Forest Research
The research agency of the Forestry Commission

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Annual Report and Accounts 2005–2006

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Annual Report and **Accounts** | 2005–2006

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

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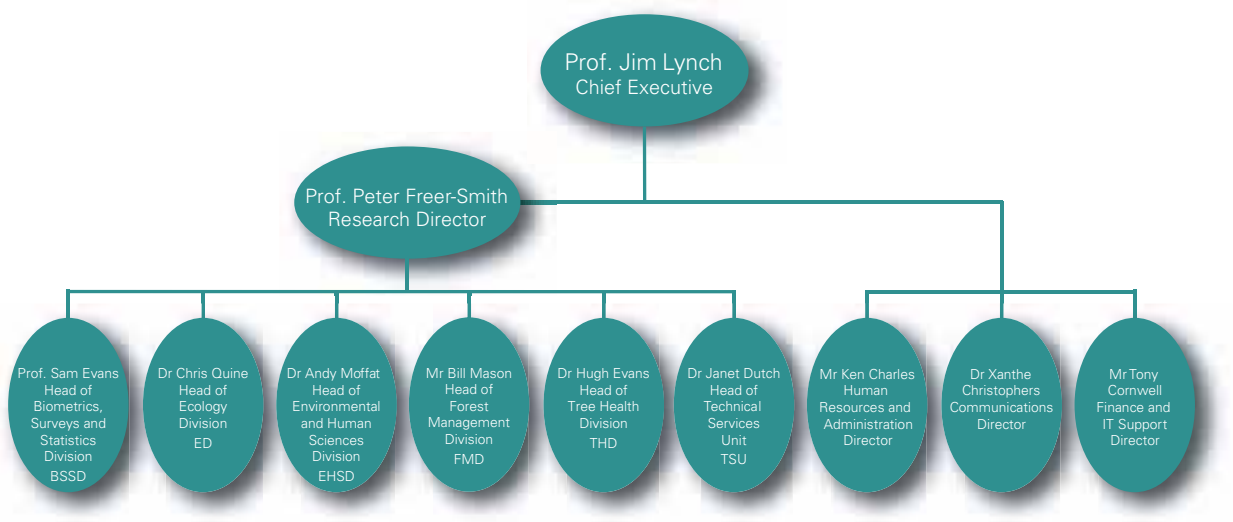

Cover photo: Bluebells *(Hyacinthoides non-scripta)* in mixed woodland in Hampshire.

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About Forest Research

Forest Research is an agency of the Forestry Commission and is the leading UK organisation engaged in forestry and tree related research.

Aims and objectives

The aims and objectives of Forest Research (FR) are to assist the Forestry Commission (FC) in achieving its high-level objective.

On behalf of all three administrations, to take the lead in development and promotion of sustainable forest management and to support its achievement internationally.

FR's Aims

To support and enhance forestry and its role in sustainable development, by providing high-quality research and development in a well-run organisation.

FR's Objectives

- To inform and support forestry's contribution to the development and delivery of the policies of the UK government and the devolved administrations.
- To provide research, development and monitoring services relevant to UK forestry interests.
- To transfer knowledge actively and appropriately.

Research funding

Much of FR's work is funded by the FC with Corporate and Forestry Support 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 was responsible for managing the FC estate during 2005–06, and purchased research, development and surveys specifically related to this estate. In recent years FR has successfully applied for external (non-FC) funding from government departments, the European Union, UK research councils, commercial organisations, private individuals and charities. Collaborative bids with other research providers and consortium funding have become increasingly important, placing emphasis on effective partnerships.

Activities

Research and development are essential components in delivery of the benefits of sustainable forestry in a multifunctional landscape. FR's research, surveys and related scientific services address the social, economic and environmental components of sustainability. There is a focus on providing new knowledge and practical solutions based on high quality science. Our projects provide understanding, policy advice and guidelines on implementation of best practice (e.g. on forest hydrology, continuous cover forestry, timber quality, land reclamation to woodland, and restoration of native woodlands). Much of the research is directed at increasing the biodiversity, landscape and recreational benefits of woodlands. Protection of GB woodlands from pests and diseases, and predicting the impacts of environmental change are also overarching themes.

FR works closely with the FC, the Commission of the European Communities and other international organisations to ensure compliance with international agreements on the sustainable management of forests and related subjects. The Agency also carries out work on genetic conservation, tree improvement, seed testing, method studies, product evaluation, crop inventory, surveys (e.g. *The national inventory of woodland and trees*) 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 (now part of Forest Management Division) is located at Ae in Dumfriesshire with subsidiary offices in the English Midlands and Wales. The Agency also has 9 field stations (the Technical Support Units) from which an extensive network of field trials, sample plots and monitoring sites is assessed. Contact information is given on the inside back cover of this Report. The Agency employs *c.* 280 staff, not including visiting scientists and sandwich students. FR's Corporate Plan for the period 2005–2008 is available to download from www.forestresearch.gov.uk/corporateplans

Chief Executive's Introduction

Last year I was pleased to report successful achievement of our targets over the past 5 years. I am glad to be able to do that again this year and also to focus on the new opportunities that are presented to us for the coming years.

In January 2006 we were delighted to hear from the Office of Science and Technology (OST) of the Department of Trade and Industry (DTI) that we had been awarded £495,000 over 3 years to build capacity in Forest Research (FR) and develop our intellectual property. This is an exciting opportunity, not only to manage our intellectual property but to increase FR's engagement with the forestry and wider environmental industries. I am pleased to announce that this has already led to four new patents, which quadruples the number of patents filed since Forestry Commission research began in 1919. Soon after our award, the OST was merged with the DTI's Innovation Group (IG) to create the new Office of Science and Innovation (OSI). This came about as a result of the review of science, innovation and support for business.

We were also pleased to hear in March 2006 that a Regulatory Reform Order went through Parliament to enable Forest Research alongside the Forestry Commission to engage in commercial activity such as the creation of spin-out companies, spin-in companies and joint venture activities. This is strongly in line with the OSI's Agenda, that economic benefit should flow from publicly funded research as well as serving policy development.

One of the potential problems in Public Sector Research Establishments (PSREs) is that the activity and function that they are engaged in may not be sustainable. The OST review of sustainability considered six aspects: (1) nature of business, (2) governance management, (3) income profile, (4) physical infrastructure, (5) staff and (6) financial management. An overall assessment was then produced and FR was assessed as 'Green/Green, defined as Good: achieved or on track. Low risk of non-delivery'. This analysis was fully supported by consultants. Only five other PSREs, out of around 40, were similarly assessed as Green/Green. This exercise provided an external perspective of FR, indicating that compared with many other establishments, it has a clear business focus, is delivering relevant work, has sound management practices and enjoys a strong relationship with its sponsoring department. The last factor was found by the exercise to be a crucial determinant of sustainability. It was also pleasing that in the first issue of a new electronic cross-government newsletter for scientists and engineers produced by OSI, FR was the PSRE to be spotlighted for review under the heading 'Reclaiming our Future'.

It was pleasing to have such assessment from OSI as we strive to increase the FR company base at external income. We have been particularly pleased about the income that has been generated on land remediation and social sciences within our Environmental and Human Sciences Division. We are also keen to foster the collaborative work across divisions and with our customer bases in the three countries that we serve primarily. One new initiative created in January 2006 was the establishment of a Woodfuel Research Centre as a joint venture led by Forest Management Division and Biometrics, Surveys and Statistics Division but also incorporating expertise from other FR divisions. This has stemmed from our practical expertise in developing woodfuel supply chains and our substantial, detailed studies on short rotation coppice. In the Gill Report to the Department for Environment, Food and Rural Affairs (Defra, and DTI) a recommendation was made for the establishment of a National Biomass Energy Centre (BEC). After much deliberation it was pleasing that FR was invited to provide the base to create that centre in association with the Forestry Commission. This will not only be dealing with woodfuel but will also be covering fuels derived from energy crops, agricultural crops and the waste sector. This is also an indication of our wider environmental remit.

In order to achieve our targets and goals we need advice, and we have been served particularly well by the Advisory Committee on Forestry Research (ACFR). We also recognise that in commissioning research from our main customer, the Forestry Commission, we need good relationships with the Research Strategy Management Board (RSMB) which has been created by the Forestry Commission, together with its sub-committees as Programme Advisory Groups. We are also pleased to report that the ACFR will also now provide advice on scientific direction and strategy to the RSMB. Clearly, liaison is necessary to ensure that the customer user groups in the three countries are fully aware of what we are trying to deliver against the research commissioning process. Therefore we are please and encouraged to have appointed a Research Liaison Officer (RLO) for each country to further that need. Each RLO will be supported by a member of the FR Executive Board (FREB) as the Country Liaison Officer (CLO) who, where appropriate, will attend Executive Boards of each country.

We have been increasingly aware of the need for social sciences in our activities and have been acutely conscious that our primary approach has been from a sociological basis and that there is a need for more economic input into our analyses. Therefore it is pleasing to announce that we have appointed a research leader in the field of Forest Economics. Much of our future will still depend on close co-operation with our European partners and this has been achieved through ongoing development and winning research contracts in projects such as EFORWOOD and SENSOR. It has also been useful for us to interact at policy levels in areas such as the EU Framework Directive.

We also believe our future very much lies in partnerships both in the UK and globally. In the UK a network of universities and research institutes that are carrying out research activity in the field of forestry are crucial to our future development. So, welcoming new partners into that network is always good news; as an illustration we are particularly pleased to have as a new partner the University of Exeter who are working alongside us in developing molecular biological approaches to the analysis of the productivity of forest soils. Further afield we are in the process of signing a Memorandum of Understanding (MoU) with our sister institute in New Zealand (SCION) and we will be developing joint projects and arranging exchange visits between the two organisations.

Advisory Committee on Forestry Research

The Advisory Committee provides guidance for the Agency and FC on the quality and direction of FR's research. The Advisory Committee met in April 2005, for a tour of research work in Kielder Forest, and in November 2005 at Alice Holt Lodge. These meetings allow members to meet staff and to keep up-to-date with FR's work; focus is usually on those research programmes to which visiting groups have been appointed in the year. Thanks are due to Professors Brian Kerry and Mike Jeger who have completed their terms on the committee. They have been generous with their time and highly supportive of Forest Research, and we hope that they will maintain their links with us in the future. I am very pleased to

Targets and achievements over the past six years

Target		2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
Customer satisfaction	Target	96%	96%	97%	90%	90%	90%
	Achieved	97%	97%	98%	97%	97%	97%
Peer-reviewed papers	Target	43	48	48	45	45	45
	Achieved	48	48	48	45	47	45
Reports, FC publications and articles [a]	Target	–	–	–	25	25	25
	Achieved	–	–	–	25+	25+	25+
Increase number of hits on FR website (new target in 05/06)	Target	–	–	–	–	–	15%
	Achieved	–	–	–	–	–	Target exceeded
External review of research programmes [a]	Target	–	–	–	Silviculture	Social Research	Biometrics
	Achieved	–	–	–	Completed	Completed	Completed
Unit cost/ research day (unweighted) 98/99 =100	Target	94	94	92	90	88	86
	Achieved	82	81	79	78	75	72[b]
Unit cost of support services	Target	96	94	92	89	87	85
	Achieved	92	86	84	82	82	73[b]
Cost recovery	Target	100%	100%	100%	100%	100%	100%
	Achieved	101%	100%	100%	100%	99.8%	100%
Income from customers other than FC [a]	Target	–	–	–	£1.5m	£1.5m	£1.9m
	Achieved	–	–	–	£1.65m	£2.11m	£2.01m

[a] New targets set following the Agency's first Quinquennial Review.

[b] Efficiencies achieved during 2005-06 following divisional reorganisation.

welcome Professor Chris Gilligan and Dr Keith Kirby who will join the committee during 2006.

The committee appointed and received a report from an external Visiting Group to Biometrics, Surveys and Statistics Division (chaired by Professor Paul Jarvis, FRS with Professors Erikki Tampper, Hubert Sterba and John Grace as members). The Visiting Group obtained a very good impression of the division as a whole. They found that no programme failed to meet customer needs in some respects, that all programmes made good use of current and new scientific methodology and are innovative in the sense that new ideas, methods and technologies often imported from without are recognised and applied within forestry. With this in mind cutting edge innovation was rated and no programme was scored below 3 (satisfactory). The Visiting Group evaluated science quality on a 4-point scale, finding one programme at 1 (significantly above customer expectations and of international quality), five at 2 (fully meeting customer expectations) and one at 2/3 (as for 2 but with some implementable room for improvement). The group made detailed recommendations on the programmes and also raised seven general issues, ranging from comments on relationships between the support programmes and projects, the development of a biofuel project, use of remote sensing and the publication record. The group recognised the value of FC and other publications for widespread external use, but emphasised that the quality of the science needs to be recognised internationally and this can only be achieved through peer review and publication in international journals.

The Advisory Committee's remit has been extended to reflect the devolution of forestry and associated changes within the FC. The new remit includes provision of advice on the science, which is provided by FR and commissioned externally, needed to support the FC and Northern Ireland Forest Service in development and implementation of the Science and Innovation Strategy for British Forestry. The committee will also advise the FC Research Strategy Management Board and contribute to the FC's horizon scanning and peer review activities for FR and external research. To reflect this broader remit the committee will now be called the Advisory Committee on Forestry Research.

Finance

Income in the year increased by 6% compared to the previous year with a similar increase in payroll costs whilst other operating costs increased by only 3.4%.

The net surplus for the year from normal operations, after the cost of capital charge of £441,000 and depreciation, was £19,000, representing a cost recovery rate of 100.1%. After providing for restructuring costs the net deficit for the year was £350,000.

Capital investment amounted to £489,000 covering a wide range of scientific and technical purchases as well as office, laboratory and infrastructure refurbishments.

In cash flow terms the Agency generated a net surplus of £210,000.

People

Many FR staff have been honoured by awards and have achieved qualifications over the past year, reflecting success and recognition both nationally and internationally. These include:

Peter Freer-Smith who was honoured with a Visiting Professorship at the University of Southampton; Chris Quine who achieved Fellowship of the Institute of Chartered Foresters; and Sam Evans who was elected Fellow of the Chartered Management Institute. Christophe Coudon was awarded a PhD from the University of Nancy in France; Sue Benham received a Postgraduate Certificate in Biological Recording and Species Identification from Birmingham University; and Kirsten Wright obtained a DTA scholarship (based at Reading University), looking at wetland restorations on brownfield sites. Eric Casella was appointed a Visiting Scientist at the University of Southampton and Mark Lawrence became UK representative on the COST E43 Management Board. Special successes relating to forestry journals came in the award of the ICF prize for Silviculture by *Forestry* to Mark Broadmeadow, Duncan Ray and Sam Samuel for their paper 'Climate

change and the future of broadleaved trees in Britain' and the appointment of Ralph Harmer to the new Editorial Panel of the *Quarterly Journal of Forestry*.

During the past year there were new members of staff across most FR sites.

These include Kieron Doick to work as a land regeneration biogeochemist, Matt Williams as environmental research support officer, Alberto Morales as an analytical chemist, Chris Peachey as an environmental scientist, Jake Morris as a social scientist and Lynn Jordan as admin support officer, all in EHSD. Ecology Division welcomed Darren Moseley, as an ecological project officer, Amy Eycott, as a landscape ecology analyst and Elaine Abbot to work on red squirrel management. Alan Brewer and Mark Lawrence both joined BSSD: Alan as Head of Empirical Modelling, having recently worked in the cocoa market on growth yield models, and Mark as Head of Surveys and Measurement. Shelagh McCartan joined FMD as a seed scientist; Shelagh's previous work included studies on the *in vitro* conservation of threatened plants used for traditional medicinal purposes. Other new staff across FR include Shirley Spencer as finance support officer at NRS and Jonathan Tetley at TSU Shobdon.

This year we said goodbye to several staff who have been with FR for much of their working lives, totalling 187 years of service.

Sam Samuel formally retired after 35 years at FR following a career which included work in Statistics at Alice Holt and Head of Tree Improvement at NRS. Sam has returned on a part-time basis working on Forest Reproductive Material Regulations in Ecology Division. Jane Smyth, in a long and varied career of almost 33 years, oversaw many changes in computing, from punch cards to flat screens and from huge machines to www and the BlackBerry. Bill Jones' 24-year career with FC included forester in Glentrantar Forest, work study and District Manager at Ae, and Head of Technical Development from 1998 to 2005. Carole Lishman's 20 years with FR as an admin officer in Tree Products and Pathology also included valuable secretarial support for several Alice Holt Committees. Mike Johnston's career as workshop engineer at Alice Holt spanned 40 years, providing a huge variety of robust, practical, fit-for-purpose equipment for many trials, experiments and exhibits. John Williams retired in January 2006 after 35 years as graphic illustrator at Alice Holt. During that time John contributed to a huge range of publications, posters and displays, with many unique hand-drawn illustrations and later with computer graphics.

Visitors and events

Forest Research operates in the increasingly high profile area of the environment and natural resources alongside universities and other research organisations. Over the past year, visits from UK and overseas scientists and interested policymakers, and participation at a wide range of events, have ensured that FR is increasingly known for providing excellent research coupled with practice-based outputs both within and beyond the UK.

During the April 2005 IUFRO Conference on Sustainable Forestry in Theory and Practice, at Edinburgh University, 90 international forest scientists enjoyed field trips to Glentress Forest, Dawyck Botanic Gardens and a visit to NRS. The conference opening address was given by Jim Lynch who described the links between research and policy supporting sustainable forestry management in

IUFRO international forest scientists on their visit to NRS.

Britain. Other visitors from abroad included a group of agricultural and forestry policymakers from the Jiangsu province of China who focused particularly on FR's UK environmental monitoring activities.

Tim Rollinson, FC Director-General, visited Alice Holt and NRS in October as part of a wider series of briefings focusing on FC's future plans. Following a summary of the future direction of FC, Tim outlined the implications for FR. The future direction of the Agency now focuses on its ability to be flexible and make the most of the opportunities that lie ahead. Key elements of this approach include extending UK and worldwide collaboration, the development of our intellectual property portfolio and expanding external research income. Whilst recognising that support for some current activities will reduce there are really significant opportunities in areas such as climate change, social and economic research and specifically areas such as woodfuel, land remediation, biocontrol agents, sustainable land practice, conservation of biodiversity and protection from pests and diseases.

Other UK visitors to Alice Holt included English Heritage, working with Peter Crow (EHSD) as part of a collaborative study into the stability of buried artefacts in woodland soils, and Pam Alexander, CE of the South East Regional Development Agency (SEEDA), as part of a tour of Surrey's research and enterprise base, organised by the Surrey Economic partnership.

FR was again well represented at many UK and international conferences, meetings, workshops and exhibitions.

The Urban Greening Team, represented by Tony Hutchings, Danni Sinnett and Caroline Kilbride, enjoyed a second successful year as exhibitors at the NEC's International CleanUp/Environmental Technology Exhibition. The event provided a good opportunity to showcase the benefits of using woodland in land regeneration and to keep up to date with new land and water remediation technologies from collaborators and competitors. Further exhibitions are planned to raise awareness of the work of FR in this area and to build on existing collaborations.

Caroline Kilbride, Tony Hutchings and Danni Sinnett at the International CleanUp Exhibition.

'Trees in a changing climate' at the University of Surrey in June attracted wide media coverage. Opened by Elliot Morley MP, the Minister of State for Environment and Agri-Environment, the conference included a wide range of speakers from FR, English Nature, Oxford Forestry Institute, the National Trust, the Woodland Trust and the University of Bordeaux, France. Highpoints at the conference included presentations by Mark Broadmeadow on predictions of the effects of climate change on tree growth and function, and Clive Brasier who looked at the issues around invading pests and diseases and the argument for more effective controls.

Robert Matthews, Ian Tubby and Ewan Mackie (BSSD) attended the World Renewable Energy Congress in Aberdeen, which was held in tandem with the All-Energy Exhibition. Robert presented a paper on FR's BSORT model which produces estimates of standing biomass for UK woodlands. Presentations and discussions covered a wide range of renewables – biomass, fuel cells, solar, tide and marine energy, and wind power – and the congress included the launch of the important report on the potential of biomass technology in Scotland, commissioned by the Scottish Executive.

In June, Max Hislop (EHSD) and Chris Quine (Ecology) were involved in the Macaulay Institute's landscape research week at Huntly. The exhibit showcased the 'Woodland Change' project, in which FR collaborates with the Macaulay Institute as part of the VisuLands project.

A workshop on the control and management of *Rhododendron ponticum* brought together academics and practitioners from the UK and Turkey. Organised by the National Trust for Wales and supported by EU, FR, Wild Resources and the University of Wales Bangor, the aim was to develop a *R. ponticum* control network to facilitate exchange of information and future action plans. Colin Edwards (FMD) presented two papers and chaired a workshop.

Visits much further afield included Australia, Malaysia, China and Nepal.

In August Jim Lynch, Peter Freer-Smith, Liz O'Brien and Bill Mason all represented FR at the 22nd IUFRO World Congress in Brisbane, entitled 'Forests in the balance: linking tradition and technology'. Jim contributed to the Directors Forum; Peter presented two papers on 'The biological sustainability of European forests' and 'The effects of trees on pollutant transport and fate: modelling of the benefits to the urban and peri-urban environment'. Liz gave a presentation on woodlands and well-being while Bill's paper described a Scottish perspective on 'Sustainable forest management in an era of declining timber prices'.

The congress also enabled FR to strengthen links with some of the other world leaders in forestry research and to see just how much FR is at the cutting edge of forestry research.

Also in August, Jim Lynch visited the Forestry Institute of Malaysia, near Kuala Lumpur, and was particularly interested in their move towards commercial co-operation, for example in the production of pharmaceuticals using ingredients derived from trees. Jim also gave a lecture overviewing opportunities which the UK perceives for the development of forests and woodlands and associated research needs.

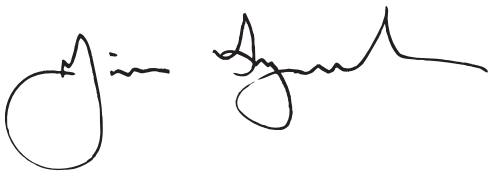
Bill Mason went to Liaoning Province in northeastern China to consider the potential role of continuous cover forestry (CCF) and to advise on future research needs. With national policies in the UK and China both encouraging the diversification of plantation forests and the expansion of native woodlands, the UK's use of CCF is directly relevant to plantation management in China. Anna Brown and Clive Brasier were part of an FAO-funded expedition to Nepal to investigate potential *Phytophthora* pathogens in native Nepalese forest ecosystems. Starting in Kathmandu and moving to more remote areas, their fieldwork included surveying wild olive groves, sampling plants, streams and soils in coniferous forests and broadleaved forests, and DNA and serological tests.

In January FR's Chris Jones, Paul Tabbush, Kevin Watts and Amy Eycott were part of the Woodlands for Wales Strategy meeting at Llandrindod Wells. Introduced by Carwyn Jones, the Welsh Assembly Minister for the Environment, Planning and the Countryside, delegates discussed the progress of the strategy's implementation.

As UK National Team Leader for the IEA's Bioenergy Task 31 'Biomass production for energy from sustainable forestry' for 2005–2006, Andy Hall (Technical Development, FMD) represented the UK at an international biomass workshop in Perth, Western Australia. The workshop was a great opportunity to compare with other countries the UK's recent progress in developing its biomass resources.

During the past 2–3 years, we have been encouraged to see a large increase in the number of PhD students linked with Forest Research. We have been positively seeking to extend and strengthen our student links; we see the benefits and cost-effectiveness of co-funded studentships. Genuine input is provided by FR researchers and, in many cases, location of research activity means that students spend a significant proportion of their time at Alice Holt or NRS. Joining us from many of the leading universities across the UK, and fostering our long-term partnerships, students are working on a range of subjects which reflect our wider remit. These include: forest soil quality indicators; eco-toxicological methods for evaluation of contaminated land; social impacts of regenerated brownfield sites; conservation implications of landscape use by lesser horseshoe bats.

In addition, students from overseas choose to come and work with us on a variety of collaborative programmes, for example, in forest growth modelling and social forestry. Several FR staff are registered with UK universities and are studying for higher degrees as part of FR's continuous professional development policy.



Professor Jim Lynch
Chief Executive

Research Highlights
by Division

Biometrics, Surveys and Statistics

The first national inventory of woodland and trees: key outputs

The use of LiDAR to derive individual tree and stand parameters

Ecology

Molecular methods to differentiate pine marten and fox scats

Environmental and Human Sciences

A monitoring and evaluation strategy for created greenspace on regenerated land

Chemical Analysis Services and their role in project support

Forest Management

Direct seeding for the establishment of native woodlands: practice and problems

EMIS: advising on tree establishment in the uplands of Britain

Tree Health

Green spruce aphid and the growth of Sitka spruce

Horse-chestnut leafminer, *Cameraria ohridella*

The first national inventory of woodland and trees: key outputs

Mark Lawrence and Graham Bull

The *National inventory of woodland and trees* (NIWT) (1995–1999) was the most comprehensive survey of woodland across Great Britain ever undertaken and gives a definitive record of the nation's woodland at the close of the 20th century. NIWT was required to measure whether the FC was achieving its mission to protect and expand Britain's forest and woodland cover. It would provide a high level means of monitoring regional and national compliance with the UK Forestry Standard, and provide data for some of the key formal indicators adopted for monitoring and reporting on UK forestry. The Inventory found 11.6% of Britain covered by woodland, totalling over 2.6 million hectares. This represents a more than doubling of woodland area in Britain over the course of the 20th century. To illustrate the breadth of the survey some of the main NIWT outputs are outlined below and in Figure 1.

Digital woodland map A specific aim was the production of the first digital map of all woodland of 2 ha and over, which was incorporated into a Geographic Information System (GIS) together with the field sample data. This allows the sample data to be analysed by any geographically defined area, e.g. National Parks. It also allows for the combination of the data with other geographical datasets, e.g. the Woodland Grant Schemes or the Ancient Woodland Inventory (AWI). The map has been made available to other government departments, local authorities etc. via Spatial Licence Agreements.

Statistical reports A series of Inventory Reports has been published for Great Britain, Scotland (national and regional), England (national, regional and county) and Wales (national and county). The reports are based on the analysis of the field sample data in both printed and digital format, with the latter available on the Forestry Commission Internet site: www.forestry.gov.uk/inventory. Each country report incorporates a wall chart of NIWT data and information.

Survey methodology In response to the need for good reference documentation of NIWT methodology and results, a NIWT *Methodology of the survey 1995–1999* publication is in preparation and will be available during 2006.

Other supporting data A document based on the analysis of other new data gathered within the NIWT survey that is not presented within the context of the country, region or county reports is also under review and will be added to the Inventory www site at the same time as the *Methodology* document. Examples of data are woodland structure assessment (both horizontal and vertical) and estimates of deadwood.

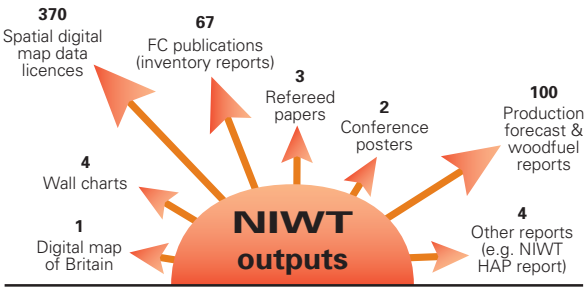


Figure 1 Summary of the variety and number of NIWT outputs.

Other uses of NIWT data These include special advisory work on behalf of the FC, reports commissioned by the FC, private sector and other departments. The ready availability of inventory data has established usage in relation to risk assessment in pathology and entomology, the potential value of NIWT structural measures as indicators of biodiversity to timber production forecasting and, more recently, to biomass and carbon assessments.

NIWT has been a success story of an enormous 'green' investment in the British countryside; of increasing landscape diversity; of a huge recreational resource for people; of new and improved habitats for wild plants and animals; and of increasing opportunities for sustainable businesses, jobs, prosperity and rural development.

Looking ahead A NIWT2 Management Board with representatives from FC Great Britain, England, Scotland, Wales and FR Biometrics, Surveys and Statistics Division is discussing the specification for the next survey (NIWT2). The scope for future applications of technology, in particular digital remote sensing, needs to be kept under review and, where necessary, assist with ground truth information from surveys. NIWT2 aims to collaborate with other national surveys such as:

- Forestry Commission (Scotland)/Scottish Natural Heritage – Scotland Native Woodland Survey
- Department for Environment, Food and Rural Affairs/Centre for Ecology and Hydrology – Countryside Survey 2007 and Land Cover Map
- English Nature/Scottish Natural Heritage/Countryside Council for Wales – Ancient Native Woodland Surveys.

The use of LiDAR to derive individual tree and stand parameters

Juan C. Suárez

Light detection and ranging (LiDAR) applications in forestry are becoming increasingly important for extracting individual tree and stand parameters. Airborne LiDAR is an active sensor that emits laser pulses and measures the return time for each beam to travel between the sensor and a target using ultra-accurate clocks. The location of every return to a known coordinate system is achieved by precise kinematic positioning using differential global positioning systems (GPS) and orientation parameters obtained by an inertial measurement unit (IMU). With the ranging data accurately measured and time-tagged by the clock, the position in the horizontal and vertical planes of the return points can be calculated.

Data capture is obtained as the aircraft moves forward. The majority of the commercial systems can collect between 20 000 and 100 000 records per second. Point density per unit area depends on the number of pulses transmitted per unit time, the scan angle of the instrument, the elevation of the aircraft above ground level and the forward speed of the aircraft. The system is capable of achieving high vertical (15–20 cm RMS) and horizontal (20–30 cm) accuracies.

LiDAR instruments are used to generate tree canopy height models and models of the underlying terrain. This information is subsequently used to provide accurate estimations of canopy heights, stand volume or the vertical structure of the forest canopy. The estimation of tree heights is performed by the subtraction of bare ground values from the canopy layer. In commercial airborne systems, the canopy layer is estimated from the first laser return, which measures the intensity of the signal as it first encounters an object on the ground. In semi-opaque objects like vegetation, the signal will penetrate them until it reaches a definite barrier. The last return will provide information about the location and height of the mid-point of the last strong waveform that is normally associated with the ground (see Figure 1).

Individual tree tops were estimated following an object-oriented classification method, which was aimed at the identification of individual tree tops using a rule-based system implemented in eCognition (Definiens Imaging GmbH, 2001; Trappenstreustrasse 1, 80339 Muenchen, Germany). The classification combined digital aerial photography and an interpolated image of the canopy height model. Results produced an underestimation of around 7% and R^2 of 0.89.

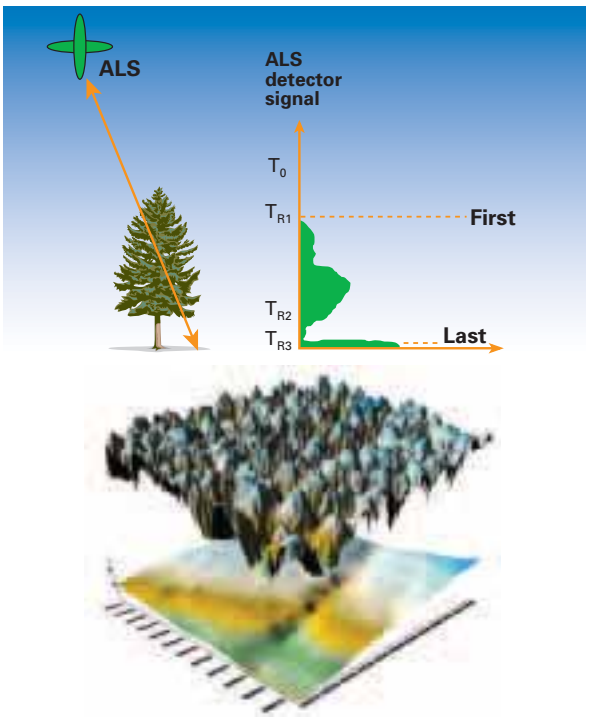


Figure 1 Interactions between the commercial airborne laser systems (ALS) and the vegetation. First return signal is used to derive canopy models, whereas the last return signal generates high resolution terrain models. Vegetation height is estimated as the difference between the first and the last laser returns (NTCM – normalised tree canopy model).

Top heights were estimated using a different method based on percentiles. The 99th percentile of a normalised tree canopy model (NTCM) produced predictions very close to the observed values in the field (Table 1). The variability in the results could not be related to stand density, age, density of LiDAR returns or percentage of ground hits.

Table 1 LiDAR predictions of top height against measured top height in Kielder Forest, Northumberland.

Plot ID	Observed top height (m)	Estimated top height (m)	Accuracy
6	32.81	32.53	**0.99**
7	28.15	28.15	**1.00**
8	20.33	19.48	**0.96**
9	21.35	19.9	**0.93**
10	17.92	17.82	**0.99**
11	20.78	20.42	**0.98**
12	21.24	21.01	**0.99**

Molecular method to differentiate pine marten and fox scats

Joan Cottrell, Roger Trout, Chris Quine and Catherine O'Reilly*

Direct observation of pine martens (Figure 1) is difficult due to their rarity and secretive, nocturnal habits. Therefore, their presence and abundance have traditionally been evaluated from the collection and identification of their scats (droppings) and tracks. This approach depends on the extent to which field evidence of pine martens can be distinguished from those of other predators, particularly foxes. Recently, doubts have been expressed about the accuracy with which scat identification can be achieved on the basis of smell and appearance alone. Modern molecular techniques developed in the Waterford Institute of Technology (WIT) in Eire offer a method by which fox and pine marten scats can be reliably distinguished. The technique is based on markers located in the mitochondrial DNA where there are areas in which the sequence found in fox is consistently different from that of pine marten. Forest Research and WIT have recently collaborated in a pilot study to apply this technique to determine the degree of error when scat identification is based on smell and appearance alone.

Figure 1 Pine marten: we can easily recognise the head end but what it leaves behind is more difficult to identify.

Scats had been collected at monthly intervals along transects in two Scottish woodlands at Morangie and Allean in the course of a wider study on the incidence of predators (EU LIFE Project: Urgent Conservation Management for Scottish Capercaillie). The scats were classified by a wildlife expert into those of fox or pine marten and the identifier also provided a qualitative level of certainty to each identification. A sub-sample of 100 scats which covered a range of identifier certainty, season and site were then analysed using the molecular method. This involved DNA extraction from the scats followed by the analytical technique known as real-time PCR (polymerase chain reaction). Successful amplification of the DNA was achieved in 98% of the scats.

A comparison of the results showed that all the samples actually from pine martens had been correctly identified on the basis of morphology/smell whereas 40% of the fox scats had been misidentified as pine marten. The field identification thus had produced a considerable overestimate of the number of pine marten scats present relative to those of foxes. Further examination of the results showed that the misidentified samples were not always those for which the identifier had felt uncertain. There was no difference in the level of misidentification between the two sites and the highest incidence of mistyping occurred in those samples gathered early in the season during March and April.

This study highlights the need to apply modern molecular methods to scat identification if accurate determination of pine marten presence is to be achieved. Plans are now being developed to enable extensive use of this form of assessment.

*Waterford Institute of Technology (WIT).

A monitoring and evaluation strategy for created greenspace on regenerated land

Kieron Doick

Urban greenspace makes an invaluable contribution to society and the environment (Figure 1). Greenspace can promote social interaction and cohesion, offer places to learn and play, and provide an environment which promotes mental as well as physical health. Greenspaces improve air and water quality, enhance biodiversity, reduce nuisance from noise, and improve microclimate and the landscape aesthetic. The establishment of greenspace can also invigorate the local economy by increasing surrounding land and property values, attracting inward investment within the surrounding area and promoting tourism. Greenspace creation in and around urban areas delivers and supports a wide range of government headline agendas such as the creation of sustainable communities, urban renaissance, health, climate change and environmental protection.

Economic and planning pressures typically drive the regeneration of derelict, underused and neglected land (otherwise known as brownfield land) towards a hard end use such as domestic or commercial property. However, an increased appreciation of the utility of greenspace has led to stronger emphasis within national and regional policies for the provision of quality greenspaces in and around our towns and cities. Supported by the Scottish Executive, Welsh Assembly, Department of Communities and Local Government and the regional development agencies, the Forestry Commission is actively reclaiming and restoring brownfield land to greenspace for the provision of public benefit and environmental improvement.

Nevertheless, there is no formal integrated process for evaluating the performance of created greenspaces. Monitoring and evaluation would also cast some light on the various impacts of greenspace establishment and optimise the benefits attained. Significant progress has been made in developing a methodology for monitoring and evaluating urban and peri-urban greenspace. This will incorporate specific measurable objectives of greenspace establishment at site, programme, regional and national levels which are both realistic and achievable. Standard methodologies will be developed to target collection of consistent and repeatable data to enable assessment of key indicators of social, environmental and economic impacts of greenspace establishment. Currently, the evidence base for greenspace establishment comes from many disparate sources. In contrast, the widespread application of the strategy in preparation will ensure consistency in data collection and understanding and thereby provide a UK-wide evidence base for greenspace establishment impacts. This would allow a comprehensive analysis of national and regional drivers and opportunities, facilitate identification of gaps in the knowledge base, and target development of best practice guidance. Our overall aim is to develop a system that will support:

- integrated cost-benefit analysis of the human and environmental impacts in economic and non-economic terms;
- evaluation of the impacts of greenspace creation at personal, social and cultural, local, regional, national and international levels;
- evaluation of the sustainability of greenspace creation in the context of both sustainable development and sustainable communities;
- appraisal of public and corporate perceptions of greenspace utility.

A foundation system will be trialed in 2006/07 at a range of regenerated greenspaces.

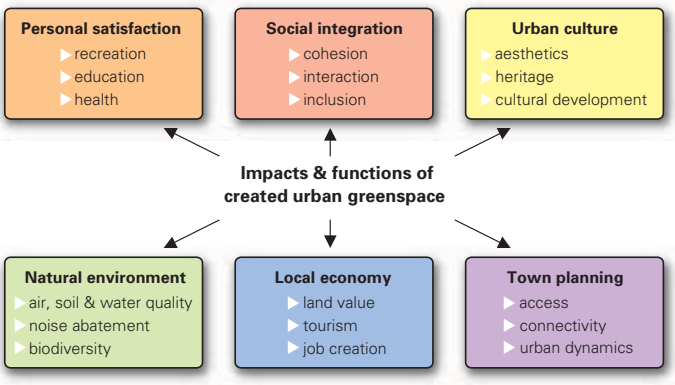


Figure 1 Examples of some of the impacts of the reclamation and restoration of brownfield land to an urban greenspace and some of the functions that the new greenspace fulfils to society, the environment and to the economy.

Chemical Analysis Services and their role in project support

François Bochereau and Tom Nisbet

Chemical analysis is at the heart of many FR research programmes, and a vital resource in our research dealing with environmental issues. The Chemical Laboratory based in the Environmental and Human Sciences Division provides a wide range of inorganic analyses for plant, soil and water samples for the benefit of internal and external customers/contracts. During the year 2005–06, the laboratory conducted 35 000 analyses on some 9000 samples (Figure 1). The number of water samples increased by around 60% on the previous year, representing an additional 10 000 analyses. A programme of modernisation and refurbishment led to the purchase of new instrumentation, including a Carbon and Nitrogen Analyser. This will allow the laboratory to support 'BioSoil' in 2006-07, a pan-European forest soil monitoring project requiring analyses worth £100,000.

The laboratory has joined many proficiency schemes to check the quality of its work. The UKAWN (UK Acid Water Network) ring test is linked to the Environmental Change project and is performed every 6 months. The Needle/Leaf inter-laboratory comparison, EMEP (European Monitoring on Environmental Pollution) and WRT-EPD (Working Ring Test – Expert Panel on Deposition) tests are performed once a year for plant and water samples in conjunction with the Level II programme in the joint European Union Scheme/ICP Forests Programme on the Protection of Forests Against Atmospheric Pollution. Another European inter-laboratory test involved the analysis of soil samples for the FSCC (Forest Soil Co-ordinating Centre) as a prelude to the BioSoil Project. The laboratory has performed extremely well in all of these tests and was ranked in second position this year in the WRT-EPD exercise out of 54 European laboratories.

Figure 1 Chemical analysis work in the laboratory.

One major ongoing project reliant on laboratory support is TaDPoLE: Trees and Drought Project on Lowland England. This project began in 1998 and is investigating the impact of forestry on the quantity and quality of groundwater draining to the Triassic Sandstone Aquifer in the Midlands of England. Of particular interest is whether forestry could help to tackle the high nitrate concentrations generated by agriculture that are severely polluting groundwater supplies. Samples of water draining through the soil and underlying sandstone have been collected under Corsican pine, oak and a grass ley and analysed by the laboratory.

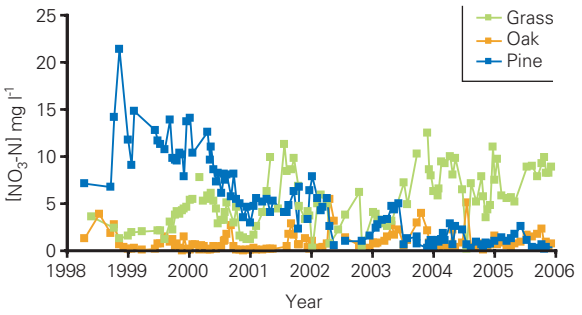


Figure 2 Comparison of soil water nitrate (NO_3-N) concentrations between grass, oak and pine (April 1998–December 2005).

An important finding is that nitrate levels are significantly lower under oak compared to grass although, unexpectedly, highest concentrations occurred under pine (Figure 2). This was thought to be due to the high water use of the pine, resulting in a large evaporation-concentration effect. Nitrate concentrations have fallen since felling of the pine in 2000, while those under grass have steadily risen following the end of the moratorium on applications of inorganic nitrogen fertiliser. Monitoring is continuing to assess the impacts of the land management practices and climate change on groundwater quality.

Direct seeding for the establishment of native woodlands: practice and problems

Alan Harrison

There is increasing interest in the use of direct seeding for the establishment of upland native woodlands, particularly in restocking areas, due to perceived cost benefits. Direct seeding of native species, where spacing, stocking, timber quality and time scale are of lower priority than creating overall woodland cover, is feasible and can provide additional benefit in producing more naturalistic woodland. Currently, operational trials and experiments in Scotland and northern England are providing an insight into how direct seeding might be successfully achieved with pine and birch.

The essential prerequisite for success is the provision of an adequate seedbed. This should be without weed competition, free-draining (but never dry) and have a friable surface that allows root penetration. The preferred method for creating these conditions is light scarification, however, sufficient suitable germination microsites may already exist due to felling or other ground disturbance (Figure 1). Seed sowing can be manual or by scarifier-mounted pneumatic sower. The density of seed is dependent upon germination rate. Research on a number of sites in northern Scotland shows poor levels of survival and massive losses between years 1 and 2 on most sites (Figure 2). South Dalchork (W18 NVC (National Vegetation Classification*)) was the best site for both species, though Rogart (W11) and North Dalchork (W4) establishment was poor, indicating that site choice is critical. Sowing between October and early April can produce satisfactory results.

Figure 1 Birch establishment after direct sowing on an uncultivated Sitka spruce restock site.

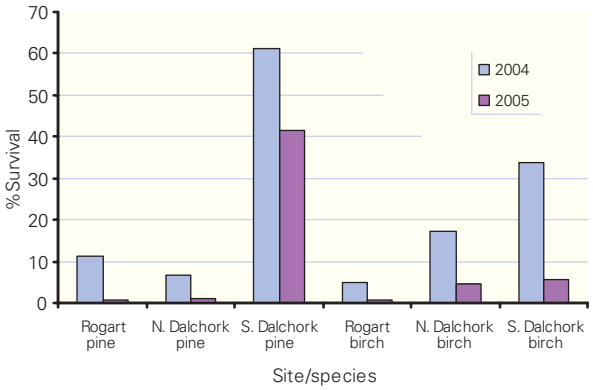


Figure 2 Pine and birch seedling tree establishment of April 2004 sown seed (% of viable seeds sown) on three site types in Dornoch, Scotland.

Research trials aimed at identifying suitable site types, establishment practices and matching these with species, by using Ecological Site Classification (ESC*) and NVC, are ongoing. To date, cultivation has increased the risk of frost heave and drought, while showing little improvement in survival compared to uncultivated areas. Continued investigations are required on the potential impacts of predation by birds, voles, insects and slugs for example, and on the influence of site climatic factors such as frost heave, drought, wash-out and waterlogging, in order to improve guidance on sowing densities.

In summary, the sowing of some native species for native woodland creation is a promising method but substantial further research is necessary to identify the most suitable site types and to improve the predictability of germination and establishment success.

* NVC provides a systematic description and classification of woodland and other vegetation types in Britain. ESC provides a sound ecological basis for the management of forests for timber production, wildlife conservation and other benefits.

EMIS: advising on tree establishment in the uplands of Britain

Mike Perks, Alan Harrison and Stephen Bathgate

EMIS – the Establishment Management Information System – is a decision support system (DSS) which integrates existing tree establishment advice on a site-specific basis. It draws upon current good practice information from numerous technical and scientific publications to provide the user with a 'walk through' system delivering acceptable (site constrained) tree establishment options. Site information (user input) allows calculation of environmental variables, via direct linkage with Ecological Site Classification (ESC) climate models, which are used to inform species choice (Figure 1), and identify appropriate on-site management practices including plant quality, cultivation and fertilisation guidance.

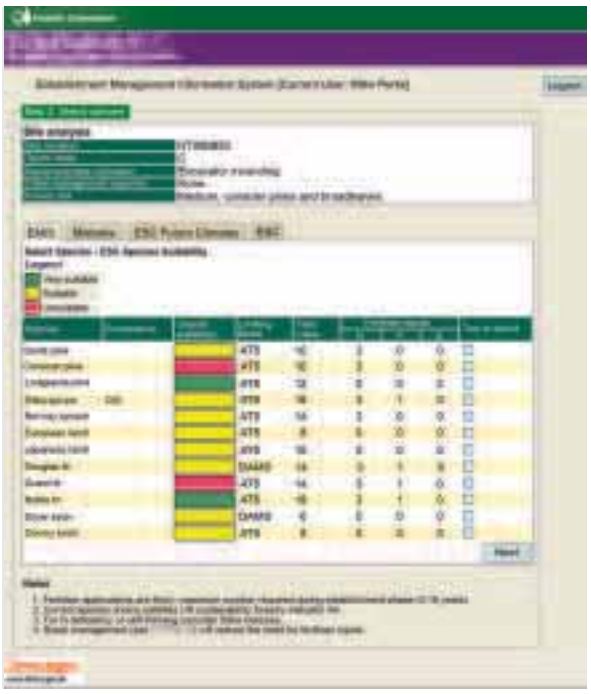


Figure 1 Screenshot of ESC-derived EMIS output for species suitability and ESC predicted yield class for a site in Fife, Scotland.

EMIS currently provides advice encompassing the main conifer species grown in upland Britain, plus birch. The evolution of the EMIS decision support system has been guided by operational requirement and existing knowledge. Whilst experienced foresters will have appropriate species, plant types and silviculture in mind when planning restocking sites, EMIS may be consulted to provide a check, the added-value being that any new guidance can be centrally updated (e.g. future climate predictions). Forest planners may consider inappropriate species (for landscaping reasons) and EMIS would identify such instances. This guidance can ensure that suitable establishment practice and species choice are achieved as required by sustainable forest management certification. The web-based decision system integrates with another Forest Research decision support tool – Ecological Site Classification (ESC) – via shared components (Figure 2). The EMIS architecture also delivers modules, i.e. advice, on *Hylobius* management and herbicide use whilst links to other damaging agents are included but not yet functional.

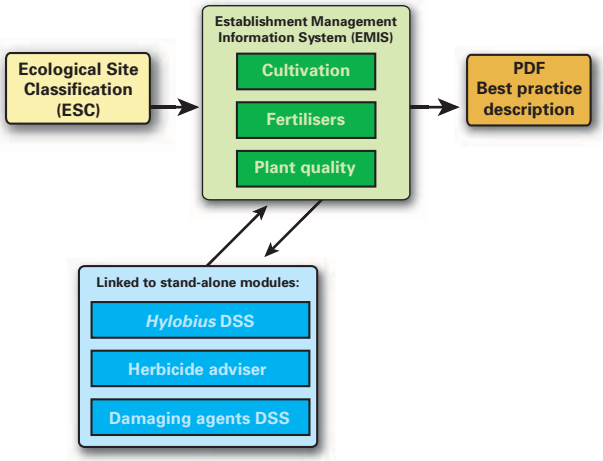


Figure 2 A schematic representation of the overall DSS Framework, which allows the delivery of EMIS modules, plus herbicide and *Hylobius* advice.

EMIS will be a web-delivered tool, but the constituent models can integrate with spatial data systems, e.g. ForesterGIS™ extension. This will enable delivery of spatially explicit good practice guidance in the future.

Green spruce aphid and the growth of Sitka spruce

Nigel Straw

Green spruce aphid *(Elatobium abietinum)* is the main defoliating pest of Sitka spruce in the UK. It feeds on the older needles (Figure 1), causing chlorosis, tissue death and premature needle abscission. Peak populations usually occur during the spring and early summer.

The intensity of defoliation is related to weather conditions during the preceding winter. If the winter is mild, more aphids survive, peak populations are higher and damage is severe. Consequently, if current predictions of climate change are correct and winters become warmer, *E. abietinum* is likely to benefit and the frequency and intensity of damage is likely to increase. In response to this threat, FR has undertaken research to quantify the impact of *E. abietinum* on Sitka spruce and to determine relationships between the aphid's populations and climate.

Studies on young Sitka spruce have demonstrated that even though low densities of *E. abietinum* cause high rates of defoliation, reductions in increment in young trees (Figure 2) are caused primarily by the aphids disrupting budset and reducing needle size. These effects occur because the aphids not only suck sap from the phloem when they are feeding, but they also inject substances into the tree that have physiological effects on other tissues.

Figure 1 Green spruce aphids on Sitka spruce.

Older trees appear to be more affected by the loss of needles from the shoots. The canopy of older trees contains a greater proportion of 1-year-old and older needles, and this restricts aphid-induced changes in needle size (which affect only the new needles) to a smaller sub-set of the total needles, but makes more of the canopy vulnerable to defoliation. Older trees also operate with a more marginal internal carbon budget. Their photosynthetic tissues have to support more stem and root material, and this limits the resources available to counteract the effects of defoliation and for recovery. Consequently, *E. abietinum* is likely to have a greater impact on older and larger Sitka spruce trees than on young trees.

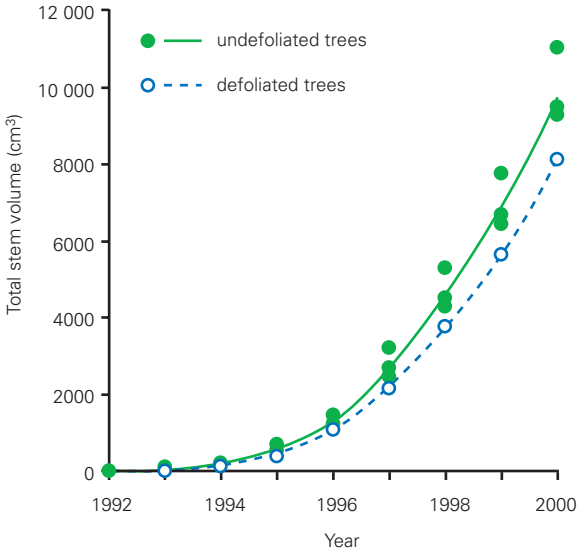


Figure 2 Growth curves for Sitka spruce trees that were defoliated/not defoliated by green spruce aphid. The trees were 10 years old in 2000.

This hypothesis is being tested in field studies at Radnor Forest, mid-Wales. The aim is to quantify the impact of *E. abietinum* on mid-rotation, 20–25 year old Sitka spruce, using methods that are directly comparable with those used to quantify impact on young trees. The within-canopy distribution of aphids at Radnor and its influence on sampling has recently been published and effects on growth and relations with climate will be presented after this year's field season. The results will be used to estimate the potential future impact of this key forest pest. Further information on the impacts of insects on tree growth is available at:
www.forestresearch.gov.uk/fr/infd-68uelu

Horse-chestnut leafminer, *Cameraria ohridella*

Hugh Evans, Nigel Straw and Christine Tilbury

The horse-chestnut leafminer, *Cameraria ohridella*, is a small moth belonging to the family Gracillariidae whose larvae mine within the leaves of horse-chestnut, principally the European white-flowering species *Aesculus hippocastanum*. The moth has invaded Britain recently (the first record was in 2002) from mainland Europe, where it has been spreading following an initial outbreak in northern Greece in the mid-1980s.

Wherever *C. ohridella* has become established, it has reached high population densities and caused severe damage to horse-chestnut on an almost annual basis. The moth can complete 3–4 generations per year in favourable seasons, particularly in warmer regions, and the number of larval mines accumulates over the summer until, by August and September, the majority of leaves are disfigured and fall early (Figure 1).

Figure 1 Disfiguring of horse-chestnut leaves by leaf mines of *C. ohridella*.

Horse-chestnut trees with large numbers of *C. ohridella* leaf mines were discovered in the London borough of Wimbledon in July 2002. Since then, the moth has spread to most of south-east England and East Anglia (Figure 2). Forest Research is monitoring the spread of the moth and provides a map of its current distribution, alongside information on host plants, impact and management, on its website at www.forestresearch.gov.uk/fr/INFD-68JJRC

Damage caused by *C. ohridella* is primarily an aesthetic problem. The presence of large numbers of mines and the loss of leaves earlier than normal spoils the visual appearance of the trees. Severely damaged trees cause considerable concern, but there is no evidence from Europe to suggest that horse-chestnut trees decline or die as a direct consequence of attack by the moth. However, it is possible that differences in climate or interactions with other pests and diseases (especially 'bleeding canker' of horse-chestnut: www.forestresearch.gov.uk/fr/INFD-6KYBGV) might lead to greater impact in Britain.

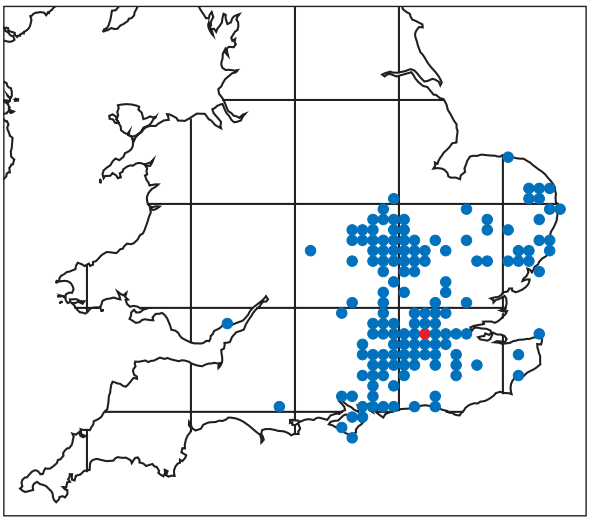


Figure 2 Distribution of *C. ohridella* in the UK in November 2005.The location of the original infestation in Wimbledon is marked by the red symbol. (Map produced using DMAP © Dr A. Morton 2004.)

To determine the long-term impact of *C. ohridella* on horse-chestnut, and its interaction with other pests and diseases, Forest Research is monitoring 300+ chestnut trees in two areas in southern England (Hampshire/Surrey and Worcestershire). The trees are assessed twice each year for leaf mines of *C. ohridella*, the incidence of other insect pests and diseases, foliage density, shoot and branch dieback, and growth. Data collected in 2002–2005 provide a picture of tree condition before the arrival of the moth, and subsequent monitoring will indicate how tree health changes after the moth becomes established and the trees are defoliated. See also Monitoring amenity tree health in England, page 42.

Restoration of lowland conifer PAWS

Ralph Harmer and Andrea Kiewitt

Introduction

During much of the 20th century British forestry was driven by a policy that aimed to ensure a strategic supply of timber in case of war. This led to the successful development of silvicultural systems based predominantly on plantation forestry using fast growing, non-native conifer species. As a consequence there was a large expansion in forest cover due mainly to the afforestation of unwooded land in upland areas. However, the policy also resulted in the replacement of uneconomic, slow-growing, semi-natural broadleaved woodland with more productive conifers or more economically viable broadleaved trees such as beech. About 40% of ancient woodland that existed in the 1930s was converted to plantations, mostly between 1950 and 1980: these plantations on ancient woodland sites are commonly known as PAWS. Despite intensive silvicultural practices, the conversion of existing broadleaved woodland sites to conifers was often less successful than afforestation. The process of conversion became a contentious issue and was abandoned in 1985 when the government's policy for broadleaved woodlands was introduced. PAWS often retain a number of features characteristic of the preceding native woodland, including remnants of the ground flora, old coppice stools and veteran trees which can provide a nucleus around which a new broadleaved woodland can be created. Restoration of native broadleaved woodland is an important aim of current policy and a significant management objective of many PAWS. The aim of restoration is to create the conditions needed to promote the development of native woodland over the long term; it is a process which attempts to re-establish a functioning ecosystem by:

- Securing features from the former ancient semi-natural woodland.
- Removing introduced species of trees, shrubs and other plants.
- Encouraging the re-establishment of native species.
- Initiating and enhancing ecological processes which may be absent or damaged.

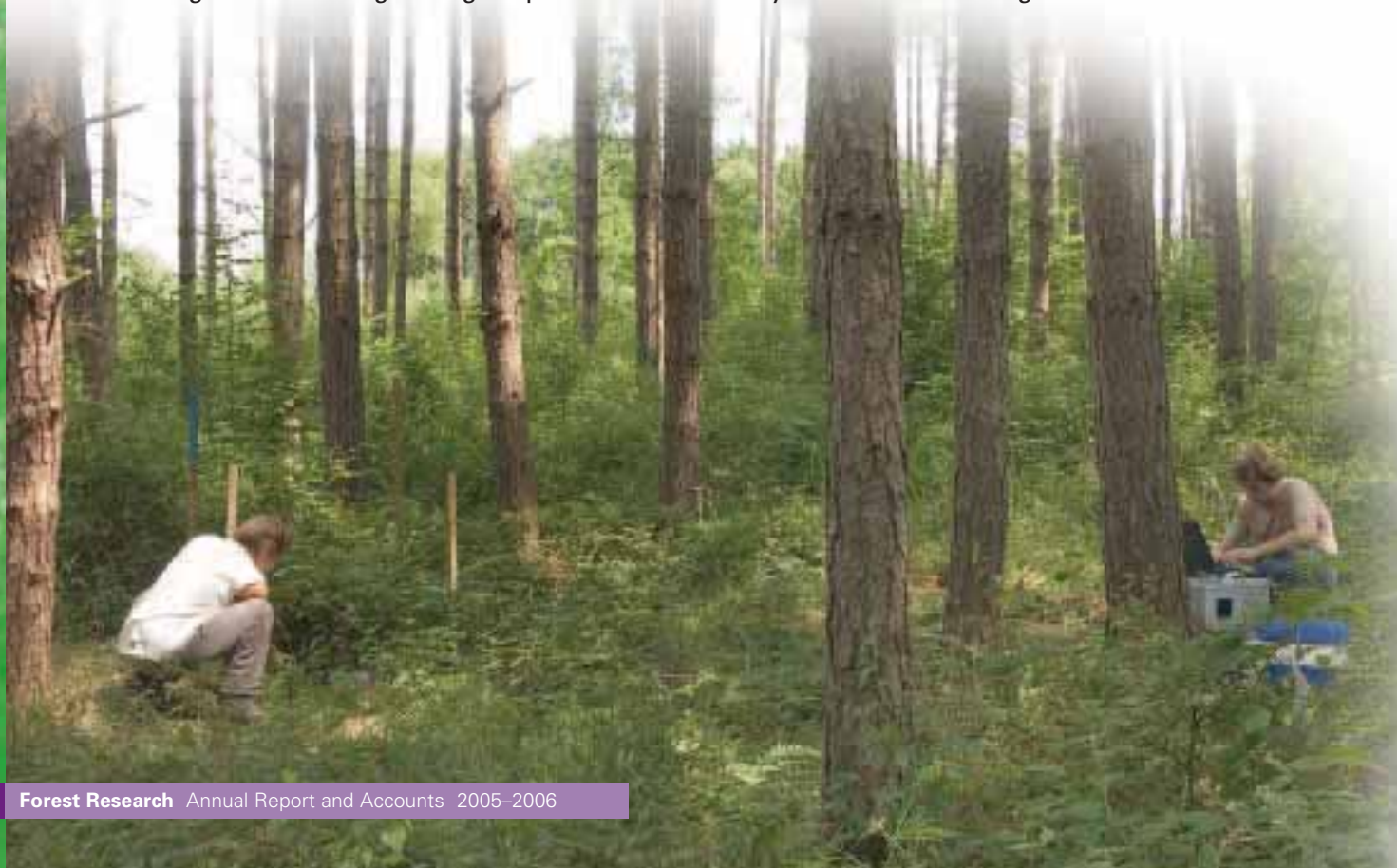


Figure 1 (a), (b) Examples of treatment plots immediately after felling and (c), (d) permanent quadrats after four years' growth (a, c = 20%; b, d = 80%).

It is generally accepted that restoring PAWS to native woodland will enhance woodland habitats for a range of plant and animal species, but the potential for success will vary with the remnant features present on the site and the methods used. Current guidance suggests that restoration should take place gradually using some form of continuous cover forestry to maintain woodland conditions while the planted species are removed and native broadleaves regenerate naturally. While this method may have a number of potential benefits (e.g. no major disturbance to fauna, retention of moist microclimates for epiphytes and deadwood invertebrates, control of ground vegetation by the presence of overstorey cover) it has never been adequately tested. This article briefly describes some of the studies within lowland PAWS that were established to examine current guidance and improve advice.

Sites and treatments

In 2001 experiments were established at Fineshade, Northamptonshire; Wakehurst Place, Sussex; and Chiddingfold, Surrey. All were within stands of *c.* 35-year-old Corsican pine growing on clay soil. The work at Chiddingfold, which is the largest, is described here. Although the initial treatments and the subsequent assessments varied slightly between sites the results obtained were similar.

The stand at Chiddingfold, which is managed by Forest Enterprise, was planted in 1966 and prior to treatment had 450 stems ha^{-1} with a basal area of 20 m^2. In autumn 2001 four thinning treatments were applied to remove 10, 20, 40 and 80% of basal area (Figure 1a–d); there were four replicates of each treatment. The site was unfenced and in all years the presence of deer was evident throughout the stand.

Assessments

Before thinning two permanent quadrats 2 x 2 m in size were established within each of the 16 treatment plots. After initial assessments the following have been observed annually within each quadrat:

- cover and height of ground flora present by species;
- growth and survival of a marked cohort of ash seedlings;
- species of trees regenerating and height of tallest seedlings;
- browsing damage.

Canopy cover above each quadrat was assessed using hemispherical photography both before thinning and in the following summer.

Results

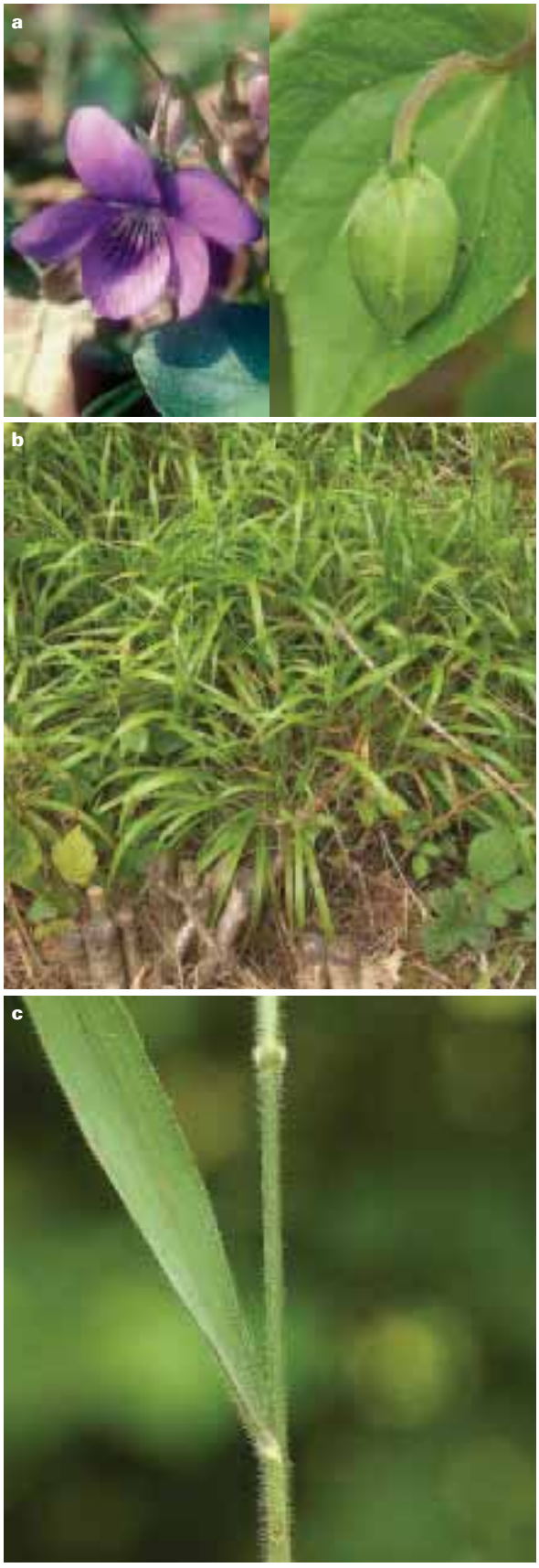
Observations are ongoing and the following is an interim résumé of some of the data collected.

Changes in the ground flora vegetation

In 2001, before thinning, there was a total of 50 species present in the ground flora of the permanent quadrats: four years after thinning there were the same number. However, there appeared to have been a change in the species composition, with 20% of the species initially present being replaced by a similar number of new species. More than half the species present occurred in only one or two quadrats, but a few including common violet *(Viola riviniana)* and wood false-brome *(Brachypodium sylvaticum)* were present in more than 60% of quadrats (Figure 2a, b and c); in 2005 bramble *(Rubus fruticosus)* occurred in all quadrats.

The abundance of most species was low and only nine species ever exceeded 5% cover on any quadrat on which they were present. Bramble was the most abundant species and by 2005 the site was becoming dominated by a dense thicket. More than half of the quadrats had 50% or more bramble cover but this varied with treatment. The height of the bramble thicket increased with time: by 2005 the height of that in the 80% thinning plots was twice that in the 20% plots (Figure 3). The response of bramble was expected and detailed studies to investigate its growth have been made in all thinning treatments (see Box 1).

Figure 2 (a) Common violet flower and seed pod, (b) wood false-brome and (c) close up showing node and fine hairs on stem which can be useful in identification.



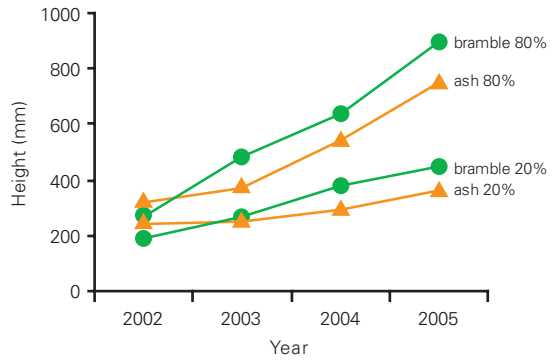


Figure 3 Mean height of tallest ash seedlings and bramble thicket in the 20% and 80% thinning treatments between 2002 and 2005.

Tree seedlings

In all years the same eight species of broadleaved trees have been found regenerating on the site. The only notable change that occurred following thinning was an increase in the frequency of willow *(Salix* sp.*)* and birch *(Betula* sp.*)* seedlings. Subsequently there has been little recruitment of any species. Ash *(Fraxinus excelsior)* has always been the most common species occurring on all quadrats; by 2005 birch, willow and oak *(Quercus* sp.*)* were found in about half of the quadrats; holly *(Ilex aquifolium)*, wild cherry *(Prunus avium)*, hazel *(Corylus avellana)* and hawthorn *(Crataegus monogyna)* all occurred on less than 15% of quadrats.

Thinning had a positive influence on the growth of the tree seedlings, those in the heaviest thinning treatment growing more than those in the lighter thinnings. For example, between 2002 and 2005 the mean height of the tallest ash seedling present on a quadrat increased by about 120 mm in the 20% treatment compared with an increase of about 400 mm in the 80% treatment (Figure 3). After 2002 the mean heights of the tallest ash seedlings were less than those of the bramble thickets in which they were growing whatever the thinning treatment (Figure 3).

Should advice on methods of restoration be changed?

Woodland regeneration and restoration may take many years and it is difficult to draw definitive conclusions from four years of observation. The results described are representative of those from the two other experimental sites which suggests that the changes observed may be typical of sites similar to those studied. However, a decision on whether the current advice needs modifying may depend on the criteria used to assess success. Although maintaining canopy cover by using light thinning reduced bramble growth to some extent, it did not allow tree seedlings to establish any better than under heavy thinning. Similarly, light thinning did not promote the growth and establishment of herbaceous species in the woodland ground flora; the only species that flourished was bramble. If short-term observations of tree seedling establishment and ground flora development can be used as criteria to assess the merit of gradual restoration, then on sites similar to those studied, they indicate that light thinning over a long period of time may have little benefit relative to rapid clearance of trees.

Additional experiments to aid both understanding of woodland development and management practice have been established to investigate the development of tree seedlings and ground flora. These studies are taking place in a variety of coniferous and broadleaved woodlands and include: the development of bramble thicket from the seed-bank with and without competition from other ground flora plants in a beech PAWS; the development of naturally regenerating trees and ground flora after thinning neglected ash woodland; management of bramble and enrichment planting in conifer PAWS; woodland development on windblown and clearfelled conifer sites.

Box 1 Summary of detailed studies.

Bramble is a very common native species found in the ground flora of almost all woodland and scrub communities described by the National Vegetation Classification. Although it is typical of lowland deciduous woodlands it is found almost everywhere in Great Britain growing at altitudes of up to about 450 m. It grows on a wide variety of soil types being most frequent on well-drained, fertile, moderately acid soils. Best growth occurs in the open and, although its flowering will be suppressed, bramble grows well in semi-shaded conditions. The flowers are an important source of nectar and pollen, and the fruits are eaten by a variety of animals. The structure of the habitat provided by bramble provides important shelter for some birds and small mammals. However, bramble can present significant problems for woodland managers especially during regeneration.

The vigorous growth of bramble to form dense thickets following thinning or felling operations can make it a troublesome weed on many sites; it can inhibit the growth of both naturally regenerating and planted tree seedlings, and suppress other species in the ground flora. The impenetrable nature of dense thickets may protect young saplings against browsing by deer, but it also provides shelter for small mammals which can consume tree seeds and severely damage tree seedlings.

Although the general pattern of bramble growth following thinning is understood there is insufficient knowledge of its response to canopy opening that can be used predictively to guide management. Several investigations were made to improve understanding of bramble thickets. Growth, flowering and fruiting were observed between June 2002 and August 2004 within 5 x 1 m permanent transects located in each of the different thinning treatments.

Vegetative growth

Results of non-destructive observations of vegetative growth reflect those for permanent quadrats and showed that bramble cover, height and shoot length increased steadily over three years of observation in all thinning treatments. Most bramble was recorded in the 80% thinning treatment with final cover being almost 60% at an average height of 60 cm; this compares with about 45% bramble cover at 45 cm height in the 20% thinning treatment.

Flowering and fruiting

Flowering and fruiting of bramble was assessed by counting numbers of inflorescences and recording fruit development using ten categories from an unopened bud to a ripe blackberry (Figure 4). Seeds were extracted by mashing the fruits through a sieve and their quality was assessed by cutting them in half and observing them under a microscope. A seed was either filled with live embryonic and storage tissue or it contained a collapsed embryo whose tissue was dry and shrivelled (Figure 5).

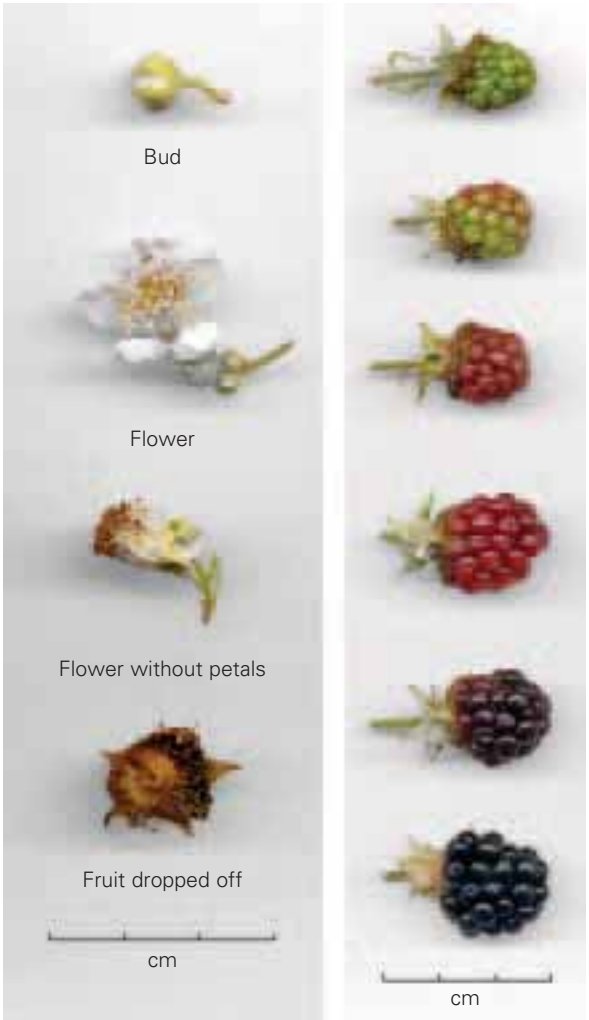


Figure 4 Different stages of flower and fruit development in bramble.

Figure 5 Entire bramble seed after extraction with examples of full and empty seed after cutting.

Box 1 Summary of detailed studies (continued).

Both the numbers of inflorescences and berries were affected by the thinning treatments; there were considerably more inflorescences and berries in the 80% thinning treatment. In 2002 there was about 1 inflorescence per m^2 which increased to 7 in the 10% thinning treatment and to 23 in the 80% treatment by 2004. Similarly, the berries increased from an initial number of about 4 per m^2 to 43 in the 10% thinning and 188 in the 80% thinning (Table 1).

Fruit development was fastest in the 80% thinning, but the ripeness stage of a berry had no influence on the number of seeds within it or the proportion of filled seeds. Similarly, the different thinning treatments had little effect on either the number of seeds in the berries or the proportion of filled seeds.

Table 1 Characteristics of bramble fruiting under different canopy covers in 2004.

	Thinning treatment			
	80%	40%	20%	10%
No. of inflorescences (m^{-2})	23	16	10	7
No. of berries (m^{-2})	188	114	66	43
No. of seeds/berry	18	15	13	9
Proportion of filled seeds	28%	27%	31%	22%

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The use of DNA technology to advance the Sitka spruce breeding programme

Steve Lee, Stuart A'Hara and Joan Cottrell

Improved planting stocks are now available for a number of conifer species including Sitka spruce *(Picea sitchensis)*, Scots pine *(Pinus sylvestris)*, Corsican pine *(Pinus nigra)* and hybrid larch *(Larix* x *eurolepsis)* (Lee, 2004). The greatest effort and progress has been made with Sitka spruce for which volume gains of improved planting stocks at rotation age have been predicted to be between 21% and 29% (Lee and Matthews, 2004). The process of selection, testing and breeding is long-term and costly. Final selections for breeding populations are currently made around 9 years after planting, based on data collected in replicated field trials. The cycle length between selection, testing and making improved material available to the industry is around 20 to 25 years. Therefore, despite the fact that the conifer breeding effort commenced in the early 1960s, it was not until the late1980s that improved planting stocks became generally available.

Biotechnological approaches are continually developing and are recognised as potentially powerful tools for tree breeding and conservation (Lee *et al.,* 2004). The development of DNA based molecular markers may offer a specific tool to enable tree breeders to shorten this breeding cycle and improve the accuracy of selection. If DNA markers can be identified that are consistently associated with characteristics that can only be measured when a tree is much older, then there is the opportunity for early selection of trees in the laboratory by screening for those markers.

The Conifer Tree Breeding Unit in Forest Research (FR) has recently started a project aimed at utilising DNA technologies within the breeding of Sitka spruce. The project is referred to as Marker Aided Selection (MAS) and its objective is to shorten the breeding cycle and improve the rate of genetic gain that reaches the forestry industry. If success in the development of clonal forestry techniques continues, it could be possible to mass produce trees selected in the laboratory and make them available to forest managers in as little as 2 to 5 years following initial screening.

Linking phenotypic performance with DNA markers

Suitable field trials are required to identify and verify trait and DNA marker associations. Early attempts to apply this technology elsewhere in the world relied on existing field trials with just a restricted number of progeny (100 to 200) per family. These studies often found marker and trait associations in a limited number of trees but there was no facility for verifying the findings in larger numbers of progeny or in other families (cf. Devey *et al.,* 2004). Elsewhere, simulation studies suggested that larger progenies of the order of 1000 trees were actually required to verify marker/trait assoiations with improved accuracy (Beavis, 1994, 1998). One successful study of identification and verification involved measurements on nearly 4500 trees from a single full-sibling radiata pine *(Pinus radiata)* family planted in a commercial forestry plantation (Devey *et al.,* 2004).

It was important that the design of any new trial should contain sufficient genotypes to allow accurate trait and marker associations. Soller and Beckmann (1990) emphasised the additional accuracy gained from the use of clonal replication of progenies, but even then, as many as 1260 genotypes may be required per family to provide Type I error 0.01 and power 0.80. Bradshaw and Foster (1992) agreed that the successful application of MAS depends upon precise estimation of phenotypic variation attributable to the markers and that clonal testing is the best experimental design to achieve this goal.

In spring 2005, FR planted three large clonal tests designed to investigate the association between markers and phenotypic variation in Sitka spruce. The experiments involve the same 1500 progeny from each of three full-sibling families. Each progeny (or genotype) is replicated four times at a single site and the whole experiment is repeated at three climatically contrasting sites (Figures 1, 2 and 3). In this way, breeders can investigate whether the marker/trait associations are stable across a range of environmental conditions. If markers are found to be specific only to a certain climate type or family, then the technology becomes of limited value. Each family consists of contrasting parents for which we have good knowledge of their genetic quality, e.g. a parent of good stem straightness crossed with a crooked parent; or a parent of high wood density crossed with one of low wood density.

The replicated clones representing each family in the field will be measured in the normal way for a range of characteristics, such as wood density, stem straightness or growth rate. The top and bottom echelon for a given trait (perhaps 5%, equivalent to 75 clones) will have tissue collected from them for further investigation in the laboratory. Breeders will then look for markers which are consistently associated with a given trait. If a high proportion of the total variation in, for example, wood density is associated with a limited number of markers, then in the future selection could take place in the laboratory by choosing trees which possess this complement of markers. Devey *et al.* (2004) found that eight markers explained more than 14% of the variation of juvenile wood density in radiata pine.

In a similar way, it is hoped that other markers will be identified which are associated with good stem straightness, fast growth rate, good insect resistance or perhaps high frost tolerance. It is possible that for some correlated traits, such as wood density and growth rate, the same markers for one trait may show an association with another. However, it is more likely that individual traits will have associations to a unique set of markers. This means that breeders using this technology will require a comprehensive set of markers, evenly spread across the genome, to enable these different marker/trait associations to be identified.

Figure 1 Location of the three trials, planted in spring 2005 at Huntly (north Scotland), Llandovery (south Wales) and Holsworthy (north Devon).

Figure 2 Planting on the upland site near Huntly.

Figure 3 Successful establishment on the mid-ranged Llandovery site.

Composing a genetic linkage map for Sitka spruce

Although the trial has only recently been planted and the plants are too young for the traits of interest to be measured, work has begun on marker development and the construction of a rudimentary genetic linkage map. The objective of map development is to determine the relative position of DNA markers in the genome, with the goal of building up a suite of markers that provide an even coverage across all chromosomes. The positions of the markers on the map are based on the frequencies of recombination between markers during crossover of homologous chromosomes at meiosis. At a simplistic level, the greater the frequency of recombination (segregation) between two genetic markers, the farther apart they are assumed to be. Conversely, the higher the frequency of association between any given markers, the smaller the physical distance between them. A rudimentary map has already been created (Figure 4).

As field data for different traits become available for analysis, the map will be used to identify regions of the genome which are consistently associated with the traits under investigation. This part of the work

involves the use of powerful computer software, which analyses the molecular data in conjunction with the field data and identifies robust marker/trait associations.

We are initially using a type of molecular marker known as a microsatellite. A microsatellite is a small length of DNA comprising a short motif which is repeated a variable number of times, e.g. $(CA)_5$ would represent the dinucleotide repeat CACACACACA and $(ATT)_5$ would represent the trinucleotide repeat ATTATTATTATTATT. These are highly informative markers as they are codominant (the alleles from both parents can be tracked in the offspring) and highly polymorphic (variable between individual genotypes). Microsatellites were historically expensive to develop because cloning and sequencing from custom-made genomic libraries was required for their discovery. In addition, the large, repetitive nature of conifer genomes made single-locus microsatellite discovery a low return to effort process. However, the recent public release of expressed sequence tag (EST) information – the sequences of transcribed genes – from a number of *Picea* species in DNA databases has opened up this avenue of microsatellite development. 'Datamining' is the term used to describe discovery of microsatellite sequences from DNA databases.

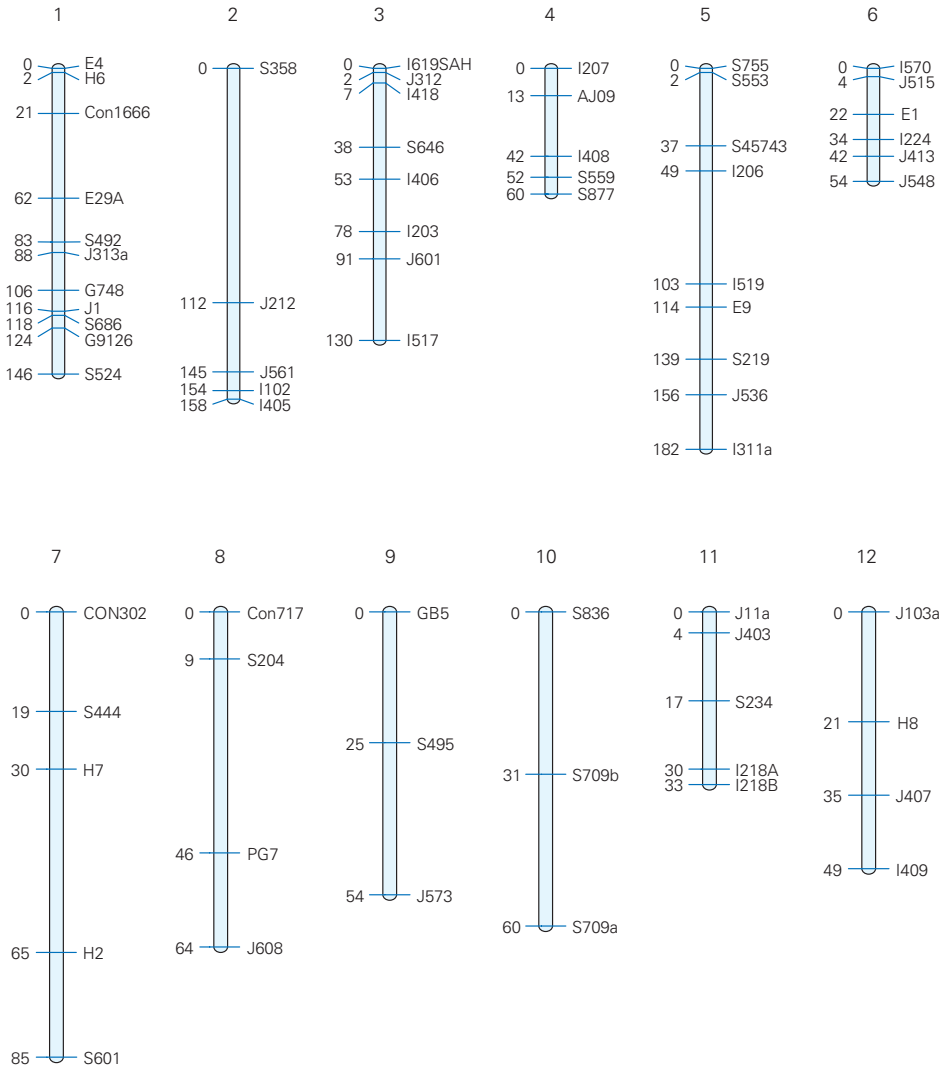

Figure 4 Preliminary genetic linkage map for Sitka spruce comprising 68 microsatellite markers. There are markers on all 12 chromosomes and as more are found the number on each chromosome will increase to ensure even coverage across the genome.

FR is searching for 200 microsatellites to create the framework map (Figure 5). Once this major step is completed, other classes of marker will be used to increase the marker density and ensure there are no gaps on the map. Microsatellite markers are often cross-species transferable, thereby allowing maps with other species to be combined. The other classes of markers, known as dominant markers (e.g. AFLPs and ISSRs) are not as informative as microsatellites and cannot be transferred across species, but can be generated in greater numbers and are less costly to develop. There are also plans to explore the use of a further type of marker known as single nucleotide polymorphisms (SNPs).

Figure 5 Preparing Stika spruce needles for DNA extraction prior to PCR. FR scientists hope to amplify 200 microsatellite markers and position them on a framework map.

Currently, we have 180 of our 200 microsatellite target: 50 genomic and 150 EST based following datamining of *Picea* databases. Given that there were only six available in the literature when the project started in 2004, substantial progress has been made.

All of these molecular techniques are made possible by a process called the polymerase chain reaction (PCR), which can amplify many millions of copies of

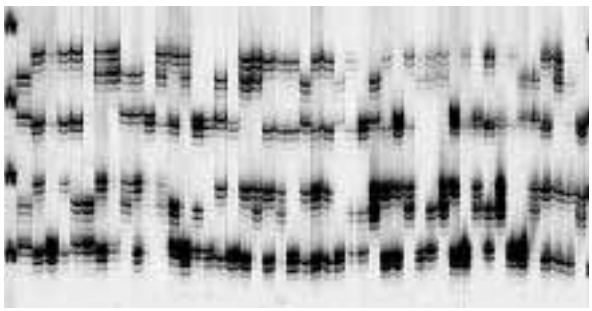

Figure 6 Example of a microsatellite gel. Ninety-six individual trees (two banks of 48) are scored for one microsatellite marker. A DNA size standard is run at either side of the gel.

specific fragments of DNA, allowing scientists to visualise the fragments on a gel (Figure 6). PCR uses short pieces of DNA, known as primers, which bind to unique, non-variable, regions of DNA on either side of a variable microsatellite motif. The process then cycles through a number of heating and cooling steps which accurately multiply the targeted region of DNA at an exponential rate. Primers are designed from the DNA sequence information to be specific for a particular microsatellite. Each microsatellite therefore has its own unique primer pair which will amplify only that microsatellite. The difference in the number of repeats between the primers produces a length difference that can be seen on the gel.

The MAS clonally replicated field trials are now entering their second growing season and the linkage map is about 12 months away from completion. It is intended that around six years from now we shall be trying to find an association between particular markers and the first trait measured in the field – stem straightness or wood density are the prime candidates. Markers for other characteristics are expected to follow.

Collaboration with other partners

This area of research is the focus of considerable international interest. Forest Research has joined forces with Genome Canada based at the University of British Columbia, Vancouver to develop a joint linkage map between Sitka spruce and white spruce *(Picea glauca)*: (www.genomecanada.ca/xresearchers/researchPrograms/projects). In addition, the new clonal tests are also seen as a robust resource for

verifying marker and trait associations which may have been identified by any third party.

Elsewhere, a collaborative project with Southampton University aims to determine the genes associated with traits such as wood density. This work will hopefully provide the basis for selecting those genes in which SNP markers will be developed and has the potential of finding a shortcut marker to a candidate gene directly influencing a given trait.

Future value of these new tools

If it proves possible to identify genetic markers in the laboratory which explain a sufficient proportion of the total phenotypic variation for a given trait in the field, then expensive and time-consuming field trials may become a thing of the past. In practice, breeders will need to be cautious and thorough verification will be necessary before deployment of selected genotypes.

DNA marker technology is developing rapidly. The computer software to help find the markers is also becoming cheaper and more sophisticated. Forestry can benefit from the molecular advances made in more valuable crops such as rice, tomato and poplar. By planting the field trials and developing a linkage map of the Sitka spruce genome, we are at the forefront of biotechnology on a global scale and are already collaborating with partners who share our interests.

Our vision is that ten years from now screening for clones of high wood density, good stem straightness, perhaps fine branches and good growth rate, will be aided by work in the laboratory. Once selected, many copies will be made of the chosen clones for rapid deployment to the field. The forest industry will benefit from planting a more uniform stock which grows faster and is better targeted to satisfy the construction timber market. Stands of trees will not only produce more volume of timber at a given age but will also produce a greater proportion which satisfies higher log grades in the forest and construction timber grades at the sawmill.

Acknowledgement

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Monitoring amenity tree health in England

The Condition Survey of Non-woodland Amenity Trees

Katherine Tubby

For over a decade, numerous volunteers have been involved in a Forest Research (FR)-led survey which enables us to monitor the condition of amenity trees in parks, city streets and stately homes across England. The concept behind the project grew from the *Forest Condition Survey* – a pan-European annual survey of forest condition which has been carried out across the UK and other European countries since 1987 (Hendry, 2005). Whilst the *Forest Condition Survey* concentrates on forest trees, *The Condition Survey of Non-woodland Amenity Trees* focuses on 16 genera of amenity trees commonly found in urban and rural environments within England. The aim is to identify, assess and publicise problems relating to pests, pathogens and other factors affecting the condition of non-woodland trees. In addition, participation in the survey encourages a greater awareness of the health and landscape value of amenity trees, while enabling the volunteer assessors to feel a greater ownership of the trees within their environments. This article provides an overview of the history, structure and findings of the survey.

Background

Since its inception in 1993-4, the condition survey has run in a number of slightly different forms and has been supported by various government departments. The first generation of the survey, funded by the Department of the Environment, grew from the government's growing awareness of the importance of trees within the urban environment, and also increasing public concern following the Dutch elm disease epidemic, recent drought problems and the Waldsterben debate (forest death attributed to acid rain) in Germany. Prior to this, the collection of data on tree health relied upon people contacting diagnostic services, such the Disease, Diagnosis and Advisory Service (DDAS) of FR, and the advisory services of the Royal Horticultural Society at Wisley. Consequently, the data tended to be patchy, occasionally unreliable and not very comprehensive. In an attempt to collect data on the health of amenity trees in a more systematic and rigorous way, plots were set up in 1993 to monitor tree condition. This was the first national scheme in the UK to attempt to monitor the health of non-woodland amenity trees, and also the first government sponsored tree health monitoring exercise to involve volunteer observers.

Tree plots containing pre-existing, mature trees were set up in both 'rural' and 'urban' situations. In some cases they mirrored those used in the initial survey *Trees in towns* (Department of the Environment and Land Use Consultants, 1993) and the *Countryside survey* (Department of the Environment, Institute of Terrestrial Ecology and Institute of Freshwater Ecology, 1993). Many rural plots were set up in the grounds of National Trust properties. Overall, a network of 106 plots was established. These first plots followed a fairly loose prescription, including between 100 and 200 trees, encompassing at least 12 genera, with as wide a range of species as possible. This gave the opportunity to study problems in species that would otherwise receive little attention. The emphasis at that time was on 'variety,' and some plots encompassed almost as many species as trees! In addition to recording any unusual or striking symptoms, the basic information collected included: tree species, estimated height and girth, foliar and shoot characteristics and crown density. Assessments were conducted twice yearly in June and September by volunteer observers. The volunteers came from a wide range of backgrounds, and included professional arboriculturists, local authority tree officers and parish tree wardens, as well as interested amateurs. The very general nature of this first generation of the survey meant that the data collected provided a valuable but rather qualitative picture of tree condition. In combination with the growing casebook of advisory data, such information formed the backbone of the reference book *Diagnosis of ill health in trees* (Strouts and Winter, 2000). A copy of this text is now made available to volunteers to encourage and reward participation in the survey.

The current amenity tree survey

Following a review of the project in 1998 there was a move towards more quantitative data collection, and perhaps a greater awareness of the potential social benefits of participation. Some of the main aims of the survey are detailed in Box 1.

Box 1 Main aims of the amenity tree health survey.

- Identify significant tree problems and promote awareness amongst tree managers.
- Identify trends in tree health and factors that may cause changes in them.
- Highlight issues that warrant further detailed investigation and reporting.
- Disseminate information to assist and enhance the personal development of all those involved in the management of amenity trees.

Survey design was streamlined to achieve replication and focus. A restriction was placed on the number of different tree genera; only the 16 genera most commonly found in the existing plots (see Table 1) were chosen for inclusion within the new survey. Each new plot had to contain at least five representatives of six of these genera, resulting in plots of around 30 trees. Many of the old plots proved suitable for inclusion within the new survey, but a number of new plots had to be set up in other locations to maintain a total of around 100 active plots across England. Active plots in 2005 are illustrated in Figure 1.

Table 1 Genera of trees included in the current survey.

Common name	Genus
Sycamore and Norway maple	*Acer*
Horse-chestnut	*Aesculus*
Birch	*Betula*
Hawthorn	*Crataegus*
Lawson cypress	*Chamaecyparis*
Beech	*Fagus*
Ash	*Fraxinus*
Holly	*Ilex*
Plane	*Platanus*
Poplar	*Populus*
Cherry	*Prunus*
Oak	*Quercus*
Willow	*Salix*
Swedish whitebeam and rowan	*Sorbus*
Yew	*Taxus*
Lime	*Tilia*

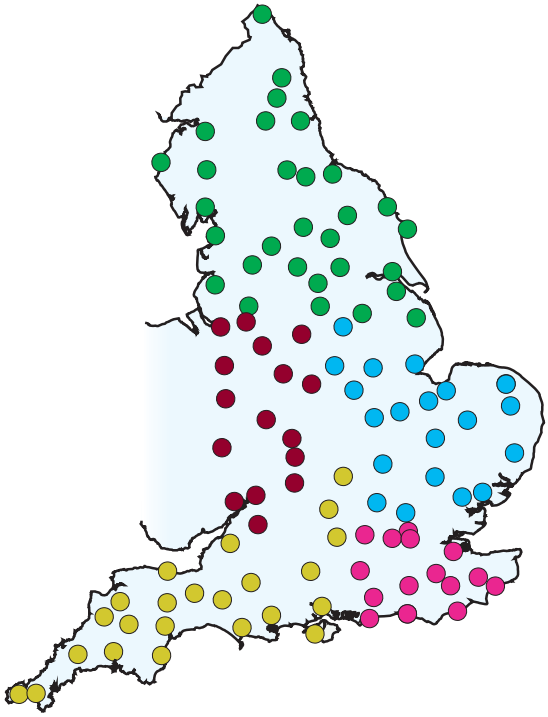

Figure 1 Distribution of amenity tree plots across England in 2005. The different colours illustrate how the survey is divided into distinct 'management areas' for easier administration.

Just as before, the trees continued to be assessed by volunteers, but rather than ask for two assessments, just one a year was carried out in mid-summer, as even some of the most dedicated volunteers had found it difficult to commit to more than one assessment. Although the numbers of trees within the plots was reduced in the new survey, volunteers were now asked to perform a much more detailed and systematic examination of each tree. The incidence and severity of a range of pests and diseases was recorded and, as tree condition in quite a broad sense was of interest, the new system also allowed the recording of abiotic disorders and even anthropogenic damage. Figure 2 shows an example of the assessment form used in the survey.

Amenity tree assessment form

The front of each form is split into sections, the first containing basic information such as the tree number and diameter at breast height. This allows easy identification of the trees for annual assessment in future years, to allow monitoring of ongoing changes in condition. In the main section of the form, volunteers are asked to submit information on the condition of the wood and bark, the condition of the crown and the state of individual leaves. For certain genera volunteers are also asked to look out for specific pests and diseases of interest. These tend to be relatively easily identifiable disorders which are specific to just one genus within the survey, and which may vary between years, perhaps in relation to local climatic conditions. For example, volunteers assessing *Acer* species look for signs of tar spot and sooty bark disease caused respectively by the fungi *Rhytizma acerinum* and *Cryptostroma corticale*. Both can cause striking symptoms (see Figure 3), and although the former is only really of aesthetic significance, following periods of very hot dry weather the latter can occasionally be the cause of tree death. In most cases volunteers are asked to judge the severity of any symptoms present using a very simple scale running from 0 (no symptoms) through to 3 (severe symptoms). Given the wide variation in the volunteers' experience of tree assessments, this simple system was chosen because it was practical and easy to use, while still yielding reliable data. A more complex system requires further training on the part of the volunteers, and this could deter some people from taking part.

Condition Survey of Non-woodland Amenity Trees

Year:..**2005**..... Plot Name: ALICE HOLT Plot No: 001 Observer's name: Katherine Tubby

Sheet No:..1.....of..6.... Tree species..***Acer pseudoplatanus***....................

Part A: Annual assessment of all tree species registered for the survey at the above plot

General information					Wood and bark								Crown										Individual leaves	
Date: e.g. 04.08.06 is 4th Aug 2006. (01–06)	Tree I.D. No. (07–12)	Diameter (mm) at 1.3 m height (13–16)	17 Live, dead or missing (1, 2, 8 or 9)	18 New disturbance of ground (0-3)	19 Exposed wood (03)	20 Bacterial canker/tumour (0-3)	21 Other perennial canker (0-3)	22 Bleeding canker	23 Fungal fruit bodies or rhizomorphs (0-3)	24 D-shaped insect exit holes (0-3)	25 Horse-chestnut scale (0-3)	26 New pruning (0-3)	27 Crown thinness (0-3)	28 Crown yellowing (0-3)	29 Crown browning (0-3)	30 Dark spots/blotches on leaves (0-3)	31 Leaf rust (0-3)	32 Mildew (0-3)	33 Leaf aphids (0-3)	34 Leaf-eating damage (0-3)	35 Chemical/salt damage (0-3)	36 Premature leaf fall (0-3)	37 Acer: tar spot	38 Acer: sooty bark disease
1 2 0 8 0 6	3 2 1	3 3 2	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1	0	0	0	0
1 2 0 8 0 6	4 0 0	3 5 2	1	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	1	0	0
1 2 0 8 0 6	4 0 1	2 4 7	1	0	1	0	0	0	0	0	1	1	0	0	2	0	0	0	1	2	0	2	0	0
1 2 0 8 0 6	4 0 2	3 5 3	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0
1 2 0 8 0 6	4 0 3	3 3 3	1	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	2	1	0	0	0	0

Figure 2 Example of an assessment form used by volunteers to record condition of *Acer* species. (There is an additional section on the reverse of each form where volunteers can make further notes.)

Figure 3 Tar spot and sooty bark disease on sycamore – two of the diseases our volunteers look out for.

Assessment forms are updated when necessary to take into account the changing behaviour of some organisms affecting tree health. One particular example is bleeding canker on horse-chestnut. Over the past five years reports of bleeding cankers on *Aesculus* species have risen sharply, and researchers are especially keen to collect as much data on this disorder as possible, particularly as the cause is not yet conclusively identified. An additional column was added to the form in 2004, specifically requesting information on presence and severity of such cankers on all tree species in the survey.

Training and education

Volunteers come from different walks of life bringing with them great variation in experience and background knowledge. Whilst some, for example arboriculturists and tree officers, must already be able to identify major pests and diseases as part of their work, others need more assistance. Therefore, on beginning the survey all volunteers are offered the opportunity of one-on-one assistance to get them started. Overall management of the survey is centrally co-ordinated through a project leader based at FR's Alice Holt research station. However, day-to-day management of the plots and contact with volunteers is largely devolved to trained liaison officers, one based in each of the sub-regions of the survey area. They offer regular contact with volunteers whenever needed, and are available to help set up plots, identify tree species, pests and diseases, and to answer any queries relating to the running of the survey. Such training is one of the benefits of taking part in this survey. Volunteers receive annual reports based on the data they have collected along with advisory casebook data for that particular year (Thorpe *et al.,* 2006a,b). Topical information leaflets called Tree Damage Alerts are also sent out periodically, flagging up certain pests or diseases prevalent at the time.

Results and trends

The survey in its present format allows the data to be analysed and presented more quantitatively, and provides a solid framework for monitoring ongoing changes in the health of amenity trees. Although the new survey has only been fully operational since 2000, year-to-year changes in the overall incidence of certain factors, for example crown browning and premature leaf fall, are becoming apparent as more data are collected (Figure 4a and b). In some cases crown discoloration can be attributed to the presence of a specific disease or insect. The browning apparent in the crowns of nearly half of all plane trees assessed in 2001 reflected high levels of anthracnose. The causal agent, the fungus *Apiognomonia veneta*, was particularly common in the springs of 1999, 2000 and 2001 due to a series of prolonged mild wet springs producing conditions conducive to the spread of this pathogen (Strouts, 1991). In the spring, buds may fail to flush as a result of infections from the previous year. The developing infection can also develop into twig blight, and later in the summer a leaf blight stage occurs, starting with killing of the veins and surrounding leaf tissue. If the fungus spreads down the petiole into the twig, the affected leaves fall early. In 2001 this disorder was reflected in the volunteers' data as 71% of all plane trees were recorded as suffering premature defoliation. It is now relatively common in these abundant urban trees, and it is possible that the observed rise in incidence is related to decreasing levels of sulphurous pollution in our cities. In contrast, crown discoloration in a species such as yew is much more difficult to attribute to a specific cause. The older needles go through a normal process of senescence at about the time when the trees are due to be surveyed, making it difficult to distinguish the perfectly normal change in overall crown colour from, for example, the browning caused by Phytophthora root rot.

Trees differ in their ability to withstand stress, and it was interesting to see how this was reflected in the data obtained during the summer of 2003. Southern parts of England in particular experienced some of the highest temperatures recorded in the UK and the 100 °F 'barrier' was breached east of London with 38.5 °C (101.3 °F) recorded at Brogdale near Faversham. There were many reports of limb shedding by large trees, and the high temperatures in late July/August caused some trees to lose their leaves early. Others suffered crown browning and leaf curling. The survey indicated that different species

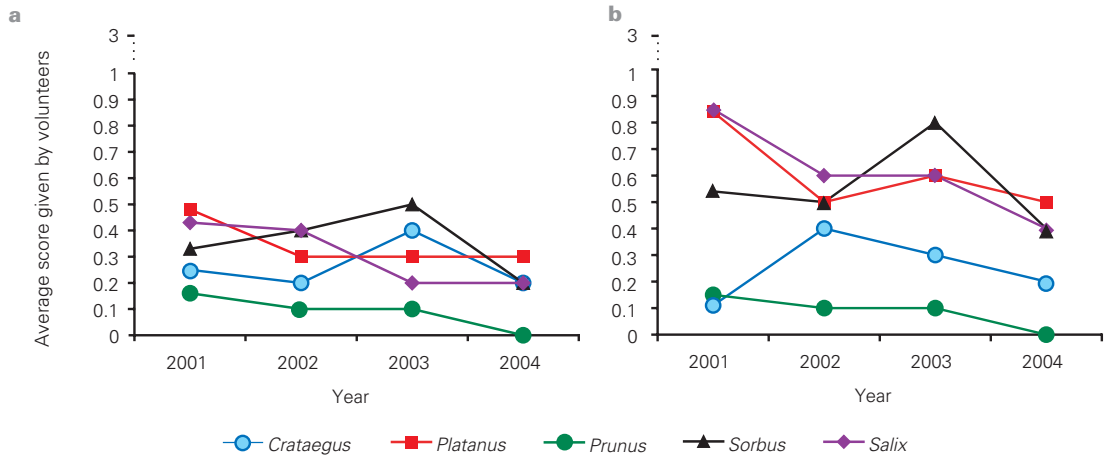

Figure 4 Examples of results on five species of tree assessed by volunteers taking part in the survey: (a) the appearance of crown browning; (b) the degree of premature leaf fall. Scale: 0 (no symptoms) through to 3 (severe symptoms).

varied in their susceptibility: *Platanus, Sorbus* and *Salix* suffered the highest levels of premature leaf drop and (excepting the evergreen species in the study) *Prunus* the lowest. The crown condition of beech also varies markedly from year to year and, although long-term drought is known to have affected the condition of some trees (Cannell and Sparks, 1999), heavy masting also has a significant deleterious effect on the crown in following years. Surprisingly perhaps, there were fewer reports of drought-related damage than expected. The dry sunny conditions also reduced the incidence of many leaf and shoot problems.

In addition to annual variation in the patterns of some pests and diseases, the data also illustrate certain geographic trends. Horse-chestnut leaf blotch, caused by the fungus *Guignardia aesculi* has been present in the UK since around 1935, following a probable introduction from the United States. The disease is recognisable by the reddish or dull brown, irregular blotches that are often concentrated at the tips and margins of infected leaflets. The blotches are usually outlined by a conspicuous yellow band (see Figure 5a). Since the beginning of the new survey it has been consistently recorded on at least 50% of all the horse-chestnuts assessed. However, it remains markedly more common in southern areas of the country (see Figure 5b). Of course this may change with global warming.

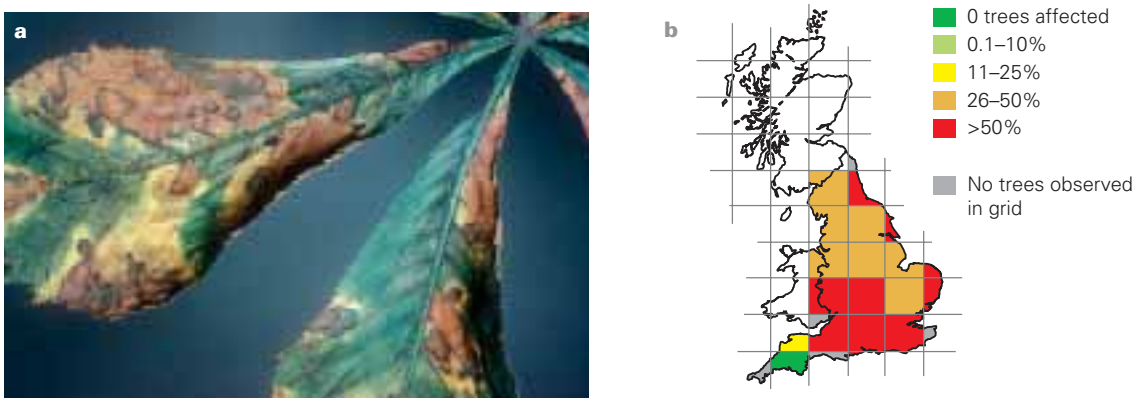

Figure 5 (a) Horse-chestnut leaf blotch showing yellow band. (b) Distribution of horse-chestnut leaf blotch in 2004, showing the percentage of trees surveyed in each square that were infected with the disease.

Figure 6 Horse-chestnut leaf miner *(Cameraria ohridella)* – a recent invader to the UK: (a) adult moth and (b) leaf mines created by the larvae. (a: photo P. Roose)

There is also potential for the survey to act as an early-warning system with respect to new or exotic organisms. Periodically, short leaflets called Exotic Pest Alerts are sent out to volunteers and the wider public to illustrate new threats such as the emerald ash borer *(Agrilus planipennis)* and the Asian long horn beetle *(Anoplophora glabripennis)*. Fortunately there have been no reports as yet and neither beetle is thought to have established in the UK. At the start of the new survey the horse-chestnut leaf miner *Cameraria ohridella* (Figure 6a and b) had not been found in the UK, although it had spread from an initial locus in Macedonia to much of Europe. However, in 2002, *C. ohridella* was found in the London borough of Wimbledon and has since spread to many parts of southeast England (Straw and Bellet-Travers, 2004; see also Tree Health Highlight 2, page 23). Volunteers involved in the survey have reported it in plots as widely spaced as south London and Norwich.

Limitations

Unfortunately, it must be said that some trends picked up by general advisory casebook data are not apparent in the data collected by the survey volunteers. Bleeding canker on horse-chestnut has become a very significant problem since 2000–2001, and although volunteers are now asked specifically to record presence of bleeding cankers, records are still very scarce compared with the actual numbers of trees that seem to be affected across the UK. Although no widespread systematic survey has been undertaken, Forest Research estimates that some 35 000 to 50 000 trees are affected, and probably a few thousands have already been felled as a result of the disease. Good quality data collected by volunteers would provide an extremely useful additional source of information.

In certain years the advisory casebook data also indicate high levels of rust (*Melampsora* spp.) on poplars and willows, and yet this is very rarely picked up in the survey. Some disease symptoms are difficult for all but the specialist to recognise and there is a fairly widespread failure to recognise rust symptoms or to distinguish between rust and mildew. Assessments of cherry also seem to generate occasional problems. It can be difficult to identify the specific cherry types selected for inclusion in the survey, as *Prunus* is an extremely large genus and exotic species or hybrids are often used in amenity plantings. Volunteers also often have difficulty identifying some of the diseases found on cherry. Consequently survey data do not always reflect the results garnered from advisory casebook data.

Although in most cases tree assessments are carried out with few problems, the possibility of missed or misdiagnosed disorders emphasises the importance of making one-on-one training available to all volunteers starting the survey. It also underlines the relevance of the annual reports and other topical information notes

provided to participants. To increase public access to information, web pages dedicated to the project have been produced setting out the aims of the project. Assessment forms are available for downloading, and copies of annual reports are available to readers (http://www.forestresearch.gov.uk/amenitytreesurvey). Free or discounted places are also made available at annual seminars to augment the professional development of volunteers. All these aids help to educate and enthuse volunteers whose background may not involve tree management at any level.

Undoubtedly the scheme has generated enormous enthusiasm and goodwill – even amongst those who do not get round to sending in their data every year! It encourages a greater sense of ownership and gives participants the feeling of being in touch with a national initiative on a subject about which they care deeply. This is a significant, if unquantifiable benefit of the scheme. The health of most of the amenity trees under assessment remains relatively good, and it is probably not an exaggeration to say that, in many cases, this is because people like the volunteers are looking after these trees and making sure they thrive in their environment.

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National and international links

The two maps reflect the range of networks we have been generating both nationally and internationally. The national map (Figure 1) shows FR's links with an increasingly wide range of UK universities and associated scientific organisations. The international map (Figure 2) shows our extensive links across Europe; in addition to this we have wider global links with New Zealand, USA, Canada and China.

National

Many of our programmes, individual and collaborative, are funded by other government agencies, UK research councils, universities and commercial organisations; these include Defra, DTI, NERC, SNH, English Nature, the Environment Agency, and the Universities of Sheffield, Southampton and London. We also collaborate with other universities countrywide, including Aberdeen, Edinburgh, Napier, Stirling, Lancaster, Bangor, Cardiff, Cranfield, Oxford, Cambridge, Exeter, Bath, Portsmouth, Reading, Surrey and Sussex.

Figure 1 Major UK links.

- **Universities**
- **Associated Scientific Organisations**
- **Field Stations**
- **FR hub**

Figure 2 International links.

International

Key European links include:

- INRA, France
- Brussels Free University, Belgium
- BBA, Germany
- INIA, Portugal
- Department of Forest Protection, Austria
- CSIC in Spain
- JRC in Italy
- METLA in Finland

Further across the globe we are working with:

- USDA in several areas of the USA
- SCION in Rotorua, New Zealand
- Canadian Forest Service,
  e.g. Victoria, British Colombia
- Forest University Beijing, China
- Madeira National Park, Madeira

Major research programmes undertaken by Forest Research

Programmes funded by the Forestry Commission

Biometrics, Surveys and Statistics Division

Sample plots

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

Ewan Mackie

Develop and promote measurement systems and instruments for the accurate and efficient measurement of trees and timber to support industry, 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.

Energy coppice and woodfuel research

Ian Tubby

Investigate environmental performance of energy coppice and woodfuel systems.

Remote sensing

Juan Suárez

Evaluate the potential of remote sensing techniques for operational use in British forest management.

National inventory of woodlands and trees

Mark Lawrence

Undertake the FC national survey of woodland 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.

Ecology Division

Lowland native woods

Ralph Harmer

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

Biodiversity evaluation and indicators

Jonathan Humphrey

Synthesise datasets from the biodiversity assessment project, identify potential biodiversity indicators, and disseminate findings.

Forest habitat management

Jonathan Humphrey and Russell Anderson

Investigate and provide guidance on the management of forests for biodiversity through developing old growth stands, and managing open ground habitats.

Species Action Plans

Alice Broome, Roger Trout, Chris Quine and Brenda Mayle

Research into the ecology of native woodland ecosystems in northern and western Britain to support restoration and extension. Current emphasis is on the Atlantic oakwoods and other broadleaved woodland habitats.

Landscape ecology

Kevin Watts 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. Investigate the impact of grey squirrels on woodland biodiversity.

Impact of herbivores

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, population dynamics of deer, deer density assessment and grazing management.

Tree protection

Roger Trout

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

Improvement of broadleaves

Jason Hubert

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

Genetic conservation

Joan Cottrell and Jason Hubert

Study of genetic variation and gene flow in natural populations. Assess the level of adaptive variation in the field trials of populations of native species.

Forest Reproductive Material Regulations

Sam Samuel

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

Environmental and Human Sciences Division

Soil sustainability

Elena Vanguelova and Rona Pitman

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.

Land Regeneration and Urban Greening

Tony Hutchings, Kieron Doick, Danielle Sinnett, Andy Moffat, Caroline Kilbride, Geoffrey Sellers and René van Herwijnen

Improve methods of establishing woodland and management practices on disturbed (brownfield) 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, Huw Thomas and Samantha Broadmeadow

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

Nadia Barsoum 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 and Matthew Wilkinson

Predict and model the impacts of climate and wider environmental change on tree growth by experimental work in open-top chambers and in forest stands. Interpret published climate change scenarios and develop guidance on future species suitability, both for production woodland management and native woodland restoration. Identify interactions between forests, woodland management and the changing global environment.

Carbon

Mark Broadmeadow, Matthew Wilkinson and Matthew Williams

Develop a network for monitoring carbon stocks and stock changes of woodland in the UK. Maintain one of only three long-term carbon flux monitoring stations in woodland in the UK, measuring carbon fluxes and constructing a carbon budget for a stand of lowland broadleaf woodland. Research the contribution that wood (including bioenergy production) and wood products can make to climate change mitigation.

Environmental change network

Sue Benham

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

Cultural heritage and historic environment

Peter Crow

Develop methods, tools and guidance to aid the day to day management of historic environment features such as archaeological evidence, veteran trees and historic woodlands/landscapes.

Social Research

Paul Tabbush, Elizabeth O'Brien, Max Hislop, Suzanne Martin, David Edwards and Jake Morris

Examine relationships between communities and woodlands in support of FC policies on sustainable forest management. Work concentrates on community involvement, publicly held values, health and well-being, sustainability indicators, impact assessment, recreation, access and rural development.

Forest Management Division

Integrated establishment systems for the uplands

Mike Perks, Alan Harrison and Colin McEvoy

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

Silvicultural effects on timber quality

Barry Gardiner, Elspeth Macdonald, Shaun Mochan and Alexis Achim

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

Silviculture of upland native woodlands

Colin Edwards and Bill Mason

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

Evaluate canopy structure manipulation to promote suitable microclimates for seedling establishment and facilitate natural regeneration to enable wider use of alternative silvicultural systems to patch clearfelling (continuous cover forestry).

Stability of stands

Bruce Nicoll, Barry Gardiner and Alexis Achim

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.

Forest vegetation management

Ian Willoughby and Richard Jinks

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

Silvicultural systems

Gary Kerr

Examine the potential for diversifying the range of silvicultural systems used in lowland forests.

Seed and seedling biology

Peter Gosling and Richard Jinks

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

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.

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

Allan John

Investigate tissue culture systems for multiplication of Sitka spruce.

Technical Development Group

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 and planting.

Continuous cover and small-scale silviculture/harvesting

Duncan Ireland

Develop methods and assess equipment with low environmental impact suitable for use in small, generally broadleaved woodlands, and suitable for use by farmers and small contracting firms.

Wood for energy

Andy Hall and Paul Webster

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.

Reduction in the use of chemicals

Ian Murgatroyd and Finlay McAllister

Examine equipment and methods that offer opportunities for non-chemical weed control.

Health and safety

Bill M. Jones and Colin Saunders

Review techniques and procedures for management of health and safety of machine operators.

Tree Health Division

Plant health

Hugh Evans and Christine Tilbury with Nick Fielding (TSU)

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).

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 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 these aspects to contribute to an Integrated Forest Management approach for control of pine weevil.

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 Division.

Advisory services

Christine Tilbury

Provide identification services for both pest and beneficial insects and provide advice on pest management and control. Assess the spread and impact of horse-chestnut leafminer, *Cameraria ohridella*.

Tree diseases: diagnosis and provision of advice

David Rose, Sarah Green and Joan Webber

Diagnose the cause of disease in trees and provide advice and information on disease identification, management and control. Disseminate the information to all interested parties through outreach activities such as Forest Health Days, workshops and seminars.

Tree health monitoring

Steven Hendry

Monitor the health of the nation's trees through the 350+ plots of the Forest Condition Survey, and raise awareness of tree health issues.

Non-chemical protection

Joan Webber

Research the potential for biological and non-chemical control of tree diseases, with special emphasis on root and butt rot of conifers caused by the fungal pathogen *Heterobasidion annosum*. Integrate this information into effective approaches to management and control of tree diseases.

Red band needle blight

Anna Brown

Research and survey the extent, severity and rate of spread of red band needle blight (caused by *Dothistroma pini*) in the UK with particular reference to East Anglia Forest District. Determine the impact that this could have on tree mortality and timber yields of Corsican pine and the suitability of the different control measures.

Diseases of broadleaf trees

Joan Webber and Sandra Denman

Investigate a range of established broadleaf tree diseases which include oak decline and Phytopthora disease of alder to determine their impact, interaction with climate and the environment and the opportunities for management and mitigation.

Dieback of birch

Sarah Green

Investigate the causes of shoot dieback that are frequently found in birch planted as part of 'new native woodlands' in Scotland. Aim to establish if fungal pathogens cause the disorder and to advise forestry practitioners and the Forestry Commission on whether they are a serious, primary factor in birch dieback and, if so, how they may be managed.

Quarantine pathogens – *Phytophthora ramorum* and *P. kernoviae*

Joan Webber, Sandra Denman and Clive Brasier

Investigate the biology and epidemiology of the two new quarantine tree pathogens, *Phytophthora ramorum* and *P. kernoviae*, which infect tree species within the Fagaceae. Use information generated from this research in Pest Risk Analysis to determine the extent of the risk these pathogens pose to trees in the UK, their impact and opportunities for eradication and control.

Programmes part-funded by the European Commission

Ash for the future: defining European ash populations for conservation and regeneration.

Demonstration of sustainable forestry to protect water quality and aquatic biodiversity.

Ergoefficient mechanised logging operations.

Development of improved pest risk analysis techniques for quarantine pests, using pinewood nematode *Bursaphelenchus xylophilus* in Portugal as a model system.

Forest condition surveys.

Forest Focus review.

Integrating ecosystem function into river quality assessment and management.

Urgent conservation management for Scottish capercaillie.

Visualisation tools for public participation in the management of landscape change.

Risk analysis for *Phytophthora ramorum*.

External timber cladding in maritime conditions. Northern Periphery.

Reintegration of coal ash disposal sites and mitigation of pollution in the West Balkan area.

Core forest sites for a Forest Habitat Network.

Fellowship: Quality of Life and Management of Living Resources.

Sustainability impact assessment: tools for environmental, social and economic effects of multifunctional land use in European regions.

Sustainable management of forest insect pests.

Development of generic 'on site' molecular diagnostics for EU quarantine pests and pathogens.

Programmes funded by individual organisations

BP Exploration Operating Co. Ltd
Scottish Forestry Alliance Biodiversity Group.

Cairngorms National Park
Update of forest and woodland framework, mapping section.

Carbon Trust
Energy efficient kilns.

CCW/FCW
Woodland habitat network strategy for Wales.

CCW, SNH and CSL
Grey squirrel fertility control vaccine bait trial.

Contaminated Land: Applications in Real Environments (CL:AIRE)
Development of an Indicator Methodology to determine the plant availability of potentially toxic elements.

Department for Environment, Food and Rural Affairs
Species boundaries on *Phytophthora*.

Yield models for energy coppice of poplar and willow.

Investigation of eradication and control strategies for *Phytophthora kernoviae* in natural environments.

Acid deposition monitoring at High Muffles.

Renewable industrial material from the hills: adding value to trees.

Condition survey of non-woodland amenity trees.

EPSRC/Sheffield
Urban greening.

Novel compost.

Climate change.

EPSRC/University of Surrey
Pollutants in the urban environment.

FCS
Scottish Native Woodlands Survey.

Potential FR Timber Quality Group.

Institute of Grassland and Environmental Research
Development of sustainable heat and power fuelled by biomass from short rotation coppice in Wales.

James Jones
Timber properties of Sitka spruce in south Scotland.

Midlothian Council
Forest Habitat Network for Edinburgh and Lothian.

Natural Environment Research Council/Sheffield University
Terrestrial carbon dynamics.

NERC
UK emissions by sources and removals due to land use and land use change policy.

Terrestrial umbrella – eutrophication and acidification ecosystems in the UK.

Plantlife Scotland
Trials for *Juniperus communis* subsp. *communis*.

Scottish Executive
Small cow-wheat species recovery project.

Scottish Forestry Trust
Distribution and biology of *Anisogramma virgultorum* on birch in Scotland.

Scottish Natural Heritage
Balancing upland and woodland strategic priorities.

Lowland habitat network.

Sheffield University
CTCD data management.

Southampton University
Short rotation coppice (poplar).

USDA
Phytophthora ramorum.

Bark infecting Phytophthoras.

Research contracts awarded by Forest Research

Avon Vegetation Research
Forestry herbicide evaluation.

Butterfly Conservation
Study of small pearl-bordered fritillary populations in Clocaenog Forest.

Cranfield University, BHR Group
Development and production of prototype systems to separate insect parasitic nematodes from rearing media.

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.

Conservation of Xylophagous beetles and their parasitoids in Britain's woodlands.

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 Abertay, Dundee
Cryopresentation of Sitka spruce tissues.

University of Birmingham
Woody debris in forest aquatic habitats.

University of Bristol
Use of landscape features and habitats by lesser horseshoe bats: management implications.

University of Leeds
Atmospheric boundary layer over forests.

Chemical transport in forests.

University of Reading
Tree root response to acidification.

Soil variability.

Soil quality indicators in forestry.

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

Molecular studies of quantitative traits in Sitka spruce.

University of Stirling
Habitat use of working forest by capercaillie.

Paleoecology of Glen Affric.

Identification and analysis of spider samples obtained from Forest Research's Biodiversity Assessment plots.

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.

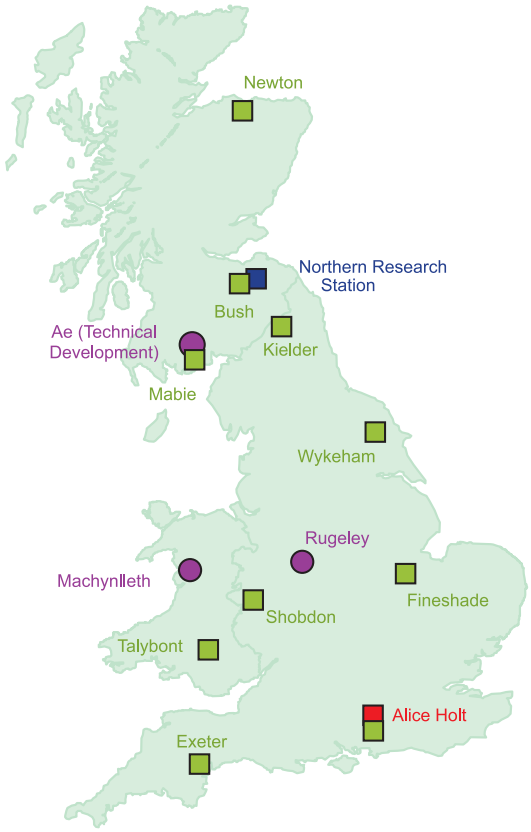
Impact of defoliating insects on forests.

University of York
Carbon stocks in UK soils and their vulnerability to climate change.

Forest Research people

Staff as at 31 March 2006, in Divisions and Technical Services based at:

- **Alice Holt**
- **Northern Research Station**
- **Ae Village, Midlands and Wales**
- **Field Stations**



Chief Executive
- Professor Jim Lynch, BTech, PhD, DSc, CSci, CChem, FRSC, CBiol, FIBiol, FIBiotech, FRSA

Research Director
- Professor Peter Freer-Smith, BSc, PhD, DSc

Personal Secretaries
- Claire Holmes
- Sue Jones, BA, MA
- Sue Stiles

Head of Northern Research Station
- Chris Quine, MA, MSc, MICFor, PhD

Personal Secretary
- Madge Holmes

Quality Assurance Manager
- Kate Fielding (during 2005)
- Carl Foster (from January 2006)

Human Resources and Administration

- Ken Charles, FMS, *HR and Administration Director*
- Christopher Baker, BSc
- Wendy Groves
- Janet Lacey
- Heather Russell
- Mandy Sennett
- Sally Simpson
- Amanda Smith
- Louise Tharnthong
- Mike Wheeler
- Maureen Wilkes
- Mike Young
- Martin Abrahams, *Head of Administration at NRS*
- Gerry Cockerell
- Evelyn Hall
- Esther Ker
- Linda Legge
- Roz Shields

Finance and IT

- Tony Cornwell, FCMA, *Finance and IT Director*
- Laura Caless
- Dai Jeffries, BSc
- Carol Knight
- Timothy Knight, BSc
- Carole Martin
- Claire Sabin
- Janet Turner
- Wayne Blackburn, BSc, *Head of IT Services*
- Alec Gaw, BSc

Communications

- Xanthe Christophers, BSc, PhD, *Communications Director*
- Jenny Claridge, BSc, ARCS
- Joanne Davies, BSc
- George Gate
- David Georghiou, BA
- Eleanor Harland, MA, DipLib
- Alison Melvin, BA
- Catherine Oldham, BA, MA, DipLib, MCLIP
- Thelma Smalley
- Sally Taylor
- John Williams
- Glenn Brearley
- Kirsten Hutchison, MA

Research Liaison Officers

- Kate Fielding (Scotland)
- Chris Jones (Wales)
- Susannah Kable (England)

FR employs 283 staff, some of whom work part time, giving a total staff number of 273 full-time equivalents at 31 March 2006.

KEY: **Alice Holt** **Northern Research Station** **Ae, Midlands and Wales** **Field Stations**

Biometrics, Surveys and Statistics Division

- Professor Sam Evans, MA, PGDip, PhD, PhD, FCMI, *Head of Division*
- Catia Arcangeli, MSc, PhD
- Miriam Baldwin, HND, BSc, MSc
- Alan Brewer, BSc, MSc, MSc, PhD
- Eric Casella, MSc, PhD
- Joy Cornwell
- Ian Craig
- Carol Foden
- Paul Henshall, BSc
- Makihiko Ikegami, BSc, MSc, PhD
- Ewan Mackie, BSc, MSc
- Robert Matthews, BSc, MSc
- Geoff Morgan, BSc, MSc, PhD
- Lyn Pearce
- Jane Poole, BSc, MSc
- John Proudfoot
- Tim Randle, BSc
- Marc Sayce
- Paul Taylor, MA, MSc, MPhil
- Ian Tubby, BSc
- Christopher Vials, BSc
- Stephen Bathgate, BSc, BSc, PGDip
- Christine Brown
- Graham Bull
- Shona Cameron
- Lynn Connolly
- Tom Connolly, BSc, PhD
- Justin Gilbert, BSc
- Mark Lawrence, BSc, MSc
- Andrew Peace, BSc
- Lynn Rooney
- Juan Suárez-Minguez, BSc, MSc
- Esther Whitton

Ecology Division

- Chris Quine, MA, MSc, MICFor, PhD, *Head of Division*
- Stuart A'Hara, BSc, MSc, PhD
- Russell Anderson
- Helen Armstrong, BSc, PhD
- Alice Broome, BSc
- Robert Coope
- Joan Cottrell, BSc, PhD
- Jason Hubert, BSc, PhD
- Jonathan Humphrey, BSc, PhD
- Darren Moseley, BSc, PhD
- Liz Poulsom, MSc
- Steve Petty, PhD, Research Fellow
- Duncan Ray, BSc
- Louise Sing, BA, MSc
- Shirley Spencer (also with FMD and TSU)
- Richard Thompson
- Andy Brunt
- Amy Eycott, BSc, PhD
- Mark Ferryman
- Robin Gill, BSc, MSc, PhD
- Matthew Griffiths, BSc, MSc
- Ralph Harmer, BSc, PhD
- Andrea Kiewitt, BSc, MSc
- Brenda Mayle, MSc
- Roger Trout, BA, PhD
- Kevin Watts, BSc, PhD

Environmental and Human Sciences Division

- Andy Moffat, BSc, PhD, *Head of Division*
- Lorraine Adams, BSc
- Nadia Barsoum, BSc, PhD
- Sue Benham, BSc
- François Bochereau, BSc, MSc
- Mark Broadmeadow, BSc, PhD
- Samantha Broadmeadow, BSc, MSc
- Sylvia Cowdry
- Peter Crow, BSc, MSc
- Cecile De Munck, BSc, MSc
- Tony Hutchings, MSc
- Lynn Jordan
- Caroline Kilbride, BSc
- Anthea McRiley, BSc
- Alberto Morales, BSc, PhD
- Jake Morris, MA, PhD
- Jacqui Neal
- Tom Nisbet, BSc, PhD
- Liz O'Brien, BSc, PhD
- Christopher Peachey
- Rona Pitman, BSc, PhD
- Geoffrey Sellers, BSc, MSc, PhD
- Danielle Sinnett, MSc
- Paul Tabbush, BSc, MSc, FICFor
- Huw Thomas, BSc, MSc
- Rene van Herwijnen, MSc, PhD
- Elena Vanguelova, BSc, MSc, PhD
- Ernest Ward, BSc, MSc, CChem, MRSC
- Christine Whitfield
- Matthew Wilkinson, BSc, MSc
- Matthew Williams, BSc
- Elizabeth Young, BSc
- David Edwards, BSc, MSc, MSc, PhD
- Max Hislop, MICFor
- Suzanne Martin, BSc, PhD

KEY: ■ **Alice Holt** ■ **Northern Research Station** ● **Ae, Midlands and Wales** ■ **Field Stations**

Forest Management Division

Incorporating Technical Development

- Bill Mason, BA, BSc, MICFor, *Head of Division*
- Alexis Achim, BSc
- Cathleen Baldwin
- Colin Edwards, BSc
- Professor Barry Gardiner, BSc, PhD, FRMetS
- Sophie Hale, BSc, PhD
- Alan Harrison, BSc
- Allan John, BSc, PhD
- Steve Lee, BSc, PhD, MICFor
- Elspeth MacDonald, BSc, MSc
- Shaun Mochan, MSc
- Bruce Nicoll, BSc
- Mike Perks, BSc, MSc, PhD
- Shirley Spencer (also with ED and TSU)
- Rob Sykes
- Colin McEvoy, BA
- Stephane Berthier, PhD
- Peter Gosling, BSc, PhD
- Lorelie Ives
- Richard Jinks, BSc, PhD
- Gary Kerr, BSc, FICFor, PhD, MICFor
- Shelagh McCartan, BSc, MSc, PhD
- Matt Parratt, BSc
- Victoria Stokes, BSc, PhD
- Christine Woods, BA
- Ian Willoughby, BSc, MBA

Technical Development

Ae, Scotland

- Andy Hall, *Head of Technical Development*
- Bill J. Jones
- Steve Morgan
- Ian Murgatroyd
- Norma Nicholson
- Joyce Rammell, BSc
- Colin Saunders

Midlands

- Andy Hall (also at Ae)
- Duncan Ireland, BSc
- Paul Webster

Wales

- David Jones, EngTech, AMIAgrE

Tree Health Division

- Hugh Evans, BSc, DPhil, FRES, *Head of Division*
- Professor Clive Brasier, BSc,PhD, DSc, Research Fellow
- Anna Brown, BSc, PhD
- Sandra Denman, BSc, MSc, PhD
- Gillian Green, BSc
- Andrew Jeeves
- Martin Jukes, Cbiol, MIBiol
- Susan Kirk
- Elizabeth Orton, BA, MSc
- David Rose, BA
- Joan Rose
- Shirley Stephens
- Nigel Straw, BSc, PhD, FRES
- Christine Tilbury, BSc
- Kath Tubby, BA, MSc, DPhil
- David Wainhouse, MSc, PhD, FRES
- Joan Webber, BSc, PhD
- David Williams, BSc, PhD
- Sarah Green, BSc, PhD
- Steven Hendry, BSc, PhD
- Stuart Heritage, MBA, Cbiol, MIBiol
- Grace MacAskill
- Roger Moore, BSc, PhD
- Corinne Russell
- Heather Steele, BSc

Field Stations

Technical Services Unit

- Janet Dutch, BSc, PhD, *Head of Unit*

North

Engineering Services

- David Brooks, *Head of Engineering Services*
- James Nicholl
- John Strachan

Bush, Inver and Bush Nursery

- David Anderson, *Head of Stations*

Bush

- Colin Gordon
- Hamish Howell
- Nelson Innes
- Gavin Mackie
- Steven Osborne, BSc
- Steven Sloan

Inver

- Nick Evans
- Bill Rayner

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Bush Nursery
- David Clark, *Nursery Manager*
- John Armstrong
- Graeme Crozier
- Alan Purves

Kielder and Mabie
- Dave Watterson, *Head of Stations*

Kielder
- Terry Gray
- Mike Ryan
- Len Thornton

Mabie
- James Duff
- Joanna McGregor
- Harry Watson
- James White

Newton and Lairg
- Alistair MacLeod, *Head of Stations*
- Pauline Simson, BSc

Newton
- Hazel Andrew
- Allison Cowie
- Andrew Kennedy, BSc
- Fraser McBirnie
- Stuart McBirnie
- Hugh MacKay, BSc
- Stephen O'Kane
- Colin Smart

Lairg
- Alexander Bowran
- Calum Murray
- Duncan Williams

South

Alice Holt
- Jamie Awdry
- Bob Bellis
- Sue Bellis
- Tony Bright
- Rory Cobb
- Steve Coventry
- Norman Day
- Kate Harris
- Ian Keywood
- Vicki Lawrence
- Tony Martin
- Jim Page
- Bill Page

Alice Holt Workshop
- Jon Davey
- Clive Muller

Exeter
- Alan Ockenden
- Anthony Reeves
- Barnaby Wylder

Fineshade and Thetford
- Dave West, *Head of Stations*
- Elizabeth Richardson

Thetford
- John Lakey
- Paul Turner
- Alistair Whybrow
- Steven Whall

Shobdon and Talybont
- Nick Fielding, *Head of Stations*

Shobdon
- Jason Jones
- Sharon O'Hare
- Martin Page-Jones
- John Price
- Jonathan Tetley

Talybont
- Chris Jones, BSc
- Lyn Ackroyd
- Sam Catchpole, BSc
- Justin Chappell
- Dai Evans
- Ben Griffin, BSc
- Steve Howells
- Richard Keddle
- Brian Jones
- Finlay McAllister, BA, BSc
- Andrew Price
- Tony Price
- Jake Thompson
- Tyrone Waldron
- Ken Williams

Wykeham
- Lee Cooper
- Nicola Corney
- Alex Hill
- Patricia Jackson
- William Riddick

KEY: **Alice Holt** **Northern Research Station** **Ae, Midlands and Wales** **Field Stations**

PhD Students linked with Forest Research

Sarah Archibald (Imperial College London)
Miriam Baldwin (Wageningen University, NL)
Eligiusz Baumgart (Imperial College London)
David Beattie (Imperial College London)
Sophie Bertin (University of Edinburgh)
Helen Billiald (University of Sussex)
Wendy Bryan (Paisley University)
Lois Canham (University of Stirling)
Fiona Caryl (University of Stirling)
Vanessa Castan-Broto (University of Surrey)
Jo Clark (University of Wales, Bangor)
Julia Cox (University of Surrey)
Richard Curtis (University of Gloucester)
Monica De Ioanni (University of Molise)
Heike De Silva (University of Aberdeen)
Hannah Drewitt (University of Durham)
Helen Ellison (Imperial College London)
Ruth Fitzgerald (Reading University)
Priya Gadepalle (University of Surrey)
Samantha Gale (Abertay University)
Rachel Gaulton (University of Edinburgh)
Nicole Harris (Southampton University)
Iain Hartley (University of York)
Jack Johnston (University of Ulster)
Tessa Knight (University of Bristol)
Bruce Lamond (University of Edinburgh)
Lucy Marchant (Reading University)
Paul McLean (University of Glasgow)
Jo Mortimer (Reading University)
Gloria Olaya (University of Edinburgh)
Vini Peteira (Imperial College London)
Martin Price (University of Wales, Bangor)
Jennifer Seaman (University of Sheffield)
Helen Sellars (University of Liverpool)
Tim Silverthorne (University of Surrey)
Danni Sinnett (Reading University)
Juan Suárez-Minguez (University of Sheffield)
Suzanne Swanwick (Cranfield University)
Janine Tan (Ulster University)
Louise Timms (Imperial College London)
Alessandra Timarco (Reading University)
Peter Torr (Aberdeen University)
Ed Wallington (University of Edinburgh)
Axel Wellpot (University of Edinburgh)
Jeremy Wingate (University of Surrey)
Georgios Xenakis (University of Edinburgh)

KEY: ■ **Alice Holt** ■ **Northern Research Station** ● **Ae, Midlands and Wales** ■ **Field Stations**

Accounts for the year ended 31 March 2006

Accounts for the year ended 31 March 2006

Contents

Annual Report For the year ended 31 March 2006

1. Basis of accounts

These accounts are prepared in accordance with a direction given by HM Treasury in pursuance of section 7 of the Government Resources and Accounts Act 2000.

Management commentary

2. Status

Forest Research became an Executive Agency of the Forestry Commission on 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, revised and published in September 2003.

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.

Two organisational reviews took place during 2002 and 2003 that impacted on the Agency's status and operational arrangements.

In line with normal arrangements for agencies, Forest Research underwent a Quinquennial Review, stage one of which was completed in January 2002, whilst between May 2001 and August 2002 an interdepartmental group carried out a review of the Forestry Commission. This reviewed the devolution arrangements for delivering sustainable forestry policies in England, Scotland and Wales and the UK's international forestry commitments.

On conclusion of stage one of the Forest Research Quinquennial Review, Forestry Ministers decided that the Agency should retain its executive agency status for a further five years. The devolution review concluded that Forest Research should continue as a GB-wide agency of the Forestry Commission but new arrangements should be set up, with an enhanced role for the devolved administrations through the National Offices in England, Scotland and Wales in determining research priorities and specifying programmes.

The stage two report of the Agency's Quinquennial Review, which addressed the issues on implementing the outcomes of the stage one review and the devolution review, was approved by Ministers and a new Framework Document was put in place in September 2003.

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 funding requirement.

Forest Research has been designated a GB entity. For Resource Accounting purposes Forest Research is within the departmental boundary. Its accounts are consolidated into the Forestry Commission England/GB accounts.

3. Strategy

The strategic aims and objectives of the Agency have been set to assist the Forestry Commission achieve its GB objective to take the lead in development and promotion of sustainable forest management and to support its achievement nationally.

These are discussed in detail in the Agency's corporate plan, which will be available on the Forestry Commission website and the Forest Research website.

4. Relationships with stakeholders

As most aspects of forestry are devolved activities, strong relationships between the wider Forestry Commission (FC) and the devolved administrations are critical. Summer 2005 saw the launch of FC's Science and Innovation Strategy, with an increased focus on the role of the FC National Offices and the Northern Irish Forestry Service to shape the research agenda and to disseminate results. Consultations associated with this process involved the participation of many of our key stakeholders, focused around meetings held during the year. The Agency subsequently appointed three Regional Liaison Officers, to support the process of research commissioning and dissemination on an ongoing basis.

As an applied research institute, the Agency's relationships with the forestry and land management industries are also of paramount importance. The Agency has recently strengthened its industrial links in a number of ways.

- The strengthening of its knowledge transfer expertise, through monies awarded by 'Public Sector Research Establishment 3' innovation capacity building fund, is enabling the Agency to take a more pro-active role in industry-led innovations.
- The Agency has become a member of the English Forest Industries Partnership, which has just completed a sector mapping study.
- The Agency's close association with the Scottish Forest Industries Cluster has resulted in full involvement in the development of the European Forestry Technology Platform and its associated strategic research agenda, which will be taken forward in the Framework 7 programme during 2007–2013.

5. Aims and objectives

The aim of Forest Research is set out in the Framework Document. It is to support and enhance forestry and its role in sustainable development, by providing high quality research and development in a well-run organisation.

The objectives of Forest Research are listed on page 4 in the Annual Report.

Current and future development and performance

6. Operating review

The year proved to be one requiring continuing flexibility in deployment of resources as requirements for work on key areas such as Phytophthora developed during the year.

The year saw the Agency's first involvement in the Scottish Native Woodland Survey and it is expected that this pilot work will lead to a substantial programme of activity over the coming years.

In line with policy to increase the value of and expand the range of involvement in non-FC funded research, the development of initiatives in sustainability forestry such as woodfuel and biomass energy, as well as land regeneration and remediation, have progressed apace. These are confidently expected to bear fruit in future years.

The successful bid for PSRE funding, which yielded £495,000 over a three-year period, will enable the Agency to accelerate the construction of its commercialisation and innovation skill base in order to pursue the government agenda for exploitation of science.

Changing requirements for fieldwork and traditional experiments have lead to a steady and increasing downturn in the financial performance of the Technical Support Unit (TSU). A thorough study, conducted over the past two years, concluded that the TSU was no longer sustainable in its present size or organisation but remained a valuable asset to the Agency and the Commission as a whole.

Restructuring plans were prepared, involving a number of early retirements and redundancies, and these were approved for implementation during 2006–07. The costs will be met from the Agency's own resources and provision has been made in the 2005–06 accounts (see note 17, page 99).

7. Financial review

This is Forest Research's ninth year of operation as an Agency. Forest Research produced a net operating surplus of £460,000 on its Income and Expenditure Account, excluding the notional cost of capital and before an exceptional item reflecting the provision made in respect of the costs of TSU restructuring, which will fall due in 2006–07 and subsequent years. A comparison of income and expenditure with the previous year's results shows that:

- staff costs increased by £516,000 (6.1%)
- other management costs by £88,000 (4.0%)
- materials and services costs increased by £77,000 (2.9%)
- income from Forestry Commission customers increased by £859,000 (7.5%)
- income from external customers reduced by £100,000 (4.7%)
- the notional cost of capital increased by £32,000 (7.8%)
- the exceptional item represents the provision for the costs of restructuring (£369,000) being the present values of the costs of early retirements and redundancy payments falling due in 2006–07 and beyond.

The net surplus for the year after the cost of capital charge of £441,000 and depreciation was £19,000, representing a cost recovery rate of 100.1%. After providing for restructuring costs the net deficit for the year was £350,000.

After adjusting the total deficit for items not involving the movement of cash and for capital expenditure, bank account movements and income, the net cash inflow for the year was £217,000, which was handed over to the Forestry Commission.

Additions to fixed assets in the year were £489,000.

8. Financial objective – Key Performance Indicators (KPIs)

Forest Research's primary 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. In 2005–06, measured before the provision for restructuring costs, this objective was met with a full cost recovery rate of 100.1%.

Performance against other operational, scientific and financial KPIs is reported in the main body of the Annual Report and Accounts. The KPI to achieve £1.9m from income from non-FC customers was exceeded by £0.1m. There are two other financial KPIs relating to the overall cost per chargeable research day and the cost of support services per chargeable research day. Following the internal restructuring of the Agency in 2004–05 efficiency savings have been achieved against both of these KPIs with the overall cost measure reducing by 6% and support services reducing by 11%.

9. Events since the balance sheet date

The Technical Services Unit restructuring plan was implemented and the formal notice to the nine staff of redundancies/early retirements were issued in April 2006 with effective dates in October 2006. These events have been provided for in the 2005–06 accounts and presented as an exceptional item in the Income and Expenditure account.

10. Future events

As a science-based government agency, FR staff are part of the wider science and technical development community maintaining world class expertise and excellence in applied forest research. Three of the key priorities for FR in the coming year will be:

- to increase our partnerships with other research establishments, across the UK, Europe and worldwide – linking with programmes of research, development, monitoring, resource evaluation and scientific services;
- to establish relationships with users of research outputs including industry, policymakers and other stakeholders in order to understand their needs;
- to monitor bodies that fund research in order to be responsive to changing needs.

FR will continue to lead research in areas of sustainable forestry which increasingly cut across its programmes and which include social, economic and environmental components. FR continues to grow as an internationally recognised centre of excellence in the traditional area of advancing the scientific understanding of sustainable forest management. However, it is also extending this reputation in areas which include research into all aspects of the environment pertaining to trees, woodlands, forests and on their value to society.

There will be continued emphasis on knowledge transfer. There will be increasing analysis of the existing routes for knowledge transfer including further development of the website. The three Research Liaison Officers (RLOs) now in place in England, Scotland and Wales lead in establishing and maintaining channels of communication with stakeholders and in developing new initiatives for improving knowledge transfer.

Other disclosures

11. Supplier payment policy

Forest Research observes the principles of the Late Payment of Commercial Debts (Interest) Act 1998. 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 2005–06 indicates that 99.92 % 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. No interest was paid under the Late Payment of Commercial Debts (Interest) Act 1998.

12. Employment policies

Forest Research adheres to the Forestry Commission's employment policy and values and respects its staff by treating each member with respect and trust, and in doing so recognises that each person is different and can make a unique contribution to the work. The purpose of the Forestry Commission's employment policy is to demonstrate that it is an equal opportunity employer and the aim is to be fair to everybody. To do this the Forestry Commission ensures that no eligible job applicant or employee receives less favourable treatment on the grounds of their gender, or gender re-assignment, ethnic origin, disability, age, nationality, national origin, sexual orientation, marital status, religion and religious or philosophical belief, social class or offending background.

All employees, whether part-time, full-time or temporary will be treated fairly and equally. Selection for employment, promotion or training or any other benefit will be on the basis of aptitude and ability. All employees will be helped and encouraged to develop their full potential and the talents and resources of the workforce will be fully utilised to maximise the efficiency of the organisation. No person shall be disadvantaged by conditions or requirements which cannot be shown to be justifiable.

The Forestry Commission also follows good employer practices aimed at ensuring that all staff work in an environment free from both illegal and unfair discrimination and harassment. Consolidated statements of the Commission's obligations with regard to equality of opportunity and diversity are shown in the Staff Handbook. Full details of these initiatives arising from our policies are also set out in the Human Resources intranet site.

The Forestry Commission will monitor the success of its policies by:

- Collecting and analysing data as appropriate.
- Regularly reviewing procedures (recruitment, performance management, promotion and pay) to ensure that they are free of unfair discrimination.
- Reporting the results of equality and diversity monitoring to the Human Resources Management Sub-Committee on an annual basis.
- Liaising closely with Cabinet Office and other Government Departments to ensure that we are keeping abreast of all changes in legislation and other developments.

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 from the Human Resources unit of the Forestry Commission.

13. Management

The Ministers who had responsibility for the Forestry Commission, including Forest Research, during the year were:

Rt. Hon. Margaret Beckett MP	*Secretary of State for the Department for Environment, Food and Rural Affairs*
Ben Bradshaw MP	*Parliamentary Under Secretary (Commons), Department for Environment, Food and Rural Affairs (until 12 May 2005)*
Jim Knight MP	*Parliamentary Under Secretary (Commons), Department for Environment, Food and Rural Affairs (from 13 May 2005)*

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

Jim Lynch	*Chief Executive*
Peter Freer-Smith	*Research Director*
Ken Charles	*Head of Human Resources and Administration*
Tony Cornwell	*Finance and IT Director*
Hugh Evans	*Head of Tree Health Division*
Sam Evans	*Head of Biometrics Division*
Bill Mason	*Head of Forest Management Division*
Andy Moffat	*Head of Environmental and Human Sciences Division*
Chris Quine	*Head of Ecology Division*
Xanthe Christophers	*Communications Director*

The Chief Executive is appointed on a fixed term basis following public advertising of the post. The term of the appointment, and provision for its termination, are governed by the Civil Service Commissioners' Recruitment Code.

Remuneration of board members who hold senior staff group posts is determined by the Forestry Commission's Senior Pay Committee in accordance with guidelines prescribed by the Cabinet Office. Other board members' remuneration is determined by the standard processes set out in the Forestry Commission's pay and grading system.

Further details on remuneration are set out in the Remuneration Report.

14. Pensions

Information on pensions is contained in the Remuneration Report and accounting policy note 1.14.

15. Auditors

These accounts are prepared in accordance with a direction given by the Treasury in pursuance of Section 7 of the Government Resources and Accounts Act 2000. They are audited by the Comptroller and Auditor General. The fee for statutory audit services in respect of these accounts was £22,500. No further assurance or other non-audit services were provided.

16. Disclosure of audit information to the auditors

So far as I am aware, there is no relevant audit information of which the Forest Research auditors are unaware. I have taken all the steps that I ought to have taken to make myself aware of any relevant audit information and to establish that the Forest Research auditors are aware of that information.

Professor J.M. Lynch
Chief Executive and Agency Accounting Officer
13 July 2006

Remuneration Report

Remuneration policy

Remuneration of board members who hold senior staff group posts is determined by the Forestry Commission's Senior Pay Committee in accordance with guidelines prescribed by the Cabinet Office. Details of membership of the Pay Committee are provided in the Remuneration Report of FC Great Britain/England. Other board members' remuneration is determined by the standard processes set out in the Forestry Commission's pay and grading system.

Employment contracts

The Chief Executive is appointed on a fixed term basis following public advertising of the post. The term of the appointment, and provision for its termination, are governed by the Civil Service Commissioners' Recruitment Code. Jim Lynch was appointed Chief Executive on 1 July 2003 on a five-year contract which expires on 30 June 2008.

Civil Service appointments are made in accordance with the Civil Service Commissioners' Recruitment Code, which requires appointment to be on merit on the basis of fair and open competition but also includes the circumstances when appointments may otherwise be made.

Other than the Chief Executive the senior staff covered in this report hold appointments which are open-ended until they reach the normal retiring age. Early termination, other than for misconduct, would result in the individual receiving compensation as set out in the Civil Service Compensation Scheme.

The performance of senior staff is monitored and reviewed through the appropriate Performance Monitoring System (PMS) of the Forestry Commission. No element of remuneration is specifically subject to performance conditions although pay progression can be affected and performance bonuses, if awarded, are based on remuneration.

Further information about the work of the Civil Service Commissioners can be found at www.civilservicecommissioners.gov.uk

Salary and pension entitlements

The salary and pension entitlements of the members of the Forest Research Executive Board were as follows.

	2005–06		2004–05	
	Salary £000	Benefits in kind (to the nearest £100)	Salary £000	Benefits in kind (to the nearest £100)
Jim Lynch	80–85	-	80–85	-
Peter Freer-Smith	65–70	2,000	60–65	1,600
Ken Charles	45–50	-	45–50	-
Tony Cornwell	45–50	-	40–45	-
Bill Mason	50–55	-	50–55	-
Sam Evans	45–50	-	40–45	-
Hugh Evans	55–60	1,300	55–60	300
Chris Quine	50–55	-	45–50	-
Andy Moffat	55–60	-	50–55	-
Xanthe Christophers (joined Board July 2005)	40–45	-	40–45	-

Salary

'Salary' includes basic salary, performance pay or bonus, overtime and any allowances subject to UK taxation.

Benefits in kind

The monetary value of benefits in kind covers any benefits provided by the employer and treated by the Inland Revenue as taxable income. They are in respect of the Car Provision for Employees Scheme.

Pension benefits

Name	Real increase in pension and related lump sum	Total accrued pension at age 60 and at 31/3/06 and related lump sum	CETV @ 31/3/05	CETV @ 31/3/06	Real increase in CETV after adjustment for inflation and changes in market investment factors	Employer contribution to partnership pension account including risk benefit cover
2005-06	£000	£000	£000	£000	£000	£
Jim Lynch	0–2.5	2.5–5	42	76	25	-
Peter Freer-Smith	0–2.5 plus 2.5–5.0 lump sum	17.5–20 plus 55–57.5 lump sum	248	340	21	-
Ken Charles	0–2.5 plus 0–2.5 lump sum	17.5–20 plus 57.5–60 lump sum	417	483	9	-
Tony Cornwell	0–2.5	5–7.5	75	100	14	-
Bill Mason	0–2.5 plus 2.5–5.0 lump sum	17.5–20 plus 55–57.5 lump sum	331	430	27	-
Sam Evans	0–2.5 plus 2.5–5.0 lump sum	5–7.5 plus 15–17.5 lump sum	54	86	12	-
Hugh Evans	0–2.5 plus 0–2.5 lump sum	22.5–25 plus 67.5–70 lump sum	407	512	13	-
Chris Quine	0–2.5 plus 2.5–5.0 lump sum	15–17.5 plus 47.5–50 lump sum	181	261	20	-
Andy Moffat	0–2.5 plus 2.5–5.0 lump sum	17.5–20 plus 52.5–55 lump sum	241	329	25	-
Xanthe Christophers	0–2.5	0–2.5	3	13	8	-

CETV: Cash Equivalent Transfer Value.

Civil Service Pensions

Pension benefits are provided through the Civil Service Pension arrangements. From 1 October 2002, civil servants may be in one of three statutory based 'final salary' defined benefit schemes (classic, premium and classic plus). The schemes are unfunded with the cost of benefits met by monies voted by Parliament each year. Pensions payable under classic, premium and classic plus are increased annually in line with changes in the Retail Prices Index. New entrants after 1 October 2002 may choose between membership of premium or joining a good quality 'money purchase' stakeholder arrangement with a significant employer contribution (partnership pension account).

Employee contributions are set at the rate of 1.5% of pensionable earnings for classic and 3.5% for premium and classic plus. Benefits in classic accrue at the rate of 1/80th of pensionable salary for each

year of service. In addition, a lump sum equivalent to three years' pension is payable on retirement. For premium, benefits accrue at the rate of 1/60th of final pensionable earnings for each year of service. Unlike classic, there is no automatic lump sum (but members may give up (commute) some of their pension to provide a lump sum). Classic plus is essentially a variation of premium, but with benefits in respect of service before 1 October 2002 calculated broadly as for classic.

The partnership pension account is a stakeholder pension arrangement. The employer makes a basic contribution of between 3% and 12.5% (depending on the age of the member) into a stakeholder pension product chosen by the employee from a selection of approved products. The employee does not have to contribute but where they do make contributions, the employer will match these up to a limit of 3% of pensionable salary (in addition to the employer's basic contribution). Employers also contribute a further 0.8% of pensionable salary to cover the cost of centrally provided risk benefit cover (death in service and ill health retirement).

Further details about the Civil Service pension arrangements can be found at the website www.civilservice-pensions.gov.uk

Cash Equivalent Transfer Values

A Cash Equivalent Transfer Value (CETV) is the actuarially assessed capitalised value of the pension scheme benefits accrued by a member at a particular point in time. The benefits valued are the member's accrued benefits and any contingent spouse's pension payable from the scheme. A CETV is a payment made by a pension scheme or arrangement to secure pension benefits in another pension scheme or arrangement when the member leaves a scheme and chooses to transfer the benefits accrued in their former scheme. The pension figures shown relate to the benefits that the individual has accrued as a consequence of their total membership of the pension scheme, not just their service in a senior capacity to which disclosure applies. The CETV figures, and from 2003–04 the other pension details, include the value of any pension benefit in another scheme or arrangement which the individual has transferred to the Civil Service Pension arrangements and for which the CS Vote has received a transfer payment commensurate with the additional pension liabilities being assumed. They also include any additional pension benefit accrued to the member as a result of their purchasing additional years of pension service in the scheme at their own cost. CETVs are calculated within the guidelines and framework prescribed by the Institute and Faculty of Actuaries.

Please note that the factors used to calculate the CETV were revised on 1 April 2005 on the advice of the Scheme Actuary. The CETV figure for 31 March 2005 has been restated using the new factors so that it is calculated on the same basis as the CETV figure for 31 March 2006.

Real increase in CETV

This reflects the increase in CETV effectively funded by the employer. It takes account of the increase in accrued pension due to inflation, contributions paid by the employee (including the value of any benefits transferred from another pension scheme or arrangement) and uses common market valuation factors for the start and end of the period.

Professor J.M. Lynch
Chief Executive and Agency Accounting Officer
13 July 2006

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

Under Section 7 of the Government Resources and Accounts Act 2000 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, recognised gains and losses 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, as set out in the *Financial reporting manual*, 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 Principal Accounting Officer, has designated the Chief Executive of Forest Research as the Accounting Officer for the Agency. His relevant responsibilities as Agency Accounting Officer, including his responsibility for the propriety and regularity of the public finances and for the keeping of proper records, and for safeguarding the Agency's assets, are set out in the Accounting Officers' Memorandum, issued by the Treasury and published in *Government accounting* (The Stationery Office).

Statement on Internal Control

1. Scope of responsibility

As Agency Accounting Officer, I have responsibility for maintaining a sound system of internal control that supports the achievement of Forest Research policies, aims and objectives, whilst safeguarding the public funds and departmental assets for which I am personally responsible, in accordance with the responsibilities assigned to me in *Government accounting*.

The Director General is the Deputy Chairman of the Forestry Commissioners and the senior official in the Forestry Commission. In addition to his role as a Commissioner, he is the Principal Accounting Officer, formally responsible to Parliament for the financial affairs of the Forestry Commission, including the Agency. In practice, the Director General's role in relation to the Agency is delegated to the Chief Executive as Agency Accounting Officer.

The Chief Executive of the Agency is responsible, normally through the Director General, to the Forestry Commissioners for the management of the Agency. The Chief Executive has a right of access to the Commissioners, and to Forestry Ministers, and will meet them at least once a year. The Director General designates the Chief Executive as Agency Accounting Officer, responsible for the Agency's accounts and financial procedures, and for the proper, effective and efficient use of resources provided to the Agency within the terms of the Framework Document and in pursuit of the agreed Corporate Plan objectives and targets. The Chief Executive is a member of the Forestry Commission's Executive Board.

In particular, the Chief Executive is responsible for:

- preparing the Agency's Corporate Plans and for achieving the targets set in them;
- appointment and organisation of the Agency's staff, and deployment of other resources to achieve the aims and objectives;
- maintaining financial and management information systems to assist in the monitoring and control of performance;
- preparing and submitting the Agency's Annual Report and Accounts;
- establishing and chairing an Agency Executive Board comprising senior managers within the Agency.

The Director General and Chief Executive are liable to be summoned to appear before the Public Accounts Committee to answer for their respective responsibilities. It will be for Ministers to decide who should represent them at other Parliamentary Committee hearings. In practice, where a Committee's interest is confined to the day-to-day operations of the Agency, Ministers will normally regard the Chief Executive as the person best placed to appear on their behalf.

2. The purpose of the system of internal control

The system of internal control is designed to manage risk to a reasonable level rather than to eliminate all risk of failure to achieve policies, aims and objectives; it can therefore only provide reasonable and not absolute assurance of effectiveness. The system of internal control is based on an ongoing process designed to identify and prioritise the risks to the achievement of the Agency's policies, aims and objectives, to evaluate the likelihood of those risks being realised and the impact should they be realised, and to manage them efficiently, effectively and economically. The system of internal control has been in place in the Agency for the year ended 31 March 2006 and up to the date of approval of the Annual Report and Accounts, and accords with Treasury guidance.

3. Capacity to handle risk

The Agency has taken a positive approach to risk management, which it feels is entirely appropriate to its role and remit. Risk management is the responsibility of every member of staff in Forest Research. Everyone has a role to play in managing the risks within their own area of authority. Risk awareness and responsibility lies in parallel with the structure of Forest Research's objectives. At every level of objective there is an equivalent delegation of responsibility of associated risk.

The resources available for managing risk are finite and so the aim is to achieve an optimum response to risk, prioritised in accordance with the evaluation of risk. The system of internal control incorporates risk management. The system encompasses a number of elements that together facilitate an effective and efficient operation, enabling Forest Research to respond to a variety of operational, financial and commercial risks. These elements include:

- Policies set by the Board of Commissioners and the Forest Research Executive Board. Written procedures support the policies where appropriate.
- Comprehensive regular reporting to the Executive Board designed to monitor key risks and their controls. Decisions to rectify problems are made at their regular meetings.
- Planning and budgeting system used to set objectives, agree action plans and allocate resources. Progress towards meeting plan objectives is monitored regularly.

The Forestry Commission has a departmental Risk Improvement Manager who chairs a Risk Management Group comprising a risk champion from each part of the organisation and an Internal Audit representative. During the year, the Finance Director of Forest Research has acted as risk champion for the Agency, including responsibility for maintenance and enhancement of the risk register.

4. The risk and control framework

Forest Research is committed to a process of continuous development and improvement: developing systems in response to any relevant reviews and developments in best practice in this area. In particular, in the period covering the year to 31 March 2006 and up to the signing of the accounts Forest Research has:

- Attended a risk management workshop conducted by a private sector expert.
- Participated in the Commission-wide Risk Management Group (RMG), whose purpose is to ensure continued development of risk management within, and sharing of best practice across, the Commission.
- Implemented the revised Forestry Commission risk policy statement presented to the Forestry Commission Executive Board in February 2005.
- Continued to update the Agency risk register in consultation with Heads of Division in preparation for cascading specific responsibilities throughout the Agency.
- Supported the purchase and development of a commercial risk management software package.

The size and membership of the Forestry Commission Audit Committee is designed to represent all parts of the Forestry Commission. The Chief Executive of Forest Research is a member of the Committee which met three times during the year, in April, July and December 2005, to consider a range of reports from management, internal audit and external audit. As part of the governance framework, the Board of Commissioners received oral reports from the Committee Chair on business during the year and a more formal annual report on the discharge of its duties in June 2006.

The Audit Committee, in the main, deals with higher level issues concerning control and governance. The Agency Chief Executive was provided with more detailed advice on the work of Internal Audit in particular, and control in general, via the Agency's Internal Control Committee (ICC).

The ICC's objectives are:

- to provide a forum for senior management to discuss internal control and audit matters;
- to promote understanding of the internal audit role and objectives;
- to assist the Head of Internal Audit in defining the scope of audit coverage and assessing priorities.

The Committee met twice during the year, in November 2005 and March 2006, to receive reports on internal audit activity, risk management and feedback on the work of the Audit Committee.

5. Review of effectiveness

As Agency Accounting Officer, I have responsibility for reviewing the effectiveness of the system of internal control. My review of the effectiveness of the system of internal control is informed by the work of the internal auditors and the executive managers within the Agency who have responsibility for the development and maintenance of the internal control framework, and comments made by the external auditors in their management letter and other reports. I have been advised on the implications of the result of my review of the effectiveness of the system of internal control by the Executive Board, the Audit Committee and the ICC and a plan to address weaknesses and ensure continuous improvement of the system is in place.

The Head of Internal Audit has prepared an annual report and assurance statement to me as the Agency Accounting Officer. The report includes an overall assessment of the adequacy and effectiveness of risk management, control and governance within the Agency. The Director General as Principal Accounting Officer has received a similar report and assurance statement including any comments specific to the Great Britain core responsibilities. The overall opinion is that internal control within Forest Research continues to provide substantial assurance that material risks to the achievement of objectives are adequately managed.

A review of the structure, interactions and functioning of the Forestry Commission's corporate governance framework was undertaken during 2005-06 by Internal Audit and the Corporate and Forestry Support Division. It covered the decision-making bodies at both Great Britain level and within countries and agencies. During the review, Internal Audit referred to two best practice guides, the draft Code of Good Practice on corporate governance in government departments and the CMPS Toolkit on maximising board effectiveness. The Forestry Commission's Executive Board will now consider the recommendations before proposing changes for approval by the Board of Commissioners. A separate review will be undertaken of the structure, relationship and work of the Audit Committee and ICCs during 2006–07.

Forest Research implemented an internal reorganisation of the Agency's management structure in July 2004 with consequential appointments of new Heads of Division, a revised Research Strategy, and preparation for implementation of a formal quality assurance scheme. During 2005–06, the ongoing work included updating management responsibility for risk to fully incorporate the new Heads of Division, where appropriate and the appointment of a full-time Quality Assurance Manager to take forward the Agency's QA objectives. Under present arrangements, I rely on the organisational structure for managing risk with clear responsibilities at every level supported by a Risk Management Group whose role is to assist in the development of good risk management practice throughout the Forestry Commission. During 2006–07, the Agency will introduce a framework of Certificates of Assurance to further support my review of effectiveness of the system of internal control.

6. Significant internal control problems

None were identified during the year.

Professor J.M. Lynch
Chief Executive and Agency Accounting Officer
13 July 2006

Forest Research Agency

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

I certify that I have audited the financial statement of the Forest Research Agency for the year ended 31 March 2006 under the Government Resources and Accounts Act 2000. These comprise the Income and Expenditure Account and Statement of Total Recognised Gains and Losses, the Balance Sheet, the Cashflow Statement and the related notes. These financial statements have been prepared under the accounting policies set out within them.

Respective responsibilities of the Agency, the Chief Executive and Auditor

The Agency and Chief Executive are responsible for preparing the Annual Report and the financial statements in accordance with the Government Resources and Accounts Act 2000 and HM Treasury directions made thereunder and for ensuring the regularity of financial transactions. These responsibilities are set out in the Statement of Accounting Officer's Responsibilities.

My responsibility is to audit the financial statements in accordance with relevant legal and regulatory requirements, and with International Standards on Auditing (UK and Ireland).

I report to you my opinion as to whether the financial statements give a true and fair view and whether the Financial Statements and the part of the Remuneration Report to be audited have been properly prepared in accordance with HM Treasury directions issued under the Government Resources and Accounts Act 2000. I also report 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 to you if, in my opinion, the Annual Report is not consistent with the financial statements, if the Agency has not kept proper accounting records, if I have not received all the information and explanations I require for my audit, or if information specified by relevant authorities regarding remuneration and other transactions is not disclosed.

I review whether the statement on pages 81–83 reflects the Agency's compliance with HM Treasury's guidance on the Statement on Internal Control, and I report if it does not. I am not required to consider whether the Accounting Officer's statements on internal control cover all risks and controls, or to form an opinion on the effectiveness of the Agency's corporate governance procedures or its risk and control procedures.

I read the other information contained in the Annual Report and consider whether it is consistent with the audited financial statements. This other information comprises only the Annual Report, the unaudited part of the Remuneration Report and the Management Commentary. I consider the implications for my report if I become aware of any apparent misstatements or material inconsistencies with the financial statements. My responsibilities do not extend to any other information.

Basis of audit opinion

I conducted my audit in accordance with United Kingdom Auditing Standards on Auditing (UK and Ireland) issued by the Auditing Practices Board. My audit includes examination, on a test basis, of evidence relevant to the amounts, disclosures and regularity of financial transactions included in the financial statements and the part of the Remuneration Report to be audited. 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 most 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 which 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, in accordance with the Government Resources and Accounts Act 2000 and directions made thereunder by HM Treasury, of the state of the Agency's affairs as at 31 March 2006 and of the deficit, total recognised gains and losses and cashflows for the year then ended;
- the financial statements and the part of the Remuneration Report to be audited have been properly prepared in accordance with HM Treasury directions issued under the Government Resources and Accounts Act 2000; 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 July 2006
National Audit Office
157–197 Buckingham Palace Road
Victoria
London SW1W 9SP

Income and Expenditure Account for the year ended 31 March 2006

	Notes	2005–06 £000	2004–05 £000
Income			
Income from research, development and survey services			
Forestry Commission customers	2	**12,348**	11,489
Non-Forestry Commission Customers			
European Union		**998**	1,133
Other		**1,015**	980
Total income		**14,361**	13,602
Expenditure			
Staff costs	3	**8,915**	8,399
Other management costs	4	**2,298**	2,210
Materials and services	5	**2,688**	2,611
Total expenditure		**13,901**	13,220
Net operating surplus/(deficit)		**460**	382
Exceptional item – provision for restructuring costs	17	**(369)**	–
Notional cost of capital	8	**(441)**	(409)
Net (deficit) for the year		**(350)**	(27)
Net (deficit) transferred to General Fund		**(350)**	(27)

Statement of Total Recognised Gains and Losses for the year ended 31 March 2006

	2005–06 £000	2004–05 £000
Net (deficit) for the year	**(350)**	(27)
Revaluation surplus for the year	**744**	404
Total recognised gains/(losses)	**394**	377

The notes on pages 89 to 100 form part of these accounts.

Balance Sheet as at 31 March 2006

	Notes	2005–06 £000	2004–05 £000
Fixed assets			
Tangible assets	6	**11,607**	11,114
Intangible assets	7	**107**	50
		11,714	11,164
Current assets			
Stocks and Work in Progress	9	**1,286**	462
Debtors	10	**750**	1,406
Cash at banks and in hand	11	**227**	548
		2,263	2,416
Creditors – amounts falling due within one year	12	**(443)**	(609)
Net current assets		**1,820**	1,807
Total assets less current liabilities		**13,534**	12,971
Provisions for liabilities and charges	13 & 17	**(443)**	(78)
		13,091	12,893
Taxpayers' Equity			
General Fund	14	**7,345**	7,852
Revaluation Reserve	15	**5,746**	5,041
		13,091	12,893

Professor J.M. Lynch
Chief Executive and Agency Accounting Officer
13 July 2006

The notes on pages 89 to 100 form part of these accounts.

Cash Flow Statement for the year ended 31 March 2006

	Notes	2005–06 £000	2004–05 £000
Net cash inflow/(outflow) from operating activities	16a	**706**	(11)
Capital expenditure	16b	**(489)**	(360)
Net cash surplus		**217**	(371)
Financing – net cash transfer (to)/from Forestry Commission		**(538)**	407
(Decrease)/Increase in cash in the period		**(321)**	36

The notes on pages 89 to 100 form part of these accounts.

Notes to the Accounts

Note 1. Accounting Policies

1.1 Form of Accounts

In accordance with Section 7 of the Government Resources and Accounts Act 2000, the accounts are drawn up in a format agreed and approved by Treasury. They are prepared in accordance with the *Government financial reporting manual* (FReM) issued by HM Treasury for 2005–06 accounts, under the historical cost convention modified by the inclusion of the valuation of assets.

The accounting policies contained in the FReM follow UK Generally Accepted Accounting Practice for companies (UK GAAP) to the extent that it is meaningful and appropriate to the public sector.

The particular accounting policies adopted by the Agency are described below. They have been applied consistently in dealing with items considered material in relation to the accounts.

1.2 Tangible 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.

Staff payroll costs and expenditure on materials, consumables, etc., of systems development software, for general use within the Agency, are recognised as tangible fixed assets. There was no relevant in-house development activity in the year 2005–06.

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.

1.3 Valuation of Assets

In accordance with UK GAAP, professional valuation of non-forest land and buildings shall be undertaken on a five-yearly basis with a formal review in the third year. The first five-yearly valuation shall be undertaken at 31 March 2008.

In 2004–05, professionally qualified staff employed by the Commission carried out a review into the use of the indices provided by the District Valuer. The review concluded that the use of the indices provided a reasonable restatement of the current value of non-forest land and buildings. The indices were therefore used to restate values as at 31 March 2006 and shall be used in each year until the professional valuation at 31 March 2008.

Other tangible and intangible fixed assets are revalued annually using a range of appropriate indices as provided by the Office for National Statistics.

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

1.4 Depreciation

Freehold land is not depreciated.

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

Freehold buildings – 20 to 80 years.

Scientific equipment – 6.5 to 20 years.

IT hardware – 3 to 10 years.

Other machinery and equipment – 10 to 20 years.

1.5 Intangible Fixed Assets

Purchases of software with an acquisition value of £1500 are recognised as intangible fixed assets and amortised over their expected useful lives to a maximum of seven years. Software purchases with an acquisition value of less than £1500 are also treated as intangible fixed assets, on a pooled asset basis, the amount being material.

1.6 Stocks and Work in Progress

Work 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.

1.7 Provision for Bad and Doubtful Debts

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

1.8 Research and Development

As a provider of research services, all income and expenditure on research and development is written off to the Income and Expenditure Account.

1.9 Cost of Capital Charges

Charges, representing the cost of capital utilised by the Agency, are identified on the Income and Expenditure Account. The charge is calculated at the Government's standard rate of 3.5% in real terms on the average carrying amount of all assets, except for cash balances, less liabilities.

1.10 Corporation Tax

Forest Research is not subject to corporation tax.

1.11 Value Added Tax

The Forestry Commission is registered for Value Added Tax (VAT) and accounts for it on a Great Britain basis, including any Agency activity. Income and expenditure shown in the accounts is net of any recoverable VAT. Non-recoverable VAT is charged to the accounts in the year in which it is incurred.

1.12 Foreign Currencies

Transactions in foreign currencies are recorded at the rate ruling at the time of the transaction. Monetary assets and liabilities denominated in foreign currencies at the balance sheet date are translated at the rates ruling at that date. Translation differences are recorded in the Income and Expenditure account.

1.13 Insurance

In accordance with normal Government accounting practice, the Forestry Commission carries its own insurance risks.

1.14 Pensions

Past and present employees are covered by the provisions of the Principal Civil Service Pension Scheme (PCSPS), which is non-contributory and unfunded. The Forestry Commission recognises the expected cost of providing pensions on a systematic and rational basis over the period during which it accrues benefits from employees' services by payment to the PCSPS of amounts calculated on an accruing basis. Liability for payment of future benefits is a charge on the PCSPS. Further information on pensions is contained in the Remuneration report and note 3 to the accounts.

1.15 Provisions

Forest Research provides for legal or constructive obligations which are of uncertain timing or amount at the balance sheet date on the basis of the best estimate or the expenditure required to settle the obligation. Where the effect of the time value of money is significant, the estimated risk-adjusted cash flows are discounted using the real rate set by HM Treasury (currently 2.2%).

1.16 Third Party Assets

Forest Research acts as co-ordinator for a number of projects partially funded by the European Commission. The duties of co-ordinators include receiving funds on behalf of partners for onward transmission once work programmes have been approved. These Third Party Assets, which neither the Agency or government more generally has a direct beneficial interest in, are not recognised in the accounts.

Note 2. Income from Forestry Commission and Forest Enterprise

2.1 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 £10.6 million not including other *ad hoc* or unplanned projects. 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 and other parts of the Forestry Commission on a full cost recovery basis.

Income from Forestry Commission customers consisted of:

	2005–06	2004–05
	£000	£000
Research, development and other services to:		
Forestry Commission	**11,185**	10,432
Forest Enterprise	**1,163**	1,057
	12,348	11,489

Note 3. Staff Costs and Numbers

3.1 Employee costs during the year amounted to:

	2005–06	2004–05
	£000	£000
Wages and Salaries	**7,090**	6,955
Social Security Costs	**547**	539
Employer's Superannuation Costs	**1,277**	904
Agency Staff Costs	**1**	1
	8,915	8,399

Average number of employees (full-time equivalents)

2005–06	2004–05
287	278

Staff were covered by the Principal Civil Service Pension Scheme (PCSPS) which is an unfunded multi-employer defined benefit pension scheme but the Forestry Commission is unable to identify its share of the underlying assets and liabilities. The scheme actuary valued the scheme as at 31 March 2003. Details can be found in the resource accounts of the Cabinet Office: Civil Superannuation (www.civilservice-pensions.gov.uk).

For 2005–06, employers contributions of £1,277,000 were payable to the PCSPS (2004–05: £904,000) at one of four rates in the range 16.2% to 24.6% (2004–05: 12% to 18.5%) of pensionable pay, based on salary bands. The scheme actuary reviews employer contributions every four years following a full scheme valuation. From 2006–07 the salary bands will be revised and the rate will be in a range between 17.1% and 25.5%. The contribution rates reflect benefits accruing during 2005–06 to be paid to the member when they retire and not the benefits paid during this period to existing pensioners.

Employees can opt to open a partnership pension account, a stakeholder pension with an employer contribution. No Agency staff have yet taken this option.

3.2 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 loans with an outstanding balance of £2,500 or more to seven individual members of staff at 31 March 2006. The total outstanding value of all loans was £51,718.24.

Note 4. Other Management Costs

	2005–06	2004–05
	£000	£000
Auditors' remuneration	**22**	22
Travel and subsistence	**533**	468
Staff transfer expenses	**71**	15
Training	**153**	131
Building maintenance	**394**	411
Utilities	**325**	251
Computer supplies	**92**	85
Early retirement/departure costs	**25**	135
Employer liability provisions and payments	**–**	55
Depreciation of fixed assets	**571**	518
Loss on disposal of fixed assets	**11**	–
Other expenditure	**101**	119
	2,298	2,210

Included within Other Management Costs are charges from the Forestry Commission and Forest Enterprise amounting in total to £118,000 (2004–05: £116,000).

Note 5. Materials and Services

	2005–06	2004–05
	£000	£000
Materials and supplies	**784**	800
Central services from Forestry Commission	**697**	722
Vehicle lease charges from Forestry Commission	**418**	401
Contractors	**368**	335
Commissioned research	**182**	147
Publications	**29**	44
Protective clothing	**25**	20
Miscellaneous expenditure	**185**	142
	2,688	2,611

Included within Materials and Services are charges from the Forestry Commission and Forest Enterprise amounting in total to £1,115,000 (2004–05: £1,123,000).

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

Note 6. Tangible Fixed Assets

	Freehold Land and Buildings	Scientific Equipment	IT Equipment	Other Machinery and Equipment	Total
	£000	£000	£000	£000	£000
Valuation:					
At 1 April 2005	**10,096**	**2,094**	**798**	**1,206**	**14,194**
Additions	70	139	148	52	409
Disposals	–	(476)	(83)	(625)	(1,184)
Transfers (note 14)	(117)	–	–	13	(104)
Revaluation	814	4	(35)	3	786
At 31 March 2006	**10,863**	**1,761**	**828**	**649**	**14,101**
Depreciation:					
At 1 April 2005	**562**	**1,304**	**417**	**797**	**3,080**
Provided in year	215	123	184	30	552
Disposals	–	(475)	(83)	(615)	(1,173)
Transfers (note 14)	(8)	–	–	9	(1)
Revaluation	43	2	(14)	3	34
At 31 March 2006	**812**	**954**	**504**	**224**	**2,494**
Net book value:					
At 31 March 2006	10,051	807	324	425	11,607
At 31 March 2005	9,534	790	381	409	11,114

Fixed assets were revalued as at 31 March 2006 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 £6.9 million and £3.0 million respectively at 31 March 2006.

Note 7. Intangible Fixed Assets

	2005–06	2004–05
	£000	£000
Valuation		
Balance at 1 April	**59**	36
Additions	**84**	23
Revaluation	**(8)**	–
As at 31 March	**135**	59
Amortisation		
Opening balance	**9**	–
Depreciation in year	**19**	9
Revaluation	**–**	–
As at 31 March	**28**	9
Net book value	**107**	50

Intangible fixed assets relate wholly to purchased software.

Note 8. Cost of Capital

Notional cost of capital based on 3.5% of average total assets, excluding bank balances, less current liabilities employed in 2005–06 amounted to £441,147 (2004–05: £409,421).

Note 9. Stocks and Work in Progress

	2005–06	2004–05
	£000	£000
Research Work in Progress	**1,286**	462
	1,286	462

Note 10. Debtors

	2005–06	2004–05
	£000	£000
Amounts falling due within one year		
EU debtors	**297**	906
Other Trade debtors	**228**	251
Other debtors	**23**	26
Prepayments	**170**	201
	718	1,384
Amounts falling due after one year		
House purchase loans	**32**	22
	750	1,406

Note 11. Cash at banks and in hand

The following balances at 31 March are held at commercial banks and cash in hand

	2005–06	2004–05
	£000	£000
Opening balance at 1 April	**548**	512
Net change in balances	**(321)**	36
Balance at 31 March	**227**	548

As part of its normal activities Forest Research maintains Sterling and Euro bank accounts primarily used for the receipt of income from non-Forestry Commission customers. These accounts are cleared to the Commission's main account on a regular basis. Sums held in these accounts on behalf of partners in European Commission projects are treated as third party assets and not included in the balances shown (see note 1.16).

Note 12. Creditors: amounts falling due within one year

	2005–06	2004–05
	£000	£000
Payments received on account	**50**	297
Trade creditors	**382**	311
Other creditors including taxation and social security costs	**11**	1
	443	609

Funds held on behalf of partners in European Commission projects are treated as third party assets and not recorded on the face of the accounts (see note 1.16). At 31 March 2006 the amount held in Forest Research Bank accounts on behalf of partners was £26,500.81, which was subsequently paid over (31 March 2005: £345,791.36).

Note 13. Provisions for Liabilities

	2005–06	2004–05
	£000	£000
Employer liability claims		
Balance brought forward	**–**	150
Utilised in year	**–**	(150)
Provided in year	**–**	–
Balance carried forward	**–**	–
Early departure costs		
Balance brought forward	**78**	–
Provided in year	**379**	94
Utilised in year	**(19)**	(5)
Unwinding of discount	**5**	(11)
Balance carried forward	**443**	78

Note 14. General Fund

	2005–06	2004–05
	£000	£000
Balance brought forward	**7,852**	6,926
Transfer from revaluation reserve – disposed assets	**–**	–
Movement in year		
Retained surplus	**39**	–
Net (deficit) for year	**(350)**	(27)
Transfer of fixed assets to(-)/from other Forestry Bodies	**(106)**	113
Cash surplus to(-)/deficit from Forestry Commission	**(538)**	407
Non-cash inter-country transfers	**7**	24
Notional cost of capital	**441**	409
Balance carried forward	**7,345**	7,852

Transfers of fixed assets from other parts of the Forestry Commission were buildings at Cairnbaan.

Note 15. Revaluation Reserve

	2005–06	2004–05
	£000	£000
Balance brought forward	**5,041**	4,637
Retained surplus	**(39)**	–
Revaluation surplus/(deficit) for the year ended 31 March 2006		
Land and Buildings	**771**	395
IT, Scientific and other machinery and equipment	**(19)**	9
Intangible assets	**(8)**	–
Balance carried forward	**5,746**	5,041

Note 16. Note to the Cash Flow Statement

16a. Reconciliation of operating cost to operating cash flows

	2005–06	2004–05
	£000	£000
Net (deficit) for the year	**(350)**	(27)
Notional cost of capital	**441**	409
Depreciation	**571**	518
Loss/(profit) on disposal of assets	**11**	–
(Increase)/Decrease in stocks and work in progress	**(825)**	74
Decrease/(Increase) in debtors	**655**	(793)
(Decrease)/Increase in creditors	**(169)**	(144)
Increase/(Decrease) in provisions	**365**	(72)
Non-cash inter-country transfers	**7**	24
Net cash inflow/(outflow) from operations	**706**	(11)

16b. Analysis of capital expenditure

	2005–06	2004–05
	£000	£000
Tangible fixed assets	**405**	337
Intangible fixed assets	**84**	23
Total cash expenditure on fixed assets	**489**	360

Note 17. Exceptional Items: provision for early retirement/redundancy costs

A provision has been made at 31 March 2006 in respect of plans to restructure the Agency's Technical Support Unit, which will involve a number of early retirements and redundancies. Implementation will begin during 2006–07. This provision has been recognised as an exceptional item in the Income and Expenditure Account and as a liability in the Balance Sheet. In year expenditure, together with ongoing commitments to staff taking early retirement, is expected to cost £369,000 at current (2005–06) prices. This will be funded from the Agency's own resources. In subsequent years net savings of more than £200,000 a year will be achieved.

Note 18. Related Party Transactions

During the year, Forest Research has had a significant number of material transactions with the Forestry Commission and Forest Enterprise country agencies 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 Trade and Industry and the Department for Environment, Food and Rural Affairs.

Professor Jim Lynch, Chief Executive, is Distinguished Professor of Life Sciences at the University of Surrey. The value of payments to the University for services provided in the year to 31 March 2006 was £48,260. Sam Evans and Peter Freer-Smith hold visiting professorships at the Universities of Sheffield and Southampton respectively, with which £11,855 and £7,000 was spent on research services. Other members of staff hold professorships at UK and foreign universities but no financial transactions took place with these in 2005-06.

Note 19. Losses Statement

Losses totalled £4,000 from 1 case (2004–05: £4,230 from 1 case). Special payments totalled £11,591.45 from 14 cases (2004–05: £12,268 from 14 cases).

Note 20. Financial Instruments

FRS 13: *Derivatives and other financial instruments* requires disclosure of the role which financial instruments have had during the period in creating or changing the risks an entity faces in undertaking its activities. Because of the way in which government departments are financed, the Agency is not exposed to the degree of financial risk faced by business entities. Moreover, financial instruments play a much more limited role in creating or changing risk than would be typical of the listed companies to which FRS 13 mainly applies. The Agency has no powers to borrow or invest surplus funds and financial assets and liabilities are generated by day-to-day operational activities and are held not to change the risks facing the Agency in undertaking its activities.

Liquidity risk

The Agency is not exposed to significant liquidity risks because its net revenue and capital resource requirements are financed by resources voted annually by the UK Parliament.

Interest rate risk

The Agency is not exposed to interest rate risk.

Foreign currency risk

The Agency has commercial relations with foreign customers and the European Commission, having dealings in foreign currencies and the Euro as well as Sterling. The treatment of gains and losses arising from transactions in foreign currencies is described at note 1.12 to the accounts. The Agency is therefore exposed to foreign currency risk, but the risk is not significant with income from these sources being no more than 9% of the Agency's total income.

Note 21. Financial Performance Measures

The Agency's net deficit after making provision for the early retirement and redundancy costs of restructuring was £350,000. Financial performance from normal operating activity achieved an operating surplus of £460,000, which, after allowing for the cost of capital, and before exceptional items, represented a cost recovery of 100.1% (2004–05: 99.8%).

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Contact addresses

Forest Research
Alice Holt Lodge
Farnham
Surrey GU10 4LH
Tel: 01420 22255
Fax: 01420 23653
E-mail: research.info@forestry.gsi.gov.uk

Forest Research
Nothern Research Station
Roslin, Midlothian EH25 9SY
Tel: 0131 445 2176
Fax: 0131 445 5124
E-mail: research.info@forestry.gsi.gov.uk

Technical Development
Forest Research
Ae Village, Dumfries
DG1 1QB
Tel: 01387 860264
Fax: 01387 860386
E-mail: research.info@forestry.gsi.gov.uk

Website
www.forestresearch.gov.uk

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Forest Research

Alice Holt Lodge
Farnham
Surrey GU10 4LH
Tel: 01420 22255
Fax: 01420 23653

Northern Research Station
Roslin
Midlothian EH25 9SY
Tel: 0131 445 2176
Fax: 0131 445 5124

www.forestresearch.gov.uk

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