example in combination with other spatial datasets. Finally, additional analyses and making the results available requires further development. The plan is to use the FC's Internet site as a convenient way of disseminating woodland inventory information.

Acknowledgements

Thanks are due to the many landowners and their agents in permitting entry of Inventory Surveyors on to their land. The author is grateful to the many people involved with the Woodland Inventory Project. In particular, thanks go to the Woodland Surveys Branch staff, the Forest Research field teams and contractors for carrying out the field survey work and Simon Gillam, Head of Statistics, FC, for providing statistical advice.

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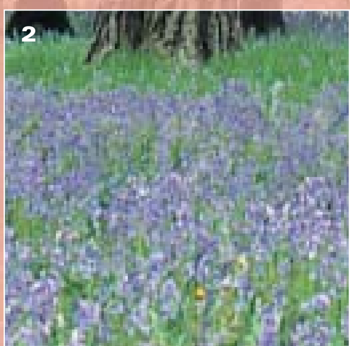

1 A selection of Technical Publications produced during 2000–2001

2 Bluebells in mixed woodland

3 Homegrown timber in use in the building industry

Appendix 1

Forestry Commission Technical Publications

The following titles were published during the year ending 31 March 2001

Report

Forest Research annual report and accounts 1999–2000. (£16.30)

Miscellaneous

Forest Research – world class research for sustainable benefits. (Free)

The various series of technical publications listed below are published for the Forestry Commission by Policy and Practice Division. New titles are listed here as authors are predominantly from Forest Research. Authors outwith the Agency are indicated by an asterisk.

Bulletins

122 Agroforestry in the UK, edited by M. Hislop and J. Claridge. (£25)

123 Managing rides, roadsides and edge habitats in lowland forests, by R. Ferris and C. Carter. (£16)

Guideline Note (free)

1 Forests and peatland habitats, by G. Patterson* and R. Anderson.

Information Notes (free)

31 Climate change – implications for forestry in Britain, by M. Broadmeadow.

32 Plant communities and soil seedbanks in broadleaved–conifer mixtures on ancient woodland sites in lowland Britain, by R. Ferris and E. Simmons*.

33 Forest condition 1999, by D. Redfern, R. Boswell and J. Proudfoot.

34 An introduction to new landscape ecology research to enhance biodiversity in British forests, by R. Ferris, K. Purdy, J. Humphrey and C. Quine.

35 Natural regeneration in broadleaved woodlands: deer browsing and the establishment of advance regeneration, by R. Harmer and R. Gill.

36 The impact of deer on woodland biodiversity, by R. Gill.

37 Environmental monitoring in British forests, by D. Durrant.

Inventory Reports

National Inventory of Woodland and Trees. Scotland – Highland Region. Part 1 – Woodlands of 2 hectares and over. (£5)

National Inventory of Woodlands and Trees. Scotland – Western Isles. Part 1 – Woodlands of 2 hectares and over. (£5)

Practice Guide

Hazards from trees – a general guide, by D. Lonsdale. (£7)

Technical Papers

18 Perceptions, attitudes and preferences in forests and woodlands, by T.R. Lee*. (£15)

29 The potential for woodland on urban and industrial wasteland in England and Wales, by D. Perry* and J. Handley*. (£5)

31 Genetic variation and conservation of British native trees and shrubs – current knowledge and policy implications, by R. Ennos*, R. Worrell*, P. Arkle* and D. Malcolm*. (£5)

*Authors outwith Forest Research

Appendix 2

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Appendix 3

Major Research Programmes Funded by the Forestry Commission*

Entomology Branch

Plant health

Hugh Evans, Nick Fielding and Christine Tilbury

Research into the risks from indigenous and non-indigenous forest insect species. Co-ordination and implementation of surveys in relation to retention of EU Protected Zone status for named bark beetle pests. The use of Pest Risk Analysis techniques to determine contingency options for potential pests. Research into alternatives to methyl bromide as a quarantine and remedial treatment against exotic pests (part EU-funded).

Restocking pests

Stuart Heritage

Research into the effective use of chemical pesticides for control of restocking pests, notably *Hylobius abietis*. Research into and development of insect parasitic nematodes for biological control of larval stages in stumps and provide direct intervention options within the Integrated Forest Management programme being developed in the Branch.

Impact of insects on tree growth

Nigel Straw

Investigate quantitative relationships between insect population pressure and the growth of trees attacked by those insects. An important aim is to separate the direct effects of damage from other biotic and abiotic variables that might mask the impacts of pest insects. The target species is green spruce aphid, *Elatobium abietinum*, which severely defoliates both Norway and Sitka spruces.

Integrated Forest Management

David Wainhouse, Roger Moore and Hugh Evans

Develop the concepts and science of Integrated Forest Management (IFM) to underpin sustainable forestry with particular emphasis on reductions in chemical pesticides. Study the population dynamics of *Hylobius abietis* and use the data to develop decision support systems for management of the restocking problem. Investigate the variability in quality of both stumps and transplants in relation to performance of *H. abietis* and use the data to refine management options within the IFM programme. Develop a decision support system for sustainable reduction of *H. abietis* populations towards the acceptable damage threshold predicted by the population dynamics models.

Mechanisms of tree resistance to insect attack

David Wainhouse

Investigate mechanisms of resistance of young conifers to the pine weevil. Determine the relative importance of genetic and environmental factors in resistance expression. Develop an Integrated Pest Management (IPM) approach for control of pine weevil.

Advisory services

Christine Tilbury

Provide identification services for both pest and beneficial insects and provide advice on pest management and control.

Environmental Research Branch

Soil sustainability

Fiona Kennedy

Research to identify and evaluate the potential impacts of both forest management and air pollution on soil status and dynamics. Develop and advise upon sustainable practices.

*Note: Further details can be found in the *Catalogue of Forestry Commission Research* on the Commission's website http://www.forestry.gov.uk

Reclamation of man-made sites for forestry

Andy Moffat, Kirsten Foot and Tony Hutchings

Improve methods of establishing woodland and management practices on disturbed (brown field) sites, taking into account changes in forestry and land-use policy, planting opportunity, environmental impacts, mining practices and technology. Develop best practice guidelines.

Forest hydrology

Tom Nisbet

Study the impacts of forests and forestry management practices on water quality and quantity. Develop and assess guidance on best management practice for the protection of the freshwater environment within forests. Provide expert advice on forestry–water issues.

Effects of air pollution on trees

Dave Durrant and Andy Moffat

Determine the role of air pollution in forest condition and growth through long-term intensive environmental monitoring in forest ecosystems, in compliance with EC regulations. Provide data under the Convention on Transboundary Air Pollution for the calculation and mapping of critical loads.

Climate change

Mark Broadmeadow

Predict and model the impacts of environmental and climate change on tree growth by experimental work in open-top chambers and in forest stands. Identify interactions between forestry and a changing global environment (e.g. exchange of greenhouse gases).

Environmental change network

Sue Benham

Monitor and understand environmental change and its impact on terrestrial ecosystems. Manage one of the national network of terrestrial sites of the ECN network.

Archaeology

Peter Crow and Andy Moffat

Evaluate the impact of tree growth and forest operations on features of archaeological interest. Examine how forest practices can be manipulated to minimise the risk to archaeological features by practical research.

Mensuration Branch

Sample plots

Janet Methley and John Proudfoot

Develop and maintain national reserve of periodic growth and yield data to support measurement, growth and yield studies using a network of permanent and temporary sample plots. Current focus: contemporary silvicultural practices, uneven-aged planting mixtures, modern planting and harvesting systems, long-term environmental change monitoring.

Yield models

Robert Matthews

Improve methods and models for forecasting growth and yield of forests. Current focus: development of interactive stand-level yield model software, site:yield relationships, biomass yield models.

Measurement

Janet Methley

Develop and promote measurement systems and instruments for the accurate and efficient measurement of trees and timber to support industry, and national and international standards. Provide independent expert advice in cases of measurement dispute.

Core model

Sam Evans

Integrate modelling initiatives within Forest Research by developing a framework of existing and new models and relevant datasets. Taking growth models as a starting point, the core model programme aims to provide modelling tools at appropriate scales of resolution to support and promote the implementation of multi-purpose sustainable forestry policy in the UK.

Pathology Branch

Tree disease and decay: diagnosis and provision of advice

David Rose and David Lonsdale

Diagnose disease in trees and provide advice and information on disease identification, management and control. Provide information on decay in standing trees, and on management of veteran trees.

Tree health monitoring

Steven Hendry

Monitor the health of the nation's trees and raise awareness of tree health issues.

Risks from altered pathogens

Clive Brasier

Investigate changes in pathogen behaviour and evaluate the potential impact of such changes.

Non-chemical protection

Joan Webber

Develop various approaches to biological control of tree diseases, with special emphasis on root rot pathogens, and the fungi that cause vascular wilts and stain and decay.

Fomes root and butt rot of conifers

Jim Pratt

Conduct research on root and butt rot of conifers caused by *Heterobasidion annosum* and investigate approaches to management and control.

Phytophthora diseases of trees

Clive Brasier and David Lonsdale

Investigate pathogenic *Phytophthora* species of alder and oak to determine their impact and the opportunities for management and control.

Silviculture (North) Branch

Forest nutrition and sustainability

Steve Smith

Investigate the influence of site fertility on tree productivity and how forest operations affect sustainability of forest site fertility, including nutrient cycling and tree growth response to fertiliser trials.

Plant quality and establishment

Steve Smith and Colin McEvoy

Integrated studies of the effect of nursery practice, seedling physiology, plant handling methods, site preparation and maintenance upon plantation establishment.

Silvicultural effects upon timber quality

Barry Gardiner and Shaun Mochan

Investigate the impact of silvicultural practices on timber quality in conifers, especially spruce. Main emphasis is on impact of site factors (e.g. exposure, fertility) on quality.

Silviculture of upland native woodlands

Richard Thompson and Colin Edwards

Research into the structure, dynamics and silviculture of native woodland ecosystems in northern and western Britain to support restoration and extension for ecological and economic benefits. Emphasis is on Scots pine forests, birchwoods and the Atlantic oakwoods.

Alternative silvicultural systems in conifer forests

Bill Mason, Colin Edwards and Sophie Hale

Investigate natural regeneration processes in major conifer species to predict and manipulate the timing and density of natural seedling establishment. Evaluate canopy structure manipulation to promote regeneration as an alternative silvicultural system to patch clearfelling.

Stability of stands

Barry Gardiner, Bruce Nicoll and Juan Suárez

Research to reduce wind damage to British forests using a GIS-based windthrow risk model for predicting the probability of windthrow in Sitka spruce forests. Carry out studies of root development and architecture in support of the model.

Shelter forestry

Max Hislop and Barry Gardiner

Research into the design and management of woodlands for shelter and the development of techniques for assessing the potential benefit that they provide.

Social forestry

Max Hislop

Research into the social values of forestry and the development of methodologies for the integration of these values into forest planning.

Silviculture and Seed Research Branch

Social forestry

Elizabeth O'Brien and Paul Tabbush

Examine relationships between communities and woodlands in support of FC policies on sustainable forest management.

Poplars

Paul Tabbush

Evaluate poplar clones with potential for timber production.

Alternative establishment systems

Ian Willoughby and Richard Jinks

Investigate alternatives to conventional establishment systems for new planting and regenerating existing woodlands, including vegetation management, reducing synthetic chemical inputs and direct seeding.

Energy coppice

Alan Armstrong

Investigate dry matter yields of willow and poplar coppice grown for renewable energy.

Lowland native woods

Ralph Harmer

Examine methods for managing, regenerating and extending lowland native woodlands.

Silvicultural systems

Gary Kerr

Examine the potential for diversifying the range of silvicultural systems used in native woodlands.

Seed and seedling biology

Peter Gosling

Improve tree seed quality and performance to reduce costs and increase reliability of direct seeding and natural regeneration.

Technical Development Branch

Large-scale forestry harvesting

Colin Saunders

Evaluate machinery and equipment, produce output guidance and investigate operational techniques relevant to large-scale forestry work in harvesting.

Large-scale ground preparation, seed sowing and planting

Steve Morgan, Andy Hall and Bill J. Jones

Evaluate machinery and equipment, produce output guidance and investigate operational techniques relevant to large-scale forestry work in ground preparation, seed sowing and planting.

Farm and small-scale silviculture/harvesting and utilisation of small woodlands

Andy Hall, Martin Lipscombe and Dave Jones

Develop methods and assess equipment, particularly with low environmental impact, suitable for use in small, generally broadleaved woodlands, and suitable for use by farmers and small contracting firms. Evaluation and development of mechanised methods of broadleaf harvesting.

Forestry operations on derelict and reclaimed land
Bill J. Jones

Undertake focused research into the cost-effectiveness of restoration techniques, with an emphasis on system and cost advice on techniques recommended by scientists.

Wood for energy
Andy Hall and Steve Morgan

Develop methods for using short rotation coppice, single-stemmed short rotation forestry, forestry residues and existing undermanaged woodlands for small-scale heating and small- or large-scale electricity generation.

Chemical weeding
Bill J. Jones

Evaluate equipment, application techniques and safety.

Health and Safety
Bill J. Jones, Colin Saunders and Dave Jones

Undertake research into various aspects of Health and Safety with particular emphasis on health issues such as ergonomics of harvesting machinery and hand–arm vibration using powered hand tools.

Tree Improvement Branch

Selection and testing of conifers
Steve Lee

Undertake plus-tree selection, progeny testing. Breeding/production populations. Demonstration of realised gain. Development of techniques for marker aided selection. Species: Sitka spruce, Scots pine, Corsican pine, Douglas fir, larch.

Breeding and production of conifers
Steve Lee

Clonal archives: conservation, advanced breeding material. Improved seed: controlled pollination, seed orchards.

Improvement of broadleaves
Ned Cundall

Selection/testing of selections at population, family and clonal level. Species: oak, ash, sycamore, beech, birch.

Origin and provenance of conifers
Sam Samuel

Identification of suitable origins of conifer species. Key species: Sitka spruce, Douglas fir.

Biochemical and molecular study of genetic variation
Ian Forrest and Joan Cottrell

Study of genetic variation and gene flow in natural populations.

***In vitro* propagation and phase-change biotechnologies**
Allan John

Investigate tissue culture systems for multiplication of Sitka spruce and hybrid larch.

Forest Reproductive Material Regulations
Sam Samuel

Devise methods for inspection of material proposed for registration. Maintain the National Register of Basic Material.

Woodland Ecology Branch

Assessing biodiversity in managed forests
Richard Ferris

Determine the biodiversity status of plantation forests, develop practical assessment methodologies and identify potential biodiversity indicators.

Forest habitat management

Jonathan Humphrey, Russell Anderson and Helen Armstrong

Investigate and provide guidance on the management of upland forest habitats, including wooded and open ground, for the conservation and enhancement of biodiversity.

Species Action Plans

Alice Broome

Undertake research in support of Forestry Commission commitments to the species Biodiversity Action Plans and provide advice on appropriate management of woodland habitats for these species.

Landscape ecology

Richard Ferris, Jonathan Humphrey and Chris Quine

Improve understanding of how biodiversity responds to management at the landscape scale, and translate this into practical management guidance for forest design.

Ecological site classification and decision support systems

Duncan Ray

Research, build and test models that predict the effect of forest management on forest ecology, and develop decision-making tools for ecological site classification and forest biodiversity.

Squirrel management

Brenda Mayle

Develop cost-effective means of managing the impact of grey squirrels on timber production. Work to secure the future of the red squirrel as a component of the British woodland fauna.

Deer population ecology and management

Robin Gill, Helen Armstrong and Brenda Mayle

Provide a sustainable basis for deer management in UK woodlands by investigating and developing new techniques and models of impacts and damage, and population dynamics of deer.

Tree protection

Roger Trout

Develop techniques and materials for cost-effective protection of trees and woodlands from vertebrate damage.

Woodland Surveys Branch

National inventory of woodland and trees

Steve Smith

Undertake the FC national survey of woodlands and trees, assessing the woodland cover. Update key statistics on forest type, species, age-class, management and ownership.

Inventory GIS development

Graham Bull

Create the digital woodland map for Britain. Develop the use of GIS for providing spatially referenced data on the woodland cover of Great Britain.

Private sector production forecast

Justin Gilbert

Develop and produce the private sector production forecast incorporating new woodland data from the national inventory.

Appendix 4

Research Contracts Awarded by Forest Research

Avon Vegetation Research
Forestry herbicide evaluation.

Centre for Ecology & Hydrology
Seedling growth modelling.

Environment Agency (Wales)
Effects of forestry on surface water acidification.

Fountain Forestry
Water monitoring, Halladale.

Freshwater Fisheries Laboratory
Effects of riparian forest clearance on fish populations.

Imperial College, London
Control of decay in utility poles.
Development of a biological control agent for Dutch elm disease.

Lancaster University
Detection and monitoring of the effects of ozone pollution on deciduous forest physiology: remote sensing as a predictive tool.

Macaulay Land Use Research Institute
Sustainability of afforestation development, Halladale.

Mountain Environments
Investigation of the long-term effects of forest management on upland catchments (Balquhidder).

Scottish Environment Protection Agency
Effects of forestry on freshwater fauna.

University of Aberdeen/University of Durham
Population dynamics in a predator–prey system.

University of Abertay, Dundee
Cryopreservation of Sitka spruce tissues.

University of Birmingham
Woody debris in forest aquatic habitats.

University of Durham
Habitat–predator–prey relationships, Kielder.

University of Leeds
Atmospheric boundary layer over forests.
Chemical transport in forests.

University of Reading
Tree root response to acidification.
Soil variability.

University of Southampton
Water and fine sediment transport in rivers with wooded floodplains.

University of Sussex
Biochemical mechanisms for plants to act as sinks for atmospheric pollutants.
Drought tolerance in poplars.

University of Ulster
Feeding ecology of the large pine weevil.
Impact of defoliating insects on forests.

University of Wales
Endophytic establishment of wood-degrading fungi.

Appendix 5

Contract Work Undertaken by Forest Research for External Customers

(some projects may also be part-funded by FC customers)

Anglia WoodNet
Mobile sawmilling guide.
Coppice working methods.

British Biogen
Woodfuel chipping.
Woodfuel moisture content measurement.

Cranfield University
Biomass production of landfill.

Department of the Environment, Transport and the Regions
Monitoring the health of non-woodland trees.
Potential for woodland establishment on landfill sites.

Department of the Environment, Transport and the Regions /Aspinwall & Company
Effectiveness of provisions for the aftercare of mineral workings.

Department of the Environment, Transport and the Regions/Loughborough University
Trees and drought in lowland England.

Department of the Environment, Transport and the Regions/Natural Environment Research Council
Cause–effect relationships for pollutant inputs to UK woodland ecosystems.

Department of the Environment, Transport and the Regions//Wye College
The use of soil-forming materials in the reclamation of older mineral workings and other reclamation schemes.

Editorial update Following the June 2001 General Election, work for Department of the Environment, Transport and Regions (DETR) and Ministry of Agriculture, Fisheries and Food (MAFF) is now covered by the new Department for the Environment, Food and Rural Affairs (DEFRA) and Department of Transport, Land and the Regions (DTLR).

Department of Trade and Industry
Carbon budget factsheet.
Yield models for energy coppice of poplar and willow.

English Nature
Reversal of woodland fragmentation.

Environment Agency
Soil quality indicators.
Phytophthora disease of alder.

European Commission
Alternatives to methyl bromide for quarantine treatment.
Bark and wood boring insects in living trees.
Control of decay.
Demonstration of sustainable forestry to protect water quality and aquatic biodiversity.
Forest condition surveys.
Gene flow in oaks.
Improving protection and resistance of forests to the spruce aphid.
Intensive monitoring of forest ecosystems.
Larch wood chain.
Native black poplar genetic resources in Europe.
Natural regeneration of oak.
Phytophthora in European oak decline.
The use of excavator base machines in forestry.
The use of excavators and backhoe loaders in forestry.
Upgrading the Level II protocol for physiological modelling of cause–effect relationships: a pilot study.

EC/Highland Birchwoods
Conservation of native oakwoods.

EC/Potsdam Institute for Climate, Germany
Quantifying forest ecosystem dynamics in northern Europe.

EC/Scottish Natural Heritage
Restoration of wet woods.

Health and Safety Executive
Mobile elevated working platforms.

Highland Birchwoods
Small scale harvesting workshop.

ITE
Terrestrial effects of acid pollutants.
UK emissions by sources.

Joint Nature Conservation Committee
Red squirrel conservation.

Kemira Fertilisers
Slow release fertilisers for cell-grown seedlings.

Leverhulme Trust/University of Ulster
Novel methods for quantifying the impact of defoliating insects in forests.

Macfarlane Smith
Vertebrate repellents.

Marches Woodland Initiative
Development of a solar kiln.

Ministry of Agriculture, Fisheries and Food
Development of a site-specific yield model for ash in lowland England and Wales.
Provenance testing of broadleaved species in farm forestry.
Yield models for energy coppice of poplar and willow.

Natural Environment Research Council/Imperial College
Variation in the Dutch elm disease pathogens.

National Forest Company
Research and demonstration in the National Forest.

Raleigh International
Conservation of the huemul deer in Chile.

Scotland and Northern Ireland Forum for Environmental Research
A coupled soil–forest–atmosphere dynamic model for predicting evapotranspiration demands at the plot and landscape scales in the UK.
Effect of riparian forest management on the freshwater environment.

Scottish Forestry Trust/UK Forest Products Association/Tilhill Economic Forestry/Scottish Woodland Owners Association
Assessing log quality in Sitka spruce.

Scottish Natural Heritage
Seed vitality in the Mar Lodge pinewoods.

University of Viterbo, Italy
Modelling long-term growth of beech.

Appendix 6

Forest Research Staff as at 31 March 2001

Chief Executive
J. Dewar, B.Sc., M.I.C.For.

Personal Secretary
M. W. Holmes

Chief Research Officer
P. H. Freer-Smith, B.Sc., Ph.D.

Personal Secretary
C. A. Holmes

Branches based at Alice Holt

Administration Branch
K. N. Charles, F.M.S., *Personnel and Administration Officer, Head of Branch*

Central Services Section
S. J. Hutchings*
D. M. Payne
M. Sennet*
A. Smith*
M. L. Young

Personnel Section
M. G. Wheeler
W. B. Groves
J. R. Lacey

Typing Section
M. C. Peacock*, *Head of Section*
S. C. Stiles*

Finance Branch
A. J. Cornwell, F.C.M.A., *Head of Branch*
L. J. Caless
P. A. Filewood
C. Martin
J. M. Turner

* denotes part-time staff

Communications Branch

Library and Information Section
C. A. Oldham, B.A., M.A., Dip.Lib., A.L.A., *Head of Section and Librarian*
E. M. Harland, M.A., Dip.Lib., *Assistant Librarian*
K. A. Hutchison, M.A. *(at Northern Research Station)*
T. D. Smalley

Photography Section
G. L. Gate, *Head of Section*
G. R. Brearley *(at Northern Research Station)*
M. Trusler *(also with Central Services Section)*
J. Williams

Entomology Branch (with section at Northern Research Station)
H. F. Evans, B.Sc., D.Phil., F.R.E.S., *Head of Branch*
G. Green, B.Sc.*
M. R. Jukes, C.Biol., M.I.Biol.
J. T. Staley, B.Sc., M.Sc.
S. A. Stephens*
N. A. Straw, B.Sc., Ph.D., F.R.E.S.
C. A. Tilbury, B.Sc.
D. Wainhouse, M.Sc., Ph.D., F.R.E.S.

Environmental Research Branch
A. J. Moffat, B.Sc., Ph.D., *Head of Branch*
L. C. Adams, B.Sc.
S. E. Benham, B.Sc.
F. J. M. Bochereau, B.Sc., M.Sc.
S. B. Broadmeadow, B.Sc., M.Sc.
M. S. J. Broadmeadow, B.Sc., Ph.D.
S. R. Cowdry*
P. G. Crow, B.Sc.
D. W. H. Durrant, B.A.
K. J. Foot, Eng.D., M.Sc., B.Sc.
T. R. Hutchings, M.Sc.
F. M. Kennedy, B.Sc., Ph.D.
A. J. McIntyre, B.Sc.
T. R. Nisbet, B.Sc., Ph.D.
R. M. Pitman, B.Sc., Ph.D.
E. Ward, B.Sc., M.Sc., C.Chem., M.R.S.C.
C. E. Whitfield*
C. A. Woods *(also with Woodland Ecology Branch)*

Mensuration Branch

J. M. Methley, B.Sc., *Head of Branch*
M. E. Baldwin, HND, B.Sc., M.Sc.
J. M. Bell*
E. Casella, M.Sc., Ph.D.
I. R. Craig
S. P. Evans, B.A., M.A., Ph.D., Ph.D., Professor
P. A. Henshall, B.Sc.
R. W. Matthews, B.Sc., M.Sc.
J. C. Proudfoot
T. J. Randle, B.Sc.

Pathology Branch (with section at Northern Research Station)

J. F. Webber, B.Sc., Ph.D., *Head of Branch*
C. M. Brasier, B.Sc., Ph.D., D.Sc., Professor
A. Jeeves
S. A. Kirk
C. A. Lishman*
D. Lonsdale, B.Sc., Ph.D.
D. R. Rose, B.A.
J. Rose
K. V. Thorpe, B.A., M.Sc., D. Phil.

Silviculture and Seed Research Branch

P. M. Tabbush, B.Sc., M.I.C.For., *Head of Branch*
A. Armstrong, M.I.C.For.
C. A. Baker, B.Sc.
P. G. Gosling, B.Sc., Ph.D.
R. Harmer, B.Sc., Ph.D.
R. L. Jinks, B.Sc., Ph.D.
G. Kerr, B.Sc., M.I.C.For.
E. O'Brien, B.Sc.
M. J. R. Parratt, B.Sc.
I. Tubby, B.Sc.
M. Robertson, B.Sc.
I. Willoughby, B.Sc., M.B.A., M.I.C.For.
A. Yeomans

Statistics and Computing Branch (with section at Northern Research Station)

B. J. Smyth, B.Sc., *Head of Branch*
R. C. Boswell, B.Sc., M.I.S.
C. A. V. Foden*
L. M. Halsall, B.Sc.
T. J. Houston, B.Sc., M.I.S.
D. Jeffries, B.Sc.
D. Johnson, B.Sc.
T. Knight, B.Sc.
P. E. Newell*
A. J. Peace, B.Sc.
L. P. Pearce*

Woodland Ecology Section (of branch at the Northern Research Station)

R. Ferris, B.Sc., Ph.D., *Head of Section*
A. J. Brunt
M. Ferryman
R. M. A. Gill, B.Sc., M.Sc., Ph.D.
B. A. Mayle, M.Sc.
R. G. Trout, B.A., Ph.D
C. A. Woods *(also with Environmental Research Branch)*

Branches based at Northern Research Station

Administration

M. Abrahams
G. T. Cockerell
E. Hall
E. E. Ker
S. F. Lamb*
L. G. Legge*
G. E. Mackintosh*
R. G. L. Shields*

Entomology Section (of branch at Alice Holt)

S. G. Heritage, M.B.A., C.Biol., M.I.Biol., *Head of Section*
R. Moore, B.Sc., Ph.D.

Pathology Section
(of branch at Alice Holt)

J. E. Pratt, *Head of Section*
S. J. Hendry, B.Sc., Ph.D.
G. A. MacAskill
H. Steele, B.Sc.*

Silviculture North Branch

W. L. Mason, B.A., B.Sc., M.I.C.For., *Head of Branch*
C. Edwards
B. A. Gardiner, B.Sc., Ph.D., F.R.Met.S., Professor
S. E. Hale, B.Sc., Ph.D.
A. M. Hislop, M.I.C.For.
J. Hubert, B.Sc., Ph.D.
C. McEvoy, B.A.
S. J. Mochan
B. C. Nicoll, B.Sc.
S. A. Smith, B.Sc., M.I.C.For
J. C. Suárez-Minguez, B.Sc., M.Sc.
R. N. Thompson

Statistics and Computing Section (of branch at Alice Holt)

R. W. Blackburn, B.Sc., *Head of Section*
L. Connolly*
T. Connolly, B.Sc., Ph.D.
A. Gaw, B.Sc.*
A. D. Milner, B.Sc., Ph.D.
L. Rooney*

Tree Improvement Branch

C. J. A. Samuel, B.Sc., Ph.D., *Head of Branch*
C. M. M. Baldwin
J. E. Cottrell, B.Sc., Ph.D.
E. P. Cundall, B.Sc., Ph.D.
G. I. Forrest, B.Sc., Ph.D.
A. John, B.Sc., Ph.D.
S. J. Lee, B.Sc., Ph.D., M.I.C.For
M. A. O'Donnell*
R. J. Sykes
H. E. Tabbener, B.Sc.

Woodland Ecology Branch
(with section at Alice Holt)

C. P. Quine, M.A., M.Sc., M.I.C.For., *Head of Branch*
A. R. Anderson
H. M. Armstrong, B.Sc., Ph.D.
A. C. Broome, B.Sc.
J. D. Clare, B.Sc., MSc.
J. W. Humphrey, B.Sc., Ph.D.
M. Plews *(also with Technical Support Unit North)*
D. Ray, B.Sc.

Branch based at Ae Village

Technical Development Branch

W. M. Jones, *Head of Branch*
W. J. Jones
S. Morgan
J. D. Neil
N. Nicholson*
J. Rammell
C. J. Saunders
A. Wallace*

Midlands

A. Hall
M. Jones
M. A. Lipscombe
P. Webster

Wales

D. H. Jones, Eng.Tech., A.M.I.Agr.E.

Branch based at Edinburgh HQ

Woodland Surveys Branch

S. Smith, B.Sc., B.A., M.B.A., *Head of Branch*
R. H. Beck
G. D. Bull
C. Brown
J. R. Gilbert, B.Sc.
S. Macintosh
E. S. Whitton

Field Station Staff

Technical Support Unit (North)
K. A. Fielding, *Head of Branch*

Engineering Services
D. J. Brooks, *Head of Engineering Services*
J. A. Nicholl
J. E. Strachan

Bush and Perth
A. J. Harrison, B.Sc., *Head of Stations*

Bush
D. R. Anderson
J. H. Armstrong
D. C. Clark
G. M. Crozier
C. D. Gordon
J. T. Howell
M. Hunter
N. R. Innes
P. J. Love
S. P. Osborne, B.Sc.
A. Purves
S. Sloan

Perth
N. C. Evans
W. F. Rayner

Cairnbaan
D. R. Tracy, B.Sc., *Head of Station*
R. Nicoll
P. M. Simson, B.Sc.
E. M. Wilson, B.Sc.
J. Wilson

Kielder and Mabie
D. M. Watterson, *Head of Stations*

Kielder
T. C. O. Gray
M. Ryan
L. Thornton
I. J. Yoxall

Mabie
L. R. Carson
J. M. Duff
W. Kelly
H. MacLean
J. Sneddon*
H. Watson
J. White

Newton, Lairg and Inverness
A. W. MacLeod, *Head of Stations*

Newton
G. Bowden*
A. R. Cowie
J. Gittins
F. McAllister
F. McBirnie
H. MacKay
S. T. Murphy, B.Sc., M.Sc.
C. Smart

Lairg
A. J. Bowran
C. M. Murray
D. Williams

Inverness
P. J. Walling

Technical Support Unit (South)
N. C. Day, *Head of Branch*

Alice Holt
N. J. Tucker, *Head of Station*
M. J. S. Awdry
R. I. Bellis
S. N. Bellis
A. Bright
J. L. Budd
S. M. Coventry
L. M. Haydon
V. Lawrence
A. Martin
R. A. Nickerson
D. Nisbet
J. E. Page
W. Page
R. M. Panton

Alice Holt Workshop
J. Davey
M. F. Johnston

Exeter
D. G. Rogers, *Head of Station*
A. Ockenden
D. J. Parker
A. M. Reeves
P. Wooton

Fineshade
D. A. West, *Head of Station*
J. Lakey
E. M. Richardson
P. Turner
A. Whybrow

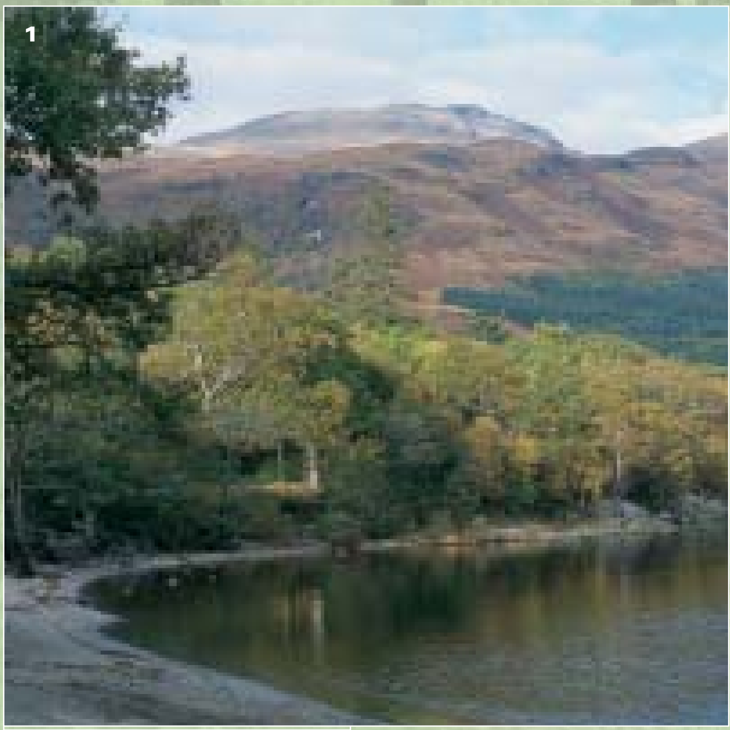
Shobdon
N. J. Fielding, *Head of Station*
N. Connor
J. Griffiths
B. J. Hanwell, B.Sc.
S.A. Hardiman*
D. M. Jones
J. P. Jones
J. J. Price

Talybont
C. D. Jones, B.Sc., *Head of Station*
L. Ackroyd*
M. J. Chappell
D. M. Evans
C. Foster
B. Jones
R. J. Keddle
T. A. Price
R. Sparks
G. K. Williams

Wykeham
D. Kerr, *Head of Station*
I. F. Blair
L. S. Cooper
A. J. Hill
P. A. Jackson*
W. Riddick

PhD students linked with Forest Research
A. Brown (Imperial College)
S. Brown (Leeds University)
L. Crawford (Imperial College)
H. Drewitt (Durham University)
S. Flint (Manchester Metropolitan University)
J. Forbes (Manchester University)
C. Hacker (Imperial College)
J. E. Hope (Stirling University)
R. Jefferies (Southampton University)
P. Loizou (Lancaster University)
T. Ogilvie (Edinburgh University)
K. Robinson (Southampton University)
S. Scozzafava (Stirling University)
E. Vanguelora (Reading University)
M. Wood (Southampton University)
E. Young (Portsmouth University)

Accounts for the year ended 31 March 2001



1 Queen Elizabeth Forest Park, Aberfoyle

2 Log parcel at roadside for sale by negotiation

3 Foresters studying a management design plan in Strathyre, Aberfoyle

Contents

Foreword

1. Status

Forest Research became an Executive Agency of the Forestry Commission with effect from 1 April 1997. It undertakes the major part of the Commission's research and development programmes as well as providing survey, monitoring and scientific services.

Forest Research remains part of the Forestry Commission, which is a cross border Government Department responsible for forestry throughout Great Britain. The relationship between Forest Research, the Forestry Commissioners and Forestry Ministers is described in the Framework Document published February 1997.

Prior to April 1997, Forest Research was managed as a Division of the Forestry Commission and its assets and financial transactions were included in the departmental accounts presented in the Forestry Commission Annual Report and Accounts.

From 1 April 1997, the Agency assumed ownership of and responsibility for the assets and liabilities appropriate to the research activity which were included in the Forestry Commission Statement of Assets and Liabilities as at 31 March 1997. It also assumed ownership of the building assets it occupies, which were previously owned and managed on behalf of the Forestry Commission by the Forest Enterprise agency, with appropriate intra-departmental charges made, and recorded on the Forest Enterprise balance sheet as at 31 March 1997.

Under the Framework Document, Forest Research is funded from the sale of its services to both the Forestry Commission and external customers. Any annual surplus or deficit is counted in the Forestry Commission's net Grant-in-Aid drawn down from Class X Vote 3 .

Forest Research has been designated a GB entity. For Resource Accounting purposes Forest Research is within the departmental boundary. Its accounts are one of a number of separate accounts produced and audited by the Commission and are consolidated into the overall Forestry Commission England/GB accounts.

2. Aims and Objectives

The aims of Forest Research are set out in the Framework Document. They are to provide:

- a capability to conduct research and development, surveys and related services relevant to the forest industry;
- authoritative advice to support the development and implementation of the Government's forestry policy.

The objectives of Forest Research are listed on page 3 of the Report.

3. Review of Activities

This is Forest Research's fourth year of operation as an Agency. Forest Research produced a net operating surplus of £580,000 on its Income and Expenditure Account, excluding the notional cost of capital. A comparison of income and expenditure with the previous year's results (as restated, see note 1.9) shows that:

- staff costs reduced by £28,000 (0.4%)
- other management costs reduced by £68,000 (3.5%)
- materials and service costs reduced by £155,000 (5%)
- income from external customers fell by £218,000 (16%).

The net surplus for the year after cost of capital of £519,000 was £61,000.

After adjusting the total surplus for items not involving the movement of cash and for capital expenditure and income, the net cash surplus transferred to the Forestry Commission was £362,000.

4. Financial Objective

Forest Research's financial objective set out in the Framework Document is to recover the full economic costs, including cost of capital, of its operations from the sale of services to customers.

5. Supplier Payment Policy

Forest Research observes the principles of the CBI prompt Payers Code. Unless otherwise stated in the contract, we aim to pay within 30 days from the receipt of goods and services, or the presentation of a valid invoice, whichever is the later. An analysis for 2000–01 indicates that 98.5% of payments to suppliers, including those made using the Government Procurement Card, were paid within the due date. Arrangements for handling complaints on payment performance are notified to suppliers on orders.

6. Employment Policies

Forest Research is committed to the principle of equality of opportunity for employment and advancement for all eligible people on the basis of their ability, qualifications and fitness for the work. Forest Research has systems to ensure that all permanent appointments are made on the basis of fair and open competition and in accordance with the guidance laid down by the Civil Service Commissioners. Further information on the employment of persons with disabilities, the provision of information to, and consultation with, employees, and the promotion of equal opportunities is available on request.

7. Year 2000

The Agency reviewed all its IT systems to ensure that each was capable of operating after 1 January 2000 and has experienced no significant problems .

8. Pension Liabilities

Forest Research staff are part of the Forestry Commission 'by analogy scheme' which is a reserved GB matter. A separate pension scheme statement has been produced .

9. Management

The Ministers who had responsibility for the Commission during the year were:

Nick Brown	*Secretary of State*
Elliot Morley	*Parliamentary Under-Secretary*

Members of the Management Board of Forest Research during the year were:

Jim Dewar	*Chief Executive*
Peter Freer-Smith	*Chief Research Officer*
Ken Charles	*Personnel and Administration Officer*
Tony Cornwell	*Head of Finance*

The Chief Executive is appointed following public advertising of the post.

10. Auditors

These accounts are prepared in accordance with a direction given by the Treasury in pursuance of Section 5(1) of the Exchequer and Audit Departments Act 1921. They are audited by the Comptroller and Auditor General.

J. Dewar
Chief Executive and Agency Accounting Officer
28 September 2001

Statement of Forestry Commission's and Chief Executive's Responsibilities

Under Section 5 of the Exchequer and Audit Departments Act 1921 the Treasury has directed the Forestry Commission to prepare a statement of accounts for Forest Research for each financial year in the form and on the basis set out in the accounts direction. The accounts are prepared on an accruals basis and must give a true and fair view of the Forest Research state of affairs at the year end and of its income and expenditure and cash flows for the financial year.

In preparing the accounts the Forestry Commission is required to:

- observe the accounts direction, including the relevant accounting and disclosure requirements, and apply suitable accounting policies on a consistent basis;
- make judgements and estimates on a reasonable basis;
- state whether applicable accounting standards have been followed, and disclose and explain any material departures in the financial statements;
- prepare the financial statements on the going concern basis, unless it is inappropriate to assume that Forest Research will continue in operation.

The Director General of the Forestry Commission, as departmental Accounting Officer, has designated the Chief Executive of Forest Research as the Accounting Officer for the Agency. His relevant responsibilities as Accounting Officer, including his responsibility for the propriety and regularity of the public finances and for the keeping of proper records, are set out in the Accounting Officers' Memorandum, issued by the Treasury and published in *Government accounting* (The Stationery Office).

Statement on the System of Internal Financial Control

As Accounting Officer, I acknowledge my responsibility for ensuring that an effective system of internal financial control is maintained and operated by Forest Research.

The system can provide only reasonable and not absolute assurance that assets are safeguarded, transactions authorised and properly recorded, and that material errors or irregularities are either prevented or would be detected within a timely period.

The system of internal financial control is based on a framework of regular management information, administrative procedures including the segregation of duties, and a system of delegation and accountability. In particular, it includes:

- comprehensive budgeting systems with an annual budget which is reviewed and agreed by the Management Board of Forest Research;
- regular reviews by the Management Board of periodic and annual financial reports which indicate financial performance against the forecasts;
- setting targets to measure financial and other performance;
- clearly defined capital investment control guidelines;
- as appropriate, formal project management disciplines;
- a programme of accounting inspections.

The Forestry Commission has an internal audit unit, which operates to standards defined in the Government Internal Audit Manual. The work of the internal audit unit is informed by an analysis of the risk to which the body is exposed, and annual internal audit plans are based on this analysis. The analysis of risk and the internal audit plans are endorsed by the Forest Research Audit Committee and approved by me. At least annually, the Head of Internal Audit (HIA) provides me with a report on internal audit activity in Forest Research. The report includes the HIA's independent opinion on the adequacy and effectiveness of the body's system of internal financial control.

My review of the effectiveness of the system of internal financial control is informed by the work of the internal auditors, the Audit Committee which oversees the work of the internal auditor, the executive managers within the body who have responsibility for the development and maintenance of the financial control framework, and comments made by the external auditors in their management letter and other reports.

Implementation of the Turnbull Report

In September 1999, the Institute of Chartered Accountants of England and Wales published the Report of the Turnbull Committee: *Internal control: guidance for directors on the Combined Code*. The effect of the Turnbull Report was to extend the existing requirement to provide a statement in respect of financial controls to cover all controls including financial, operational, compliance and management of risk.

As Accounting Officer, I am aware of the recommendations of the Turnbull Committee and am taking reasonable steps to comply with the Treasury's requirement for a statement of internal control to be prepared for the year ended 31 March 2002.

J. Dewar
Chief Executive and Agency Accounting Officer
28 September 2001

The Certificate and Report of the Comptroller and Auditor General to the House of Commons

I certify that I have audited the financial statements on pages 88 to 97 under the Exchequer and Audit Departments Act 1921. These financial statements have been prepared under the historical cost convention as modified by the revaluation of certain fixed assets and the accounting policies set out on pages 91 to 92.

Respective responsibilities of the Agency, the Chief Executive and Auditor

As described on page 83, the Agency and Chief Executive are responsible for the preparation of the financial statements in accordance with the Exchequer and Audit Departments Act 1921 and Treasury directions made thereunder and for ensuring the regularity of financial transactions. The Agency and Chief Executive are also responsible for the preparation of the other contents of the Annual Report. My responsibilities as independent auditor are established by statute and guided by the Auditing Practices Board and the auditing profession's ethical guidance.

I report my opinion as to whether the financial statements give a true and fair view and are properly prepared in accordance with the Exchequer and Audit Departments Act 1921 and Treasury directions made thereunder, and whether in all material respects the expenditure and income have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them. I also report if in my opinion the Foreword is not consistent with the financial statements, if the Agency has not kept proper accounting records or if I have not received all the information and explanations I require for my audit.

I read the other information contained in the Annual Report, and consider whether it is consistent with the audited financial statements. I consider the implications for my certificate if I become aware of any apparent misstatements or material inconsistencies with the financial statements.

I review whether the statement on pages 84 to 85 reflects the Agency's compliance with Treasury's guidance ' Corporate governance: statement on the system of internal financial control'. I report if it does not meet the requirements specified by the Treasury or if the statement is misleading or inconsistent with other information I am aware of from my audit of the financial statements.

Basis of Audit Opinion

I conducted my audit in accordance with United Kingdom Auditing Standards issued by the Auditing Practices Board. An audit includes examination on a test basis of evidence relevant to the amounts, disclosures and regularity of financial transactions included in the financial statements. It also includes an assessment of the significant estimates and judgements made by the Agency and Chief Executive in the preparation of the financial statements and of whether the accounting policies are appropriate to the Agency's circumstances, consistently applied and adequately disclosed.

I planned and performed my audit so as to obtain all the information and explanations which I considered necessary in order to provide me with sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement whether caused by error or by fraud or other irregularity and that in all material respects the expenditure and income have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities that govern them. In forming my opinion I have also evaluated the overall adequacy of the presentation of information in the financial statements.

Opinion

In my opinion:

- the financial statements give a true and fair view of the state of affairs of Forest Research and of the surplus, total recognised gains and losses and cash flows for the year then ended and have been properly prepared in accordance with the Exchequer and Audit Departments Act 1921 and directions made thereunder by Treasury; and
- in all material respects the expenditure and income have been applied to the purposes intended by Parliament and the financial transactions conform to the authorities which govern them.

I have no observations to make on these financial statements.

John Bourn
Comptroller and Auditor General
18 December 2001

National Audit Office
157–197 Buckingham Palace Road
Victoria
London SW1W 9SP

Income and Expenditure Account for the year ended 31 March 2001

	Notes	2001 £000	2000 as restated £000
Income			
Income from research, development and survey services			
Forestry Commission customers	2	**11,254**	11,253
Non-Forestry Commission customers		**1,116**	1,334
Total income		**12,370**	12,587
Expenditure			
Staff costs	3	**7,177**	7,205
Other management costs	4 & 5	**1,826**	1,894
Materials and services	5	**2,787**	2,942
Total expenditure		**11,790**	12,041
Net operating surplus/(deficit)		**580**	546
Notional cost of capital	7	**(519)**	(520)
Net surplus/(deficit) for the year		**61**	26
Transferred to General Fund		**61**	26

Statement of Total Recognised Gains and Losses for the year ended 31 March 2001

	2001 £000	2000 as restated £000
Net surplus/(deficit) for the year	**61**	26
Revaluation surplus for the year	**19**	148
Total recognised gains	**80**	174

The cumulative effect of adjustments made in respect of prior periods is a loss of £100,000.

There have been no discontinued operations during the year.

The notes on pages 91 to 97 form part of these accounts.

Balance Sheet
for the year ended 31 March 2001

	Notes	31 March 2001 £000	31 March 2000 as restated £000
Fixed assets			
Tangible fixed assets	6	**8,393**	8,182
Current assets			
Stocks	8	**31**	110
Debtors	9	**604**	489
Cash at banks and in hand		**1**	1
		636	600
Current liabilities			
Creditors – amounts falling due within one year	10	**261**	252
Net current assets		**375**	348
Total assets less current liabilities		**8,768**	8,530
Taxpayers Equity			
General Fund	11	**6,160**	5,941
Revaluation Reserve	13	**2,608**	2,589
Total Taxpayers Equity		**8,768**	8,530

J. Dewar
Chief Executive and Agency Accounting Officer
28 September 2001

The notes on pages 91 to 97 form part of these accounts.

Cash Flow Statement
for the year ended 31 March 2001

	Notes	2001 £000	2000 as restated £000
Reconciliation of net surplus to net cash flow from operating activities			
Net surplus for the year		**61**	26
Notional cost of capital	7	**519**	520
Depreciation	4 & 6	**396**	400
Decrease/(-)Increase in stocks		**79**	(54)
Decrease/(-)Increase in debtors		**(115)**	361
Increase/(-)Decrease in creditors		**9**	4
Net cash inflow from operating activities		**949**	1,257
Capital expenditure			
Payments to acquire tangible fixed assets		**(587)**	(258)
Total net cash inflow		**362**	999
Financing			
Cash surplus transferred to Forestry Commission		**362**	999
Reconciliation of net cash flow to movement in net funds			
Net funds at 1 April 2000		**1**	1
Net funds at 31 March 2001		**1**	1

The notes on pages 91 to 97 form part of these accounts.

Notes to the Accounts

Note 1. Accounting Policies

1.1 Form of Accounts

In accordance with Section 5(1) of the Exchequer and Audit Departments Act 1921, the accounts are drawn up in a format agreed and approved by Treasury. They are prepared under the historical cost convention modified by the inclusion of the valuation of assets. Without limiting the information given, the accounts meet the requirements of the Companies Acts and of the Financial Reporting Standards where relevant.

1.2 Accounting for Fixed Assets

Where the Agency is the principal beneficial user of assets of the Forestry Commission estate they are treated as a fixed asset of the Agency although legal ownership is vested in the Forestry Ministers. The normal threshold for the capitalisation of assets is £1,500, but all IT equipment costing £250 or more is capitalised as a pooled asset, the amount involved being material.

1.3 Valuation of Assets

Land and buildings are revalued every three years by professionally qualified staff employed by the Forestry Commission. Research and office equipment is revalued every three years using prevailing current prices for replacement items. Between revaluations, tangible fixed asset values are updated annually using a general price index.

All revaluation surpluses and deficits are taken to the Revaluation Reserve.

1.4 Depreciation

Depreciation is provided on all tangible fixed assets - except land - at rates calculated to write off the valuation, less estimated residual value, of each asset evenly over its expected useful life.

Buildings - over 20 to 80 years

Research and office equipment - over 2 to 20 years

1.5 Stocks and Works in Progress

Consumable materials and supplies are valued at current replacement cost.
Works in progress on long-term projects is valued at the cost of staff time and other direct costs plus attributable overheads based on the normal level of activity.

1.6 Corporation Tax

Forest Research is not subject to corporation tax.

1.7 Provision for Bad and Doubtful Debts

Specific provisions for bad and doubtful debts are set aside on the basis of a review of individual debts at the end of the year.

1.8 Foreign Currencies

Transactions in foreign currencies are recorded at the rate ruling at the time of the transaction. Exchange differences are taken to the Income and Expenditure Account.

1.9 Prior Year Figures

The comparative figures for 1999/2000 have been restated to include adjustments applicable to prior accounting periods arising from the correction of fundamental errors.

Note 2. Income from Forestry Commission and Forest Enterprise

The Agency undertakes a significant proportion of the Forestry Commission's overall annual research programme in the form of specifically commissioned projects to deliver agreed outputs. A separate annual charge is agreed for each project based on full cost recovery. These charges amounted to £9.8 million as originally assessed. Costs established in one year are used to determine project charges for future years. The Agency also provides research and survey services for Forest Enterprise on a full cost recovery basis.

Total income from Forestry Commission customers consisted of:

	2001	2000
	£000	£000
Research, development and other services to:		
Forestry Commission	10,145	10,011
Forest Enterprise	1,109	1,242
	11,254	11,253

Note 3. Staff Costs and Numbers

3.1 Employee costs during the year amounted to:

	2001	2000 as restated
	£000	£000
Wages and Salaries	5,820	5,846
Social Security Costs	431	427
Employer's Superannuation Costs	926	932
	7,177	7,205

The Agency's staff are covered by the Forestry Commission Pension Scheme which is a defined benefit pension scheme. Employer's superannuation contributions, calculated as percentages of pensionable pay, are paid to the Forestry Commission Pension Scheme and are included in the Income and Expenditure Account. The rates of employer's contributions were from 15 to 22 per cent according to grade as determined by the Government Actuary. Actual pension payments are met by the Forestry Commission. The receipts and payments of the pension scheme, its status and how it operates, and the valuation of unfunded past service liabilities, are shown in the accounts of the Forestry Commission published in its Annual Reports and Accounts.

3.2 The total remuneration, excluding pension contributions, of the Chief Executive, the highest paid member of the Management Board, was £60,195 (1999/2000: £58,849). The Chief Executive is an ordinary member of the Forestry Commission Pension Scheme.

3.3 The range of salaries of Management Board members, excluding the Chief Executive, is shown below. Management Board members are senior staff and are ordinary members of the Forestry Commission Pension Scheme.

Management Board Members	**2001 Number**	2000 Number
£30,000–£34,999		2
£35,000–£39,999	2	
£45,000–£49,999	1	1

Pension benefits are provided through the Forestry Commission Pension Scheme, which is run by analogy with the Principal Civil Service Pension Scheme. The scheme provides benefits on a 'final salary' basis at a normal retirement age of 60. Benefits accrue at the rate of 1/80th of pensionable salary for each year of service. In addition a lump sum equivalent to 3 years pension is payable on retirement. Members pay contributions of 1.5% of pensionable earnings. Pensions increase in line with the Retail Price Index. On death, pensions are payable to the surviving spouse at a rate of half the members pension. On death in service, the scheme pays a lump sum benefit of twice pensionable pay and also provides a service enhancement on computing the spouse's pension. The enhancement depends on length of service and cannot exceed 10 years. Medical retirement is possible in the event of serious ill-health. In this case, pensions are brought into payment immediately without actuarial reduction and with service enhanced as for widow(er) pensions.

Disclosures relating to members of the Management Board have been restricted in accordance with the Data Protection Act 1998.

3.4 The average number of employees (full time equivalents) during the year was as follows:

	2001 Number	2000 Number
Permanent Staff	246	256
Casual Staff and Staff on Fixed-Term Appointments	31	34
	277	290

3.5 Benefits in kind are provided under the following schemes:

(i) Advances of Salary for House Purchase
(ii) Advances of Salary for purchase of Season Tickets and Bicycles
(iii) Car Provision for Employees Scheme.

Each scheme is subject to conditions and financial limits.
The Advances of Salary for House Purchase scheme had 11 loans with an outstanding balance of £2,500 or more to individual members of staff at 31 March 2001. The total value of these loans was £82,245.06.

Note 4. Other Management Costs

Other management costs are stated after charging:

	2001	2000 as restated
	£000	£000
Exchange Rate Losses on EC Contracts	2	8
Auditors' Remuneration	19	12
Depreciation of Fixed Assets	396	400
Travel and Subsistence	399	401
Staff Transfer Expenses	60	90
Training	114	102
Building Maintenance	367	322
Utilities	227	213
Computer Supplies	109	175

Note 5. Charges from the Forestry Commission

Included within Other Management costs and Materials and Services are charges from the Forestry Commission and Forest Enterprise amounting in total to £1,210,743 (2000: £1,171,078).

Charges are made to Forest Research from the Forestry Commission and Forest Enterprise, as appropriate, for assistance with field experiments, hire of machinery and equipment and for personnel, business management, financial and other support services at Headquarters.

Note 6. Fixed Assets

	Land and Buildings as restated £000	Machinery and Equipment £000	Total as restated £000
Valuation:			
At 1 April 2000	7,330	4,074	11,404
Additions	7	580	587
Disposals and transfers		6	6
Revaluation adjustment	106	-128	-22
At 31 March 2001	**7,443**	**4,532**	**11,975**
Depreciation:			
At 1 April 2000	132	3,090	3,222
Provided in year	132	264	396
Disposals and transfers		5	5
Revaluation adjustment	5	-46	-41
At 31 March 2001	**269**	**3,313**	**3,582**
Net book value:			
At 31 March 2001	7,174	1,219	8,393
At 31 March 2000	7,198	984	8,182

Fixed assets were revalued as at 31 March 2001 in accordance with accounting policies. The valuation includes the principal research stations at Alice Holt Lodge near Farnham in Surrey and the Northern Research Station, Roslin near Edinburgh, with net book values of £5.0 million and £1.6 million respectively at 31 March 2001

Note 7. Cost of Capital

Notional cost of capital based on 6% of average total assets less current liabilities employed in 2000/01 amounted to £519,000.

Note 8. Stocks and Works in Progress

	2001	2000
	£000	£000
Stocks	0	52
Research Works in Progress	31	58
	31	110

Note 9. Debtors

	2001	2000
	£000	£000
Trade debtors	446	331
Other debtors	104	158
Prepayments	54	
	604	489

Note 10. Creditors: amounts falling due within one year

	2001	2000
	£000	£000
Payments received on account	48	45
Trade creditors	211	169
Other creditors including taxation and social security costs	2	38
	261	252

Note 11. General Fund

	2001	2000
	£000	£000
Balance brought forward	5,920	6,393
Prior year adjustment	21	
Balance as adjusted	5,941	
Movement in year		
Net surplus for year	61	126
Transfer of fixed assets from/(-) to other Forestry Bodies	1	1
Cash surplus transferred to Forestry Fund	(362)	(1,120)
Notional cost of capital	519	520
Balance carried forward	**6,160**	5,920

Note 12. Prior Year Adjustment

The net surplus for 1999/2000 has been reduced by £100,000, reflecting the net effect of adjustments to income, staff costs and depreciation. Tangible fixed assets have decreased by £21,000 and the cash surplus transferred to the Forestry Commission has decreased by £121,000.

The main element of the adjustment, a decrease in income of £167,000, is the consequence of the correction of a central book keeping adjustment which incorrectly raised duplicate invoices when new sales ledger software was installed. This adjustment, part of a total of £1,337,712 for the Forestry Commission as a whole, was identified during the resolution of a cash ledger reconciliation imbalance, which was identified during the production of the 1999/2000 accounts of the Forestry Commission.

Note 13. Revaluation Reserve

	2001	2000
	£000	£000
Balance brought forward	2,589	2,441
Revaluation surplus for the year ended 31 March 2001		
Land and Buildings	101	170
Machinery and Equipment	(82)	(22)
Balance carried forward	**2,608**	2,589

Note 14. Contingent Liabilities

There were no contingent liabilities at 31 March 2001 for damages caused to other persons' property or for compensation for personal injury to employees.

Note 15. Related Party Transactions

During the year, Forest Research has had a significant number of material transactions with the Forestry Commission and Forest Enterprise Agency who are regarded as related parties.

In addition, Forest Research has had various material transactions with other Government Departments and other central Government bodies. Most of these transactions have been with the Department of Environment, Transport and the Regions[a], the Department of Trade and Industry, and the Ministry of Agriculture, Fisheries and Food[b].

Note 16. Financial Performance Measures

The target to recover full resource costs, including capital, from internal and external customers was achieved. The Agency achieved an operating surplus of £580,000 which, after allowing for the cost of capital (£519,000) represented a cost recovery of 101% (2000 –100%).

Editorial update Since the June 2001 General Election, Government Department name changes have occurred:

[a] Department for Transport, Local Government and Regions (DTLR).

[b] Department of Environment, Food and Rural Affairs (DEFRA).

Accounts Direction given by the Treasury in accordance with Section 5(1) of the Exchequer and Audit Departments Act 1921

1. This direction applies to The Forestry Commission Research Agency.

2. The Forestry Commission Research Agency shall prepare accounts for the year ended 31 March 2001 in compliance with the accounting principles and disclosure requirements of the H.M. Treasury *Resource accounting manual* which is in force for that financial year.

3. The Accounts shall be prepared so as to give a true and fair view of the income and expenditure, total recognised gains and losses and cash flows of the Agency for the financial year and of the state of affairs as at 31 March 2001.

4. Compliance with the requirements of the *Resource accounting manual* will, in all but exceptional circumstances, be necessary for the accounts to give a true and fair view. If, in these exceptional circumstances, compliance with the requirements of the *Resource accounting manual* is inconsistent with the requirement to give a true and fair view, the requirements of the *Resource accounting manual* should be departed from only to the extent necessary to give a true and fair view. In such cases, informed and unbiased judgement should be used to devise an appropriate alternative treatment which should be consistent both with the economic characteristics of the circumstances concerned and the spirit of the *Resource accounting manual*. Any material departure from the *Resource accounting manual* should be discussed in the first instance with the Treasury.

5. This direction replaces any previous direction issued to the Agency.

David Loweth
Head of the Central Accountancy Team, Her Majesty's Treasury
Dated 30 May 2001

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