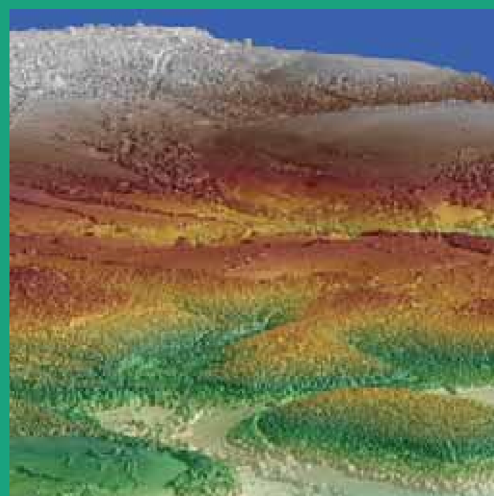
Biometrics, Surveys and Statistics

For Britain's woodlands to contribute effectively on today's key issues – climate change, biodiversity, economic viability and social value – we must know their size, location and properties. Our experts map and survey woodlands, develop models to predict their growth and potential commercial products, and write computer software for forest managers and policy-makers. We also provide essential help on statistics, database management, software development and geographic information systems.



Modelling rainfall interception

The leaves, branches and trunks of trees all catch rainfall. In heavy or prolonged rain this intercepted rainfall then falls off or runs down the trunk to the ground, whereas on showery days some of it may evaporate and never reach the ground. Rainfall interception influences many different processes and will become increasingly important as rainfall patterns alter due to climate change. For example, more direct evaporation might worsen water shortages.

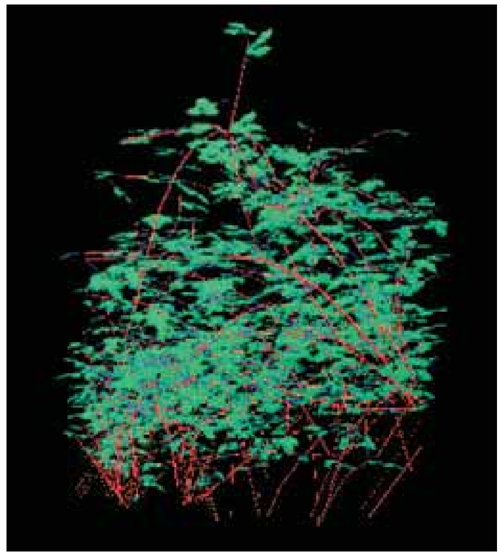
We compared ways of measuring and modelling canopy rainfall interception. After collecting detailed data for one broadleaved and one conifer species, we adapted an existing computer model and used it to investigate different time periods. For whole seasons, the model was very effective at estimating the different interception components for both species. However, at shorter timescales there was greater disparity between simulation and measurements; further research is under way to evaluate the reasons for this and improve the model. For more information, visit **www.forestresearch.gov.uk/rainfallinterception**

Developing tools for remote sensing

Remote sensing covers a range of techniques for obtaining information about forests without making measurements on the ground. Sensors are carried on planes or satellites and nowadays provide digital images rather than the photographs common just five years ago. Remote sensing in forestry is gaining acceptance as a way of providing information quickly and cheaply. Current applications include software to detect canopy changes (e.g. for monitoring illegal felling), and Light Detection and Ranging (LiDAR) to measure stands and produce thematic maps.

We recently used remote sensing to find aspen trees, a beautiful but rare feature of the Caledonian Forest. Aerial colour images were taken in late spring when most broadleaves were in leaf but aspen had yet to burst bud and was therefore more easily differentiated from surrounding species. Specialist software was then applied to the images (below), which identified and located 87% of the aspen. This technique is much faster and less expensive than field surveys, and we hope that further work will increase its accuracy.

Photography by Caledonian Air Surveys Ltd



Assessing plant architecture

A plant's success depends on its ability to capture light through its leaves and convert it to biomass through photosynthesis. Therefore, the way the leaves are arranged within the crown of a tree will affect the tree's success. Forest Research has been using geometric models to investigate these architectural arrangements in order to improve understanding of how the crown functions.

Using a three-dimensional digitiser linked to tracing software, we constructed virtual images of forest species. In one example, we analysed bramble canopies (see right: virtual image and original). Once the structure could be described digitally, it was possible to work out how much light was available for the growth of each layer of plants, as well as the amount of light reaching the ground below. This research is particularly valuable as forest managers move towards regenerating woodlands using natural processes, where an understanding of canopy architecture is important for managing seedling regeneration in the face of other competing ground vegetation.

Applying statistics to research

How can you tell which results are significant, and which are most likely due to chance? Forest Research statisticians aim to help our researchers do this across a range of scales, from fungal fruiting bodies observed through a microscope, to sampling schemes for all British forests.

Our statisticians model data on damage by pine weevils and summarise information about who walks in our forests, and the activities of squirrels, deer and capercaillie. We analyse data on the growth and quality of trees, and the vegetation that grows under the trees.

Each of these varied applications requires a different approach that reflects the type and amount of data involved, as well as the research objectives and the science itself. This is achieved by selecting the right tools from the ever-expanding toolkit of modern statistical computer packages, modifying them when appropriate.

Making the most of our data

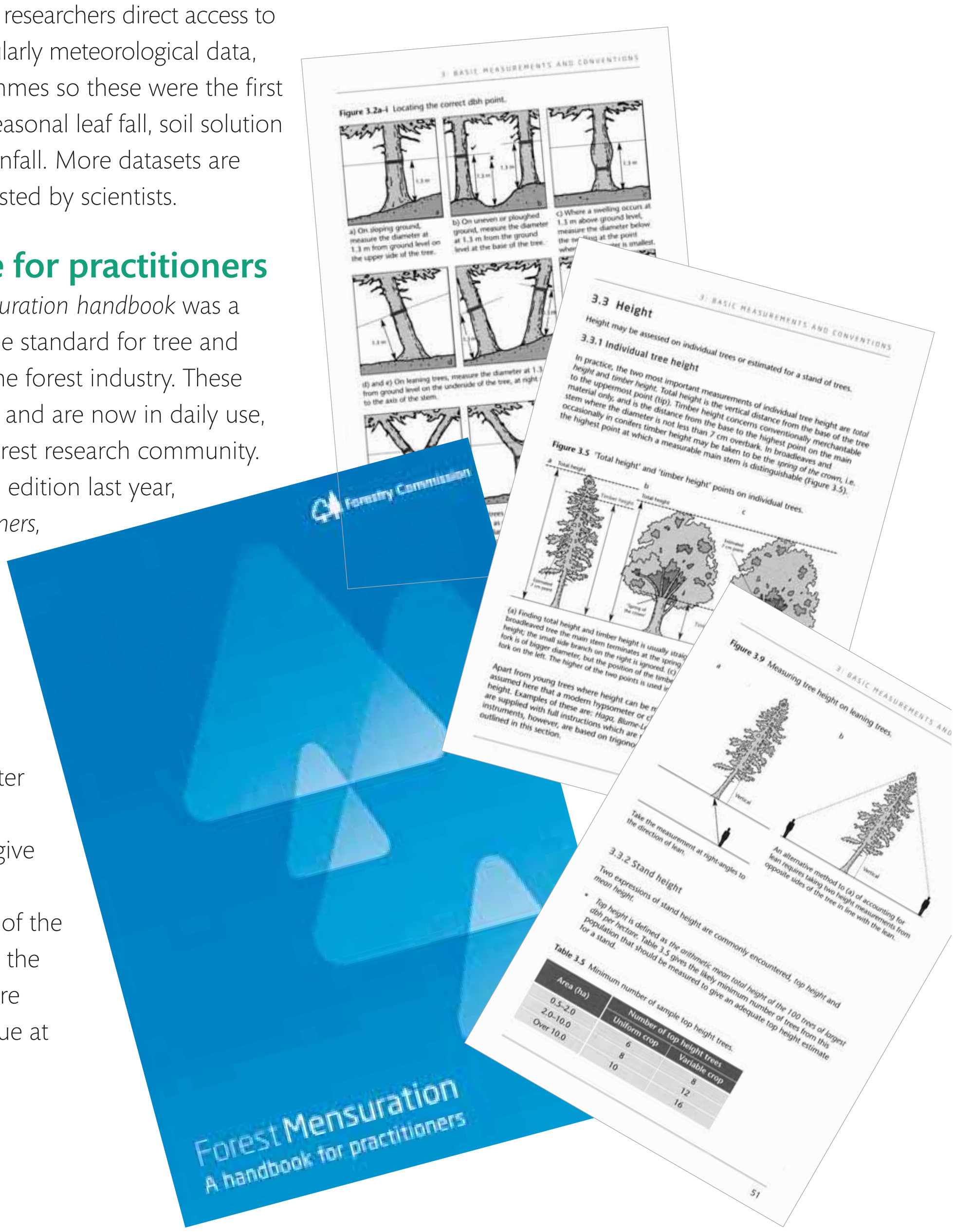
Knowledge-based organisations rely on good data management. Many of the programmes at Forest Research produce datasets of interest to other fields of research. For example, long-term monitoring projects and very intensively monitored plantation forests provide key datasets that allow us to investigate the effects of long-term environmental changes, including climate changes. Our main datasets are held in an Oracle database and managed by our central Data Centre.

To make this information more readily available to all our researchers, we are developing an intranet interface to allow researchers direct access to the Data Centre. Environmental data, particularly meteorological data, are most often requested by other programmes so these were the first to be made available, along with data on seasonal leaf fall, soil solution and deposition of chemical elements in rainfall. More datasets are being made available all the time, as requested by scientists.

Providing essential guidance for practitioners

The first publication in 1975 of *Forest mensuration handbook* was a landmark in British forestry. It literally set the standard for tree and timber measurement procedures used in the forest industry. These procedures gained widespread acceptance and are now in daily use, both in the timber trade and among the forest research community. Nearly 30 years on, we produced a second edition last year, *Forest mensuration: a handbook for practitioners*, which has proved so popular that it has already been reprinted this year.

The most notable changes in the second edition are on procedures for assessing standing volume of timber – i.e. judging how much usable timber a tree will give after felling. The section on assessment of wood quantity by weight has been expanded to give more prescriptive guidance. There are also many other improvements and the format of the book has been revised to help readers find the information they need more easily. For more details, see our online publications catalogue at **www.forestry.gov.uk/publications**



The second National Inventory of Woodland and Trees

Mark Lawrence and Helen McKay

Woodland is important to many types of user – the public, policy makers and the forest industry. Forest Research is responsible for collecting information on the amount, location and condition of British woodland and trees, by mapping and then surveying them.

In prehistoric times Britain was largely covered with woodland but, by the end of the 19th century, woodland had decreased to less than 5% of land area. The last major survey indicated that, by the end of the 20th century, woodland cover had increased to almost 12% (2.7 million hectares). The next major survey, the second National Inventory of Woodland and Trees (NIWT2), is now underway and has four elements.

First, the baseline map of main woodland blocks is being created. Main woodland is defined as woodland of half a hectare or more, with at least 20% canopy cover or the potential to achieve 20% cover. Woodland areas are divided into Interpreted Forest Types, such as Conifer, and Interpreted Open Areas, such as Grass (Figure 1). The mapping is being carried out by Infoterra and quality-assured by Forest Research; it should be completed by autumn 2009. Up to March 2008, almost one million hectares of woodland had been mapped and quality assured.

Second, a pilot survey will be carried out during 2008–09 to ascertain the timing and costs of measuring the field data required by Scotland, Wales and England, and for international reporting. This will allow Forest Research to finalise the list of woodland properties to be assessed, given the available budget. The pilot exercise will collect data on tree numbers and sizes, woodland structure and management, deadwood, soils, vegetation and veteran trees.

The third element is the full survey of main woodland, which it is estimated will take 6–8 years. Indicative results will be published at the halfway stage. It is envisaged that some of the sample plots will be revisited regularly to update the NIWT dataset.

Finally, small woods (those of less than 0.5 ha), linear features and individual trees, which were first mapped in the late 1990s, will be remapped, and a proportion surveyed again. These woodlands are often especially important for wildlife, landscape and recreation.

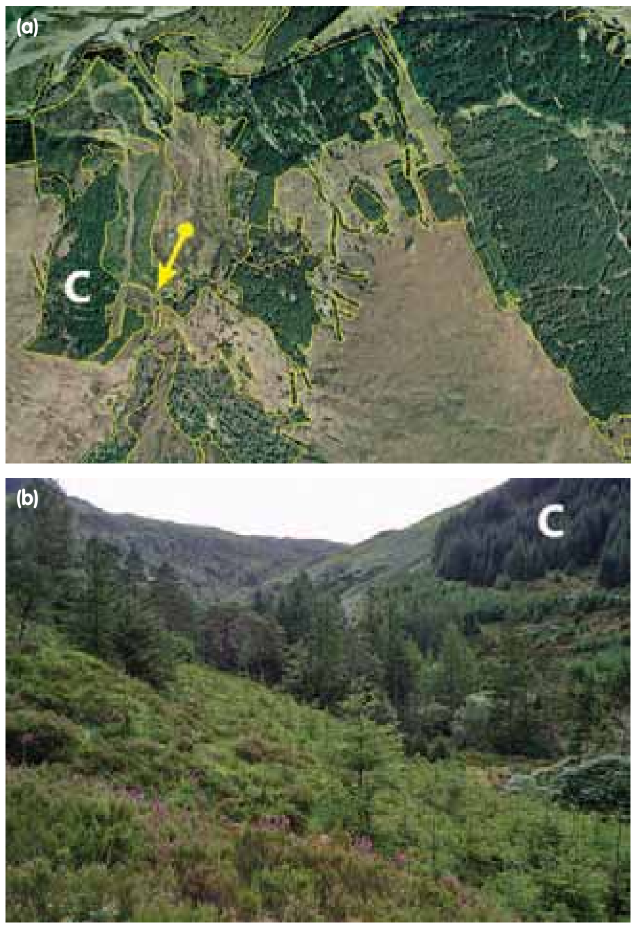


Figure 1 Scottish woodlands: aerial image and ground view. (a) Aerial image, 2005, with boundaries of NIWT2 Interpreted Forest Types.* (b) Ground view, 2006. C represents 'conifer'. The circle and arrow in (a) show the location and direction of the ground view in (b).

The temperature response of photosynthesis

Eric Casella

The concentration of carbon dioxide (CO_2) in the Earth's atmosphere has been rising over the past two hundred years, and rising much faster since the middle of the 20th century, as shown by direct measurements from atmospheric samples and ice cores. This increase in CO_2, and other greenhouse gases, is predicted to produce an increase in mean global temperatures of up to 5.5 °C by the end of the 21st century (Figure 1) unless very significant mitigation efforts are put in place. Temperature is one of the principal controls of the distribution and productivity of forest tree species, with large effects on physiological activity at all spatial and temporal scales. The central role of temperature in tree success was apparent to the earliest biologists and its influence on yield and tree fitness has led to extensive research on temperature effects throughout the modern history of plant biology.

Photosynthesis is the driving process here and is a key determinant of the rate of tree growth. In trees from temperate habitats, photosynthesis operates between 10 and 40 °C (Figure 2). It has an optimum temperature that roughly corresponds to the middle of this range, and

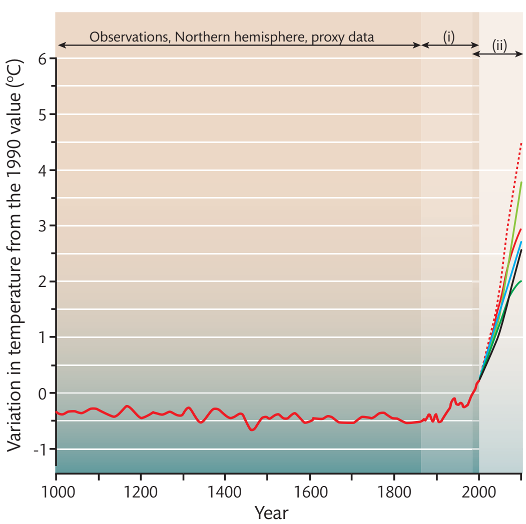


Figure 1 Predicted global averages of surface warming for contrasting climate-change scenarios*.
(i) Direct temperature measurements; (ii) model predictions. Different colour lines show different model scenarios.

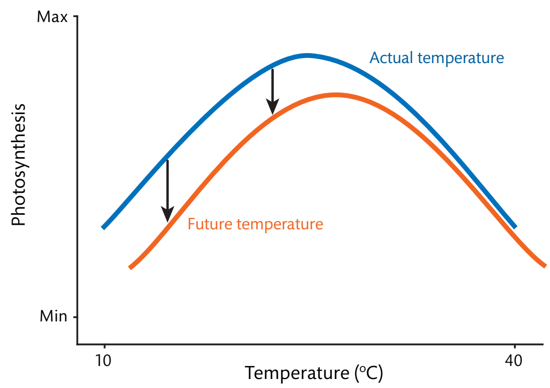


Figure 2 Typical pattern of thermal acclimation expected in temperate tree species.

photosynthesis declines as temperatures rise above or below this optimum. However, some forest plant species can acclimate, or adjust, to temperature changes, as indicated by shifts in the thermal response that will affect photosynthesis. Preliminary work over the past year has shown that the rate of photosynthesis of some poplar trees is adversely affected by an increase in temperature up to the current optimum, although most scientists would expect this to increase photosynthesis. This clearly illustrates that forest responses to increasing temperatures must not be assumed but should be checked experimentally.

Many different aspects of tree growth are affected by climate change, not just in response to temperature but also CO_2, water availability and wind. These responses are numerous and interlinked yet they can only be investigated gradually using experimentation. By adding our results together into mathematical models, we then get an indication of the effects of global warming on the overall function of forest ecosystems. With the predicted greenhouse-gas-induced rise in global surface temperature already under way, the effects of increasing temperature on tree growth and forest ecosystem function have become a major area of work for Forest Research. For more information on our research in this area, visit **www.forestresearch.gov.uk/climatechange**

* Adapted from IPCC Climate change 2001

Ecology

Our ecology teams work on a wide range of topics connected with the conservation and enhancement of biodiversity in Britain's woodlands and related landscapes. They bring ecological expertise to multi-disciplinary challenges in sustainable forest management and integrated land use. Here, we highlight some of our recent research.

Detecting gene flow and identifying species

Forensic science has demonstrated the powerful use of DNA matching, for example to link crime scenes and perpetrators, but this technique can also be applied to conservation of species and genes. Molecular markers can identify gene flow across landscapes and the concept of forest habitat networks supposes that the networks provide genetic connectivity for woodland species. We are testing this assumption using the wood cricket on the Isle of Wight.

Advances in molecular techniques permit the identification of species from minute traces of DNA. This can confirm the presence of rare species where direct observation is problematic, for example in distinguishing between the scats of pine marten and fox. We have now developed methods to distinguish the droppings of black grouse, red grouse and capercaillie. This will enable the Royal Society for the Protection of Birds to monitor the presence of these birds following habitat management in key reserves. For more information, visit **www.forestresearch.gov.uk/geneticconservation**

Conserving biodiversity through improved practice

Sustainable forest management, in policy and practice, requires the conservation of biodiversity and attention to the needs of a number of special species. Legal protection for European Protected Species has recently been strengthened by the 2007 amendments to The Conservation (Natural Habitats, &c.) Regulations 1994 and domestic legislation also identifies requirements. Consequently, Forest Research has been refining best-practice guidance for management activities.

The consequences of forest management are often poorly understood, and we target research to fill such knowledge gaps. For example, we are investigating with Plantlife Scotland whether timber extraction during thinning aids the vegetative spread of the twinflower, a rare pinewood plant. Similarly, in the West Midlands, we have been assessing the impact on dormouse populations of thinning, which can enhance shrub layers and thereby food supply.

Findings from this research will be added to the Habitats for Rare, Priority and Protected Species (HARPPS) database. This web-based tool for forest managers will come online later in 2008. For more information, see **www.forestresearch.gov.uk/harpps**

Understanding vegetation dynamics

Vegetation makes an important contribution to woodland biodiversity in its own right, but also underpins many food webs (i.e. sets of interconnected food chains). Vegetation composition in forests is dynamic and responds to a wide range of factors including tree growth, stand management and herbivory. By understanding the ecological consequences of habitat change, we can determine appropriate management activities.

We are currently working on planned change through the restoration of Plantations on Ancient Woodland Sites (PAWS). We are also investigating vegetation change following clearfelling, and assessing consequences for the conservation of black grouse. Studying natural stand dynamics can help determine how management might emulate or mimic such processes. We have recently resurveyed a number of sites in southeast England that were damaged in the storm of October 1987, looking especially at natural regeneration of trees, and whether the new woodlands are typical of local native woodlands. We hope that this will contribute to learning about how to achieve the conversion of conifer plantations to broadleaved or mixed forests. Further details are available at **www.forestresearch.gov.uk/storm1987**

Researching wild herbivores: deer and boar

Wild herbivores produce a range of effects that can threaten the sustainable management and biodiversity of woodlands. However, these impacts are not entirely negative and in some cases it can be beneficial to introduce grazing for vegetation management.

Our ecologists are developing methods that will help make the management of herbivores in woodlands more effective. The impact of deer on vegetation character continues to be an important object of study. We are further refining our population model that enables managers to understand the extent to which deer populations may require management. Data from the Forestry Commission's deer-cull database have helped us to refine some of the population parameters, such as the recruitment rate. Knowledge gained through this work is also informing advice to forest managers about local decisions on the management of wild boar populations in southern England, including the use of culling and the technical specification of fencing. Visit **www.forestresearch.gov.uk/herbivoreimpacts** for more information on this topic. See also page 33 for details of related work on collaborative deer management.

Applying habitat networks to urban areas

Habitat networks link and expand individual habitats, and can reverse the effects of fragmentation on biodiversity. They can also deliver social and environmental benefits such as enhancement of local landscape and improved public access. There is growing interest in applying concepts derived in landscape ecology to planning and management of peri-urban and urban areas, and in particular to enhance the value of greenspaces within them.

We have recently conducted a study for the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) to explore the concept of urban networks for people and biodiversity. We considered whether it was possible to meet the multiple needs for public health, education, biodiversity and ecosystem functions in planning multi-functional green networks. The application of our least-cost approach, the Biological and Environmental Evaluation Tools for Landscape Ecology (BEETLE) model seemed particularly suitable – see **www.forestresearch.gov.uk/beetletools**. We are now progressing this work in collaboration with the Glasgow and Clyde Valley Green Network programme, with a view to improving the quality of greenspaces in that area.

Investigating communication on zoonotic diseases

How can we best warn countryside users about the potential for animal-related disease without scaring them away or spoiling their enjoyment? Surprisingly little is known about how best to encourage appropriate behaviour, even when the precautions are simple. We have recently begun a project to assess and communicate animal-disease risks for countryside users, with support from the Rural Economy and Land Use programme (RELU). We are working with the Universities of Oxford and Surrey, and the inter-disciplinary team includes ecologists, psychologists and sociologists.

The project focuses on Lyme disease, caused by a bacterium *Borrelia burgdorferi* sensu lato (Bb) that is found in a number of wild animal hosts and which can be transferred to humans by infected ticks. This disease is being used as a model because it is relatively well understood, appears to be increasing in Britain, and there has been speculation that land use and climate change might make it more prevalent. We hope to help those involved in the countryside to understand how to deal with diseases such as Lyme disease, how to communicate the degree of risk effectively, and how to encourage appropriate precautionary behaviour while allowing the countryside to remain a source of pleasure and well-being for its users. For further details, visit **www.forestresearch.gov.uk/animaldiseaserisks**

Climate change: impacts and adaptation in Scotland

Duncan Ray

Forest Research has recently completed work for Forestry Commission Scotland to help advise on the impacts of climate change on Scotland's forests, and suggest how the industry might adapt. The work includes new spatial modelling research using Ecological Site Classification to assess the impact of climate projections on changes in tree-species suitability, and preliminary suggestions to modify forest management. Although a more detailed analysis will follow, the findings provide important new insights, and a basis for strategic forest planning. Forestry is a long-term activity, and trees planted now must be suited to site and climatic conditions both now and in the future.

Figure 1 Damage to a Sitka spruce following the dry summer of 2003. (a) Longitudinal lesions on the stem; (b) crack exposed after removing the bark.

Key findings include:

- A warmer climate and increased atmospheric concentrations of CO_2 will improve tree growth throughout Scotland. Where water and nutrients are not limiting, annual growth could increase by 2–4 cubic metres per hectare for conifers.
- Southern and eastern Scotland will become more favourable for growing high-quality broadleaved trees on suitable deep and fertile soils.
- Droughty soils in eastern Scotland will become unfavourable for Sitka spruce and other drought-sensitive species (Figure 1).
- Changes in the seasonal distribution of rainfall will cause more frequent summer drought and winter flooding.
- There will be changes in the ecology of pests and diseases.

It is likely that low-impact silvicultural systems and the use of mixed species will spread risk and provide a basis for adaptation strategies. Patch-clearfell silviculture could be modified to include a wider range of tree species to increase stand resilience to climatic stress. Conditions are currently suited to many non-native tree species, and there may be a strong case for accepting the colonisation of beech and sycamore as a valid adaptation strategy in some native woodlands. Changing rainfall patterns may require adjustments to operational practices to prevent site damage on wet soils, and forest nurseries will need to adapt to drier summers (e.g. more irrigation) and wetter winters (e.g. avoiding soil damage). Contingency plans should provide guidance for an effective response to increasing risks, such as fire, wind damage, and pest and disease damage.

Further research will assess impacts and adaptation strategies as new regional climate projections become available. For more information, please see **www.forestresearch.gov.uk/climatechangescotland**

Genetic fingerprinting of black poplar planting stock

Joan Cottrell and Sam Samuel

Native black poplar (*Populus nigra* var. *betulifolia*) is one of Britain's rarest native trees, with only 7000 specimens thought to remain. A long history of vegetative propagation, with transfer of cuttings over wide geographical areas, means that the number of clones present in the British population is much lower than the number of trees. Planting stock for woodland establishment falls under the control of the Forest Reproductive Material (FRM) Regulations (2002) which require marketing to be based on the clear identification of individual clones where vegetative propagation is used as the means of plant production. In the absence of any clear morphological or other features that can be ascribed to individual clones, molecular markers must be used to provide unequivocal identification.

Fourteen registered suppliers of commercial planting stock provided 83 samples of material from putative individual clones that they hold as sources of cuttings. A DNA fingerprint for each sample, based on six microsatellite markers, was established using a Licor sequencer (Figure 1). This revealed only 14 distinct clones among the 83 samples. A further molecular test indicated that one of these clones was in fact a hybrid between black poplar and another, non-native poplar species. Information on gender was available for some of the samples, and indicated a high proportion of male clones.

These findings reinforce earlier work and emphasise concerns about the genetic base of material being planted in Britain. The results will be used to rationalise current sources held by suppliers. They suggest that efforts to broaden the genetic base are unlikely to be successful without routine fingerprinting of all potential new trees selected for propagation work. This applies not only to commercial producers, but also to a range of local conservation initiatives. It is clear that a coordinated approach to widening the genetic constitution is necessary. The provisions of the FRM Regulations can be employed to certify individual clones being used, and to monitor progress in these objectives – more information on FRM Regulations can be found at **www.forestry.gov.uk/frm**

Figure 1 Loading samples of amplified DNA from black poplar on to a gel in a Licor sequencer.

Environmental and Human Sciences

Our environmental and human sciences research helps to ensure that evolving forestry policy and practice enhances the environment and people's lives, especially in response to global concerns such as climate change. It draws from expertise across the environmental, social and economic disciplines, and is increasingly multidisciplinary in approach. Our findings help to shape guidance for practitioners, as well as contributing to government policy.

Understanding the interaction of air pollution and forest functioning

Over the past 20 years, the UK has introduced policies to reduce pollution and lessen its effect on the environment. One way in which pollution most easily disperses into the environment is via rainfall. Our researchers have been evaluating the long-term trends in rainfall and dry deposition across the UK's intensive forest-monitoring network. Results have shown evidence of changes in important deposition chemistry, confirming the success of emission-reduction policies. Long-term trends at these sites also show definite, if slow, ecosystem response, with both chemical and biological recovery already observed.

Detailed analysis suggests that biological elements are an important influence on the forest chemical cycle. This is particularly significant as many insect pests may become more prevalent due to climate change, and more frequent and severe summer droughts will make trees increasingly susceptible to biotic agents. The integrated nature of intensive monitoring across the network enables the relationships between climate, pollutant exposure and chemical and biological response in forestry to be further explored. For more information visit **www.forestresearch.gov.uk/l2trends**

Protecting salmonid fish from climate warming

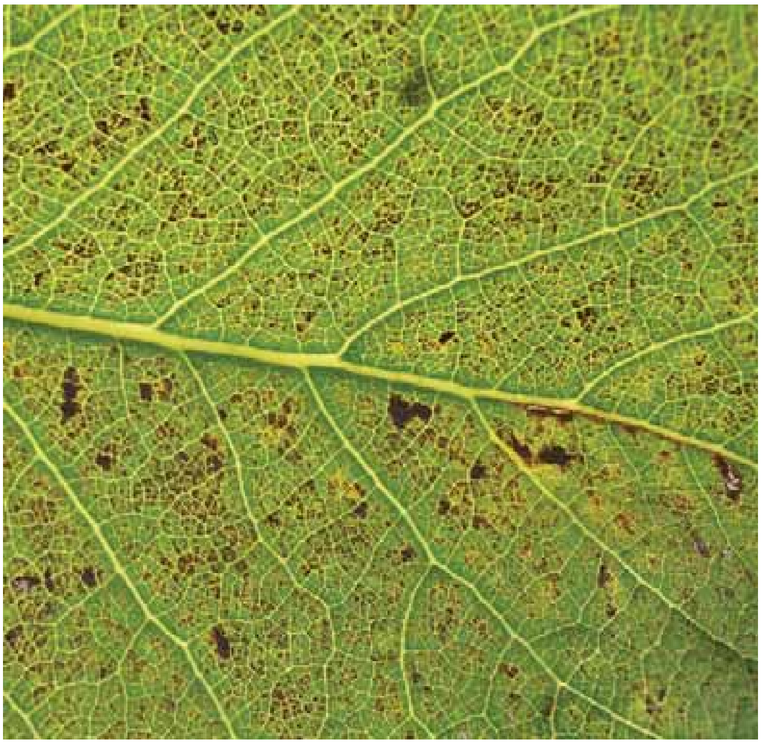
Some species of fish such as salmon and trout are very sensitive to water temperature, and so are believed to be at risk from climate warming. This is generating increasing interest in the role of riparian woodland in mitigating thermal stress. Forest Research is working with Southampton University in the New Forest to evaluate the influence of woodland shade on stream temperature and fish populations. Results show that water temperature in open grassland sections on hot summer days regularly exceeds the lethal limit of 25 °C for brown trout, increasing the risk of fish death. In contrast, maximum stream temperatures rarely rise above 20 °C in wooded sections.

This confirms the important role of riparian woodland in providing a cool-water refuge, protecting fish and other aquatic life from summer warming. These results are being used in modelling work to develop guidance on the optimum design and management of riparian woodland for mitigating climate warming. The guidance will cover species choice, woodland structure and woodland cover, for example. For more details, visit **www.forestresearch.gov.uk/riparianshade**

Mapping ozone injury to trees in Europe

Ozone is naturally present at ground level in low concentrations, but levels have been slowly increasing in recent years. Above a certain concentration, ozone can cause visible injury to the leaves of plants and trees. Forest Research has recently completed work on using biological monitors – or biomonitors – to map and monitor the effects of ozone by assessing visible injuries in commercial tree nurseries across four European countries. Tree stock in these nurseries is normally irrigated and therefore not subject to water stress, which can limit ozone uptake in woodland and forests. Meteorological and ozone-monitoring data from the sites were used to calculate cumulative ozone flux during the summer months when trees were monitored.

Ozone injury was observed in all countries, demonstrating that impacts are not restricted to Central and Southern Europe where higher ozone concentrations are experienced. In Northern Europe, longer day-length and higher moisture availability compensate for lower ozone concentrations with enhanced uptake. The highest ozone flux and the most extensive damage was found in Switzerland. The UK had the lowest fluxes and least injury, with damage here confined to late summer in the Southeast. However, ozone fluxes were lower than in previous years, so there may be more severe damage in future.



Evaluating social benefits of community woodland programmes

Forest Research is evaluating progress of Cydcoed*, a £16 million, seven-year community woodland programme, funded by Forestry Commission Wales (FCW) and the EU Objective One programme for West Wales and the South Wales Valleys. The programme aims to help community groups influence local decision-making, and its project groups have almost 8000 local members, with around 18,000 schoolchildren involved in activities. Forest Research is providing an independent assessment of the project, analysing the extent to which its longer-term desired outcomes are being achieved. These include:

- community groups being empowered to influence decisions about their locality
- woods providing long-term local social, economic and environmental benefits, and
- individuals playing a positive role in their community

We are evaluating the programme's effects on community networks, governance, and health and well-being within communities; economic analysis will provide information on the public benefit of the programme. We are also considering the Programme's contribution to wider FCW and Welsh Assembly objectives. FR's final report, due in August 2008, will help shape social forestry policy and programmes for FCW. For further information, visit **www.forestresearch.gov.uk/cydcoed**

* Pronounced 'keed koyd'. From Welsh, Cydcoed literally translates as 'shared (cyd) wood (coed)' or 'woods for all'.

Researching collaborative deer management

Wild deer are highly mobile animals that interact with people in many ways, both good and bad. However, as wildlife is not 'owned' by anyone, no one has legal responsibility for the impacts or management of wild animals, yet clearly they need to be considered and, if necessary, any matters of concern need to be attended to by someone. This presents a complicated management challenge to landowners and land managers. To address this issue, Forest Research, in partnership with other institutions, is carrying out interdisciplinary research into collaborative approaches to land management.

Collaboration is widely used and studied in the natural resources field and brings a range of benefits, including an integrated management framework, resource efficiencies and the avoidance and resolution of conflict. Our research includes an analysis of stakeholder organisations and their collaboration at a national level, a review of the evolution of deer-management legislation and local case studies in Dorset and Herefordshire.

We have also investigated how different social groups perceive and describe woodlands, wish to see them managed and respond to scientific information about them. Early analysis suggests little difference between how separate groups prefer to see woodlands, but rather that they frequently describe these preferences using different terms and phrases. This indicates clear potential for successful collaborative management, once these differences are understood. For further information, visit **www.forestresearch.gov.uk/reludeer**; see also page 26 for details of related ecology research into herbivore management in woodlands.

The impact of forest management on forest recreational use

David Edwards and Mariella Marzano

The EU-funded project EFORWOOD is developing a computer-based tool to assess the sustainability of the European forestry-wood chain under a range of future scenarios. The project began in November 2005 and will run for four years. Forest Research is contributing to several elements of the project and is leading a team of researchers on the topic of 'social and cultural values'. The overall aim of this topic is to assess the impacts of changes to forest management on social and cultural values (SCVs) associated with forests in Europe.

Research began with a review of SCVs and indicators used for monitoring and evaluation within the forestry sector worldwide. A generic SCV indicator framework was developed, based on 9 themes, 42 sub-themes and 72 indicators. The review highlighted the difficulties of attempting to quantify and model SCVs, many of which are intangible and hard to separate from each other, for example 'quality of life' and 'well-being'. For this reason, the indicator 'recreational use' was chosen for further research, since it can be easily evaluated, for example as number of visits per hectare per year, and because it can also act as a proxy for the intangible benefits gained by the public from direct use of forests.

A comprehensive study is now being conducted to bring together existing knowledge of public preferences for visits to forests (Box 1) with different attributes in different parts of Europe. The attributes considered are both silvicultural, such as age, density and species, and non-silvicultural, such as recreational facilities and services. Workshops will then be run with European experts to help synthesise and refine the conclusions. A case study is also being carried out in Craik Forest in the Scottish Borders (Figure 1) to explore the preferences of local forest users. Through these methods, it should be possible to determine the direction, and approximate scale, of impact on visitor preferences caused by specific changes in forest management. In this way, the research seeks to develop 'recreational use' as a qualitative indicator within the EFORWOOD impact-assessment tool. Further details of this work are available at **www.forestresearch.gov.uk/eforwood**

Box 1 Public preferences for forest characteristics

Public preferences for forest recreation tend to increase with the following changes to the silviculture of individual forest stands. These relationships are being examined, and where possible quantified, as part of this research.

Species:	More broadleaves, fewer conifers (in UK), more species
Age:	Increased stand age, older individual trees
Density:	Decreased stand density, more visual penetration, moderate thinning, less clearfelling and more natural regeneration
Ground cover:	Less slash, residue and products on-site; more ground vegetation – but not too much
Appearance:	Natural and semi-natural-looking, but not completely wild; 'park-like' in appearance

Figure 1 Craik Forest: what do local recreational users want?

Ecological risk assessment

Danielle Sinnett, Cécile De Munck and Tony Hutchings

Past industrialisation in the UK has resulted in a legacy of contaminated land. The Environmental Protection Act 1990 defines land as contaminated where it presents a significant harm or the risk of significant harm to any defined 'receptors'. Ecological harm is restricted to specified receptors such as Sites of Special Scientific Interest (SSSIs) or National or Marine Nature Reserves (NNRs and MNRs). An ecological risk assessment (ERA) should be conducted where contaminated sites are likely to affect these ecological receptors. An ERA may also be necessary where greenspace establishment is planned on contaminated sites, in order to ensure that there is no risk to the created habitats.

Environment Agency guidelines for conducting ERA on contaminated land recommend eco-toxicological tests, including assessments of plant germination and growth, soil-microbial function and health of soil invertebrates. Soil fauna tests are relatively simple, cheap and reliable. However, the vegetation tests primarily use food crops, which may not be ecologically relevant to greenspace created on contaminated land. In addition, no consideration is given to the transfer of pollutants through the food chain.

Forest Research is currently investigating the use of a number of plant species commonly found on urban greenspace in order to provide more relevant species for ERA. The accumulation of metal contaminants into stinging nettles *(Urtica dioica)* is also being studied, as is the resulting food-chain transfer into primary plant consumers. Results have demonstrated that stinging nettles are extremely tolerant of elevated concentrations of cadmium and zinc, and are able to accumulate significant concentrations within their above-ground biomass without any apparent toxicological effect (Figure 1). The cadmium and zinc within the plant tissues are subsequently transferred to aphids, snails (Figure 2) and earthworms at levels that may be expected to present a risk to predators. Results are currently being used to develop a modelling platform to estimate the risk of metal food-chain transfer to higher organisms. This work is being conducted as part of the EPSRC-funded Pollutants in the Urban Environment (PUrE) research consortium. For more information on this subject, visit **www.forestresearch.gov.uk/eiaurban**

Figure 1 Stinging nettles growing in zinc solution.

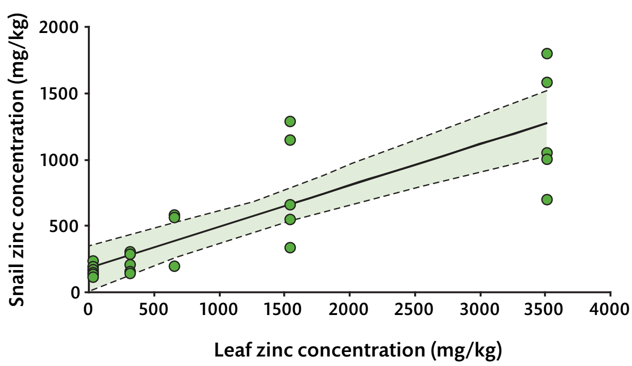


Figure 2 Concentration of zinc in snails as a function of zinc concentration in nettle leaves.
Zinc-uptake model (solid line), with standard errors (dashed lines) and data (x) for snail soft tissue.

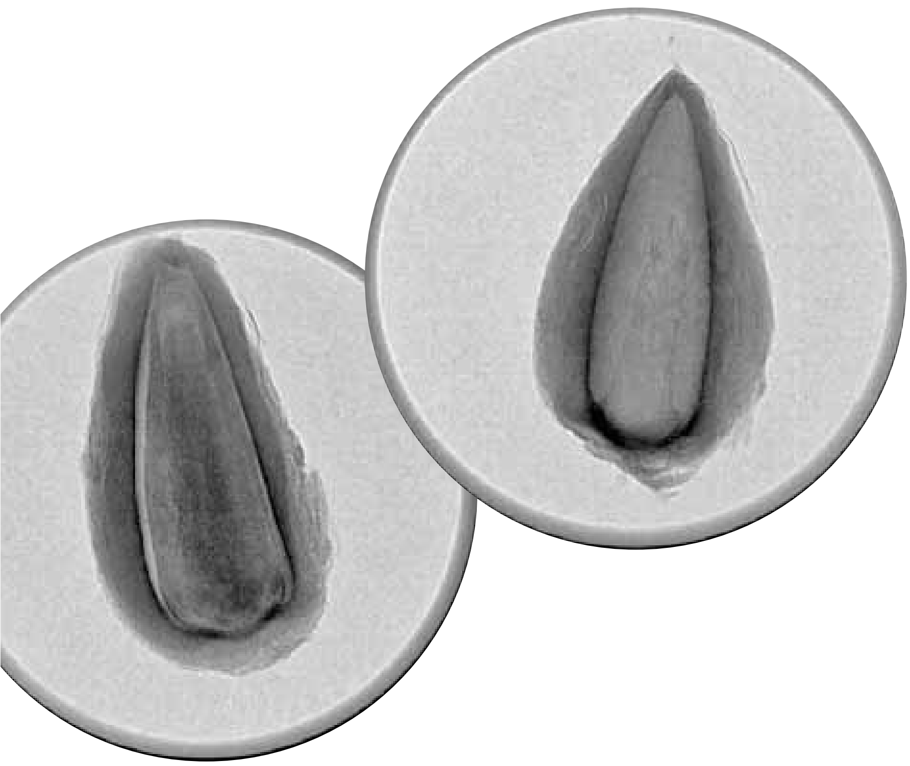
Forest Management

Our Forest Management research group carries out research and development covering all aspects of sustainable management of the forestry–wood chain, from seed or plant through to the wood products harvested from the forest. Here are some examples of our current work.

Conserving native trees – problems of seed viability

Attempts to conserve or propagate many British native trees are hampered by the absence of any quick or even reliable methods to screen seed quality. This results in empty or dead seeds being used alongside viable ones. Our seed scientists recently used X-rays to differentiate between 'filled' (see below left) and 'empty' (below right) seeds of juniper, one of three native conifer species. The seeds were then cut open to confirm whether they were filled or empty, and the filled seeds were stained with tetrazolium (TTZ), which distinguishes live seeds.

The X-ray and cut tests produced very similar results but, most excitingly, filled seeds were more often correctly identified by X-rays when the seeds were 'filled and live' than when they were 'filled and dead'. This suggests that the X-ray test could be used to identify viable seeds without destroying them. A non-destructive test for seed viability has long been sought, and may now be within sight for this species. For more information, see *Raising trees and shrubs from seed*, available at **www.forestresearch.gov.uk/seedbiology**



Investigating fallow strategies to control pine weevils

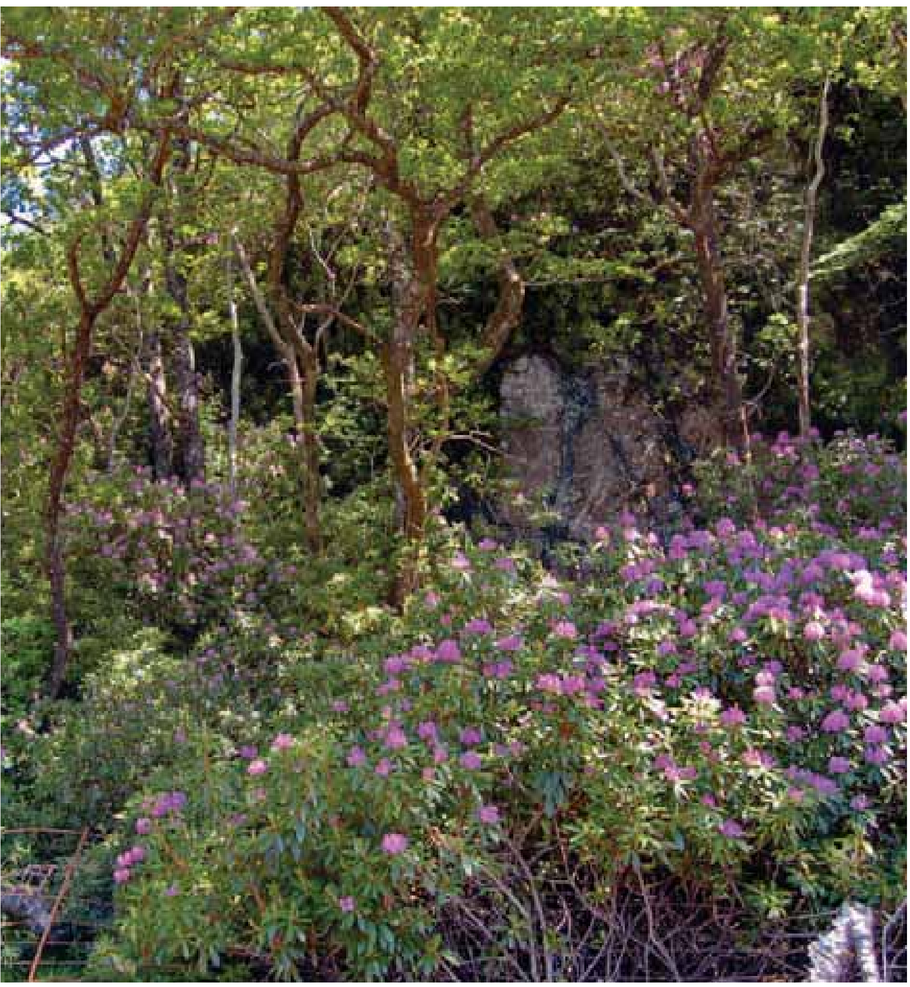
The large pine weevil, *Hylobius abietis* is the most significant insect pest in commercial forestry in Great Britain, feeding on young transplanted seedlings and causing heavy losses during restocking of forest sites. To reduce the use of pesticides, we are investigating alternatives to the chemical protection of plants. One option being assessed is to leave clearfelled sites fallow for up to five years until *Hylobius* populations have stabilised to naturally low levels. The success of this approach depends on the amount of weed growth during the fallow period, since heavy regrowth would require ground preparation and intensive herbicide application.

During summer 2007, we surveyed a range of sites felled between one and five years ago, each typical of upland Sitka spruce sites in northern and western Britain. Analysis of vegetation growth in relation to soil, climatic conditions and time since clearfelling is still in progress, but preliminary results suggest that most sites show appreciable vegetation regrowth by 3–4 years after felling. For more information, visit **www.forestresearch.gov.uk/hylobius**

Predicting rhododendron colonisation

Rhododendron ponticum is an invasive, non-native shrub that has colonised a range of natural habitats since its introduction into Britain around 240 years ago. Controlling rhododendron can be expensive, and we are investigating strategic approaches to provide value for money. In a case study in mainland Argyll and Bute, western Scotland, we mapped known populations and used a landscape ecology habitat network analysis model (called BEETLE) to predict future expansion over 20 and 50 years.

The model identified habitats vulnerable to rhododendron colonisation and predicted expansion rates by both seed dispersal and shoot layering. Current populations will cost around £12.5 million to control, and costs could increase by 23% after 20 years and 58% after 50 years. In a worst-case scenario, populations could expand by up to 350%, placing an additional 15,000 hectares at risk of rhododendron colonisation. This information is being used to inform rhododendron control strategies in western Scotland. More details are available at **www.forestresearch.gov.uk/rhododendroncontrol**



Managing forests on steep ground

Practising forestry on steep ground can be expensive and technically difficult as slopes of more than 35% can hinder the working of forest machinery. Some forests on steep ground have been neglected over the past 20 years, especially while the timber market was poor. However, there is now increasing demand for timber from these forests, yet steep sites still require careful management to ensure conservation and landscape benefits while avoiding safety risks such as landslips.

Forest Research has contributed to developments in mechanised harvesting techniques that have enabled wheeled and tracked machines to move onto steeper areas traditionally worked by felling with chainsaws and cableway extraction systems. Consequently, production has risen, ergonomic working conditions have improved and costs have been reduced. However, equivalent development is still needed for ground-preparation systems for restocking on steep sites. We are now focusing on establishing an integrated approach to sustainably managing forests on steep ground.

Introducing continuous cover forestry – a long-term example

Continuous cover forestry (CCF) can provide visual and environmental continuity in sensitive landscapes and is being promoted in country forestry strategies. However, successful CCF requires long-term continuity of management. In 1952 a trial was started in Glentress forest, south of Edinburgh, to transform 120 hectares of plantation forest into an irregularly structured mix of Norway spruce, European silver fir and beech. The goal was to complete the transformation in 60 years by felling and replanting small gaps (0.01 to 0.02 ha), but over time, larger gaps (around 0.15 ha) have been adopted. Browsing damage by deer and sheep required a wider range of species to be planted, and since the 1980s there has been greater natural regeneration. We now estimate that the transformation will be complete by 2033, some 20 years later than initially planned.

Supported by the Scottish Forestry Trust, Forest Research is undertaking a new survey of the trial area to assess the changing structure of the forest. The results will contribute to future guidance on CCF management for forest managers throughout Britain. Visit **www.forestresearch.gov.uk/ccf** for more details.

Using acoustic tools to assess timber quality

Timber used in construction must meet specific requirements for mechanical properties. However, these properties can vary substantially between trees – and even within a single tree – so being able to assess them in standing trees and felled logs would greatly help in the allocation of material to specific end-uses. It would also help to avoid sending unsuitable wood to timber mills for processing, only for it to be downgraded later.

Portable acoustic instruments have recently been developed to measure *in-situ* wood properties. Working with partners in the wood-processing industry, we have been evaluating the use of these instruments with Sitka spruce and Scots pine. Trials show that acoustic tools can segregate wood effectively, and can be easily used on standing trees, logs at roadside or in the sawmill yard. These tools are now starting to be used commercially, and research is continuing to develop them further as a means of improving efficiency and profitability within the wood supply chain. More information is available at **www.forestresearch.gov.uk/timberproperties**

Managing wind risk to forests in northern Europe

Bruce Nicoll, Barry Gardiner, Juan Suarez and Stephen Bathgate

In January 2005, a catastrophic storm damaged 85 million cubic metres of timber across northern Europe – ten times the annual production of UK forests. The STORMRISK project, funded by the EU through the Interreg North Sea Programme, was established to gather knowledge of managing forest wind damage, and to make it accessible to forest owners, managers and planners. The project is a partnership of forestry companies and research organisations from Sweden, the UK, Germany and Denmark. Forest Research was invited to participate because of its experience in modelling and mitigating the effects of wind on forest stands.

A version of FR's successful ForestGALES wind risk model can now be applied in other countries bordering the North Sea. This system is accessed via the internet and calculates risk to forest stands based on local wind data and user-provided stand characteristics. Outputs include critical wind speeds expected to overturn trees, and the likely return period of such wind speeds.

During 2007, ForestGALES was applied at the landscape scale for a STORMRISK case study in Glen Affric, Scotland, using data from the Forestry Commission's sub-compartment database to predict current and future risk (Figure 1). This risk assessment has since been used in the local design planning process. To improve calculations of wind risk to stands with an uneven structure, and to develop a method of assessing risk using remote sensing data, Glen Affric has also been scanned using air-borne LiDAR (light detection and ranging). This technique uses laser pulses that can 'see' through forest canopy (Figure 2). The resulting data were analysed to provide the tree dimensions required by ForestGALES. Development of this link between remote sensing data and ForestGALES provides a method for detailed assessment of wind risk in complex forest structures.

Forest wind risk management must consider a changing climate. Predictions of climate change for northern Europe include an increased frequency of extreme wind events and increased rainfall. Together these are expected to increase the risk of windthrow over the next fifty years. Advice on management of forests for wind risk in a changing climate, based on experiences from each participating country in STORMRISK, as well as the latest developments in wind-risk modelling, is available in an online toolbox (www.stormrisk.eu). For more information on the STORMRISK project visit **www.forestresearch.gov.uk/stormrisk**

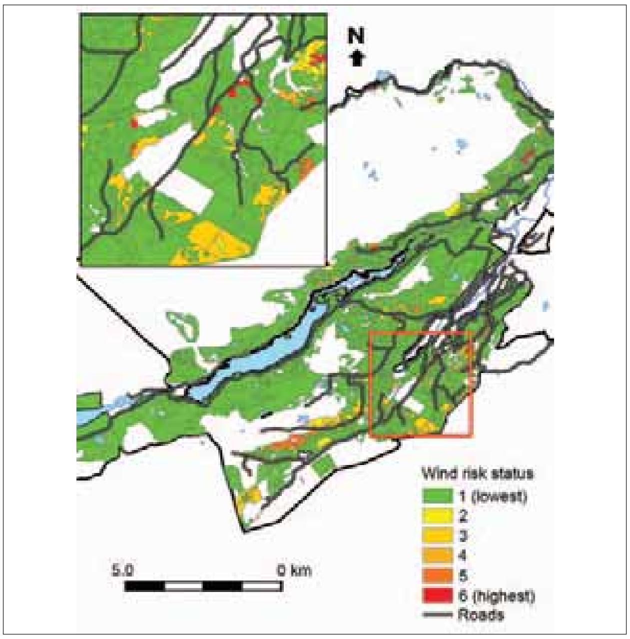


Figure 1 Geographic information system (GIS) map of wind risk in Glen Affric (areas of highest risk are shown in red).

Figure 2 Three-dimensional view constructed from air-borne LiDAR data, showing a section of forest in Glen Affric.

Impact of whole-tree harvesting on the growth of Sitka spruce

Bill Mason and Helen McKay

Whole-tree harvesting (WTH) is the removal of most branches and needles ('brash') from a harvesting site, in addition to the stem wood removed in conventional harvesting. Government initiatives to increase the percentage of energy generated from renewable resources have enhanced awareness of the potential importance of various types of wood fuel, including brash, as energy sources. However, there is some concern that removing branches and needles is detrimental to soil sustainability on particular sites and reduces tree growth.

Further information on the effects of WTH on subsequent growth is provided by three experiments in Scotland established during the 1990s. These examine the impact of intensive residue removal after clearfelling on the growth of Sitka spruce, tree nutrition and ground vegetation, and the interaction of residue removal with applications of fertiliser and herbicide. The soil types in the experiments vary in fertility to cover the range of nutrient risk categories identified by existing WTH guidance; see **www.forestresearch.gov.uk/brashremoval** for guidance notes. Growth in these experiments has now been monitored for at least 10 years, which is the age when nutritional limitations become most obvious. At all sites, both brash retention and fertiliser application had significantly beneficial effects on tree growth, although the magnitude of these effects varied. Figures 1 and 2 show comparative results at Moray, the nutritionally poorest of the three sites. No effects of herbicide application were evident after 10 years.

These findings suggest that intensive brash removal has the potential to deplete soil nutrient capital and reduce subsequent tree growth at the majority of upland forest sites, with an ultimate loss in timber volume. This effect was found even on an upland brown earth soil, which would be considered a low-risk site under current guidance. Applying fertiliser boosted growth on all sites and there was a positive interaction between brash retention and fertiliser application. This suggests that it could be possible to offset the nutritionally detrimental impacts of WTH by fertilisation, using either chemical fertilisers or possibly with wood ash. The compatibility of such remedial treatments with forest certification standards and the desire to reduce chemical inputs in forest management remains to be determined.

Figure 1 Sitka spruce growth 10 years after whole-tree harvesting at Moray, brash removed and no fertiliser applied: reduced growth.

Figure 2 Sitka spruce growth 10 years after whole-tree harvesting at Moray, brash retained and fertiliser applied: increased growth.

Tree Health

This year's research into tree health has included a number of topics on the general health of trees, as well as specific new research into aspects of climate change and alternative silviculture systems. It is notable that declining health in broadleaved trees frequently features the genus *Phytophthora, reflecting the increasing impacts of existing and exotic representatives of this highly damaging pathogen. Here, we outline some of our recent work.**

*** The name *Phytophthora* derives from the Greek for 'plant destroyer', a particularly apt term in the context of our experience of this organism.**

Investigating the causes of alder dieback

In northern Britain, alders can suffer from Phytophthora disease (caused by the pathogen *Phytophthora alni*) and from the less well-understood condition of alder dieback. While Phytophthora disease is relatively rare in this region, and has only been recorded in Scotland since 1999, severe and sometimes extensive dieback of alders has been happening for much longer in the north and west of the country. Forest Research has been monitoring several Scottish alder populations since 2000. We have found that alder dieback is episodic, with trees severely affected only in particular years.

Although one or several episodes of dieback can result in tree death, recovery is possible because the root systems usually remain alive. Death of the aerial parts of trees that succumb to dieback is rapid, however, and lesions on partially dead branches usually bear fruit bodies of the ascomycete fungus, *Valsa oxystoma*. Recent laboratory study has shown that *V. oxystoma* can be present within healthy alders, and we are investigating the conditions favouring its development in order to identify factors that may predispose alders to dieback.

Analysing trends in reports on oak decline

Over the past two years, more than 50 reports have been sent to the Forest Research Disease Diagnostic Advisory Service about a resurgence in oak decline. Affected trees show symptoms of dieback, and the worst affected often have copious bleeding on the trunk. As in the early 1990s, many reports comment on the acute and rapid nature of the decline. In some areas, particularly central and southeast England, high proportions of trees are affected and many have died or had to be removed within just 3–5 years of the first foliar symptoms becoming apparent.

The exact reasons for the current episode of oak decline remain unclear, but reduced water availability in soils may have been an important trigger. Some of the highest mean annual temperatures ever recorded in Britain occurred during 2002–2007, and 2003 and 2006 were notable drought years. For more details, visit

www.forestresearch.gov.uk/oakdecline

Protecting against oak processionary moth

Oak processionary moth *(Thaumetopoea processionea)* was found as feeding larvae in the UK for the first time in 2006. This pest has long been native in continental Europe, and its caterpillars can cause serious damage to oak and other broadleaved trees by feeding on the foliage. They are also a risk to animal and human health, as the hairs on the caterpillars cause severe irritation.

In 2007, Forest Research supported the Forestry Commission's new Outbreak Management Team, which was set up to aid co-ordination of a survey, control measures and the dissemination of information on the newly arrived pest. Analysis of the likely pathway of arrival of the moth in the UK suggests very strongly that this was live plants for planting. A formal Pest Risk Analysis was carried out in 2007 and used to support the setting up of the UK as a Protected Zone and designation of oak processionary moth as a regulated pest. For more information see **www.forestresearch.gov.uk/oakprocessionarymoth**

Developing strategies to control Phytophthoras

We are continuing work on the pathogens *Phytophthora ramorum* and *P. kernoviae* with new studies on trees in the Magnoliaceae family, including *Magnolia*, *Michelia* and *Liriodendron*, which are highly susceptible to the pathogens. These trees are valuable culturally, especially in heritage gardens, as well as being important horticultural and genetic resources. Chronic infection of mature magnolias causes blemishing, gradual defoliation and canopy thinning, sometimes leading to death of the tree.

As part of efforts to develop an integrated management strategy, we investigated the effect of injecting the fungicide phosphonate into tree stems before bud burst. This treatment aims to prevent reactivation of the pathogen in the growing season, and to bolster the plants' natural defence mechanisms against Phytophthora attacks in the spring. We found that the stem injection was very effective at delivering the chemical to the leaves but that it persisted there only briefly. Application of phosphonate by injection appears to offer the best potential for treatment, but we need to investigate further to confirm the efficacy and determine the optimum doses.

Assessing climate change effects on pests and pathogens

Increasing temperatures, changing rainfall patterns and increasing climatic variability are just some of the likely consequences of climate change in the UK. Such changes may alter the distribution, abundance and impacts of forest pests and pathogens over the coming decades, and so will influence how forestry adapts to a changing climate.

One effect of a warmer climate – in winter as well as summer – is that the growth and development rates of insects will increase. We have been investigating how this will affect insect lifecycles across the UK, an important first step in assessing future pest-risk profiles, allowing us to anticipate and therefore manage the impacts on trees and forests.

The main focus of our current research is the development of models of the rates of lifecycle development of pests (phenology models). Future research will include the study of climate impacts on pathogens and how the health of long-lived trees such as oak will be affected as the climate changes around them.

Monitoring pests under changing forest management

One of our new projects, Impact and Diversity of Insects in Alternative Management Systems, focuses on changes in the management and structure of Sitka spruce plantations, particularly conversion to continuous cover forestry (CCF) and other low-input systems. In particular, we hope to establish whether alternative systems will realise benefits in terms of increased invertebrate biodiversity and reduced damage from potential pest species.

During 2007, we carried out a full season of insect sampling at study plots in Clocaenog Forest and Cefn Llwyd in North Wales. The samples were dominated by high numbers of green spruce aphid (*Elatobium abietinum*) and leaf weevils (*Phyllobius* and *Polydrusus* spp.). These species were exceptionally abundant during the early part of the year and, although common throughout the study area, they were particularly numerous in the shelterwood plots, with natural regeneration below standing mature trees. For more information see **www.forestresearch.gov.uk/managementpestimpact**

New findings on the threat from Phytophthoras

Sandra Denman, Joan Webber, Anna Brown and Clive Brasier

The warm, wet summer of 2007 promoted disease caused by *Phytophthora ramorum* and *P. kernoviae*. Discovered 4–5 years ago, and considered recent introductions to the UK, these pathogens are a significant threat to woodland ecosystems. Both attack the foliage of shrub species such as *Rhododendron* and *Pieris*, where they produce zoospores (Figure 1). With heavy infestations of these foliar hosts, nearby trees become infected, resulting in extensive bark killing and even death of the trees. Beech is most at risk from both pathogens, but *P. ramorum* can cause potentially lethal cankers on various trees, including oak, southern beech and sweet chestnut (*Quercus cerris, Q. rubra Nothofagus obliqua*, and *Castanea sativa*).

Since 2003, over 150 *P. ramorum* outbreaks have been detected on shrubs in gardens and woodlands, mostly in England, but trees have only been infected at about eight sites. There have been about 50 *P. kernoviae* outbreaks, most in Cornwall with a few in Wales, but only ten have affected trees. Efforts at eradicating or containing the disease in woodland concentrate on destroying infected foliar hosts – mainly *R. ponticum*. However, Forest Research scientists have found that, even when foliar hosts are removed, both pathogens can persist for at least 1–3 years in soil and litter layers.

More recently, late in 2007, *P. kernoviae* was found infecting native bilberry plants (*Vaccinium myrtillus*) in Cornwall, in an ancient semi-natural woodland within a World Heritage Site. In early 2008, *P. kernoviae* was found for the first time on rhododendrons in gardens in Argyll and Arran, Scotland. In both instances, it is uncertain how disease spread to these new locations.

The plant trade is considered to be the most significant pathway for spread of these pathogens, and phytosanitary measures rely on visual inspections to detect infected plants. However, Forest Research has found that both Phytophthoras can infect foliage and even produce spores without causing visible symptoms. Although more study is needed to understand the circumstances that allow pathogens to behave in this way, it raises the risk of inadvertently importing these organisms. Other studies have shown that Phytophthoras not only infect tree bark but also invade the underlying sapwood. Previously it was thought that Phytophthoras causing cankers and bark necrosis were restricted to the inner bark (phloem) which could be stripped, leaving the wood pathogen-free.

Both these discoveries have implications for phytosanitary measures and disease management. Further information can be found at **www.forestresearch.gov.uk/phytophthoraimpact**

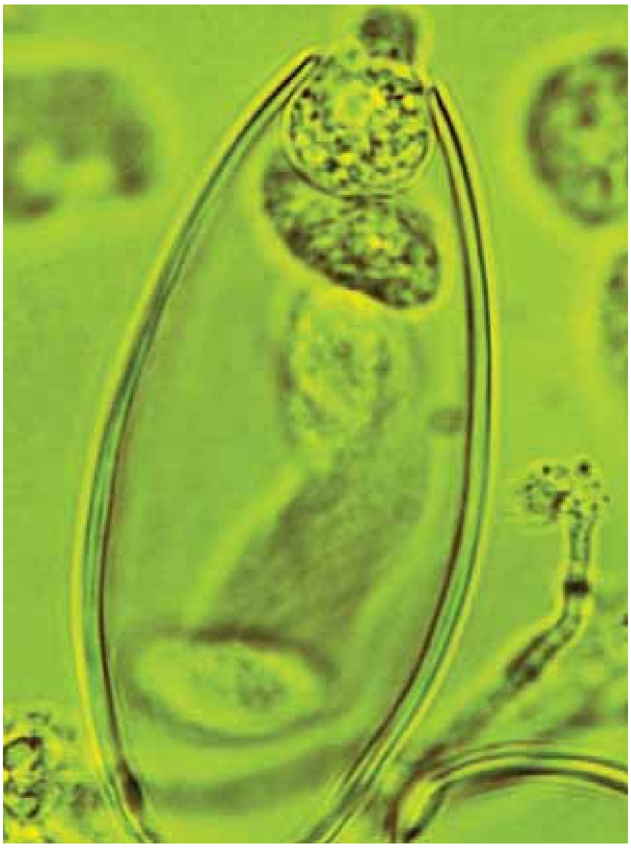


Figure 1 *Phytophthora ramorum* releasing zoospores, which cause disease on foliage and bark.

Online management support system for *Hylobius*

Roger Moore, Hugh Evans, Stephen Bathgate and Andrew Peace

Detailed research into population dynamics of the pine weevil, *Hylobius abietis*, has provided information relating population size to potential transplant damage on any given forest restocking site. For forestry practitioners, it is essential to know how weevil populations correspond to likely transplant damage in relation to different options for managing the restocking of a site. They can then select the management intensity and timing in relation to the level of risk from *Hylobius*, helping to reduce insecticide use, tree losses and hence restocking costs.

Forest Research has modelled the cumulative numbers of weevils per day on sites between mid-April and mid-October in each of the five years of potential weevil attack following colonisation. From this, a statistical measure of weevil feeding pressure called 'weevil days', based on population size and persistence, has been calculated for each site in each year studied, and related to levels of damage. A method for monitoring weevil populations in relation to feeding pressure and damage predictions has also been developed. This forms the basis of the *Hylobius* Management Support System (HMSS) (Figure 1) and employs a simple process of placing cut-conifer billets (pieces of small-diameter roundwood) on site for 28 days. The billets attract adult weevils (Figure 2) which are counted each week to indicate population size on site. This has been tested extensively and now provides robust estimates of *Hylobius* population size when used with the HMSS.

To deliver this improved understanding of *Hylobius* impacts to forest managers, a practical web-based HMSS has been developed, incorporating the models described above and others, to help:

- plan future clearfell restocking strategies to minimise transplant damage by *Hylobius*
- reduce initial insecticide use and subsequent top-up applications to transplants, by identifying and targeting where insecticide is necessary
- reduce restock failure and the subsequent need to replace destroyed transplants
- meet operational goals for restocking, and satisfy requirements of the Forest Stewardship Council and UK Woodland Assurance Scheme
- reduce overall costs of restocking by helping managers to make informed, site-specific decisions
- indicate the impacts of using nematodes as biocontrol agents to reduce *Hylobius* populations

Further information is available at
www.forestresearch.gov.uk/hylobiusmss

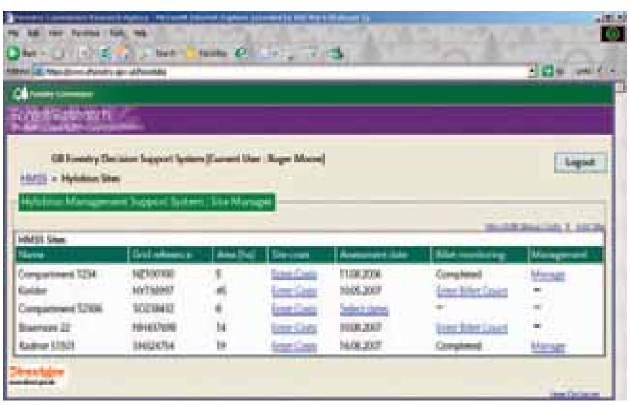


Figure 1 New HMSS software for site-specific management of *Hylobius*.

Figure 2 An adult pine weevil *(Hylobius abietis)*.

Biomass Energy Centre

The Biomass Energy Centre (BEC) provides independent, up-to-date information to potential users and producers of biomass fuels. Launched in 2006, the BEC is managed by Forest Research on behalf of the Forestry Commission and the Department for Environment, Food and Rural Affairs (Defra).

The UK Biomass Strategy, published by the Government in May 2007, identified biomass as playing a 'central role' in meeting EU and UK targets for increased use of renewable energy and the reduction of carbon dioxide (CO_2) emissions. During 2007, the price of heating oil rose by around 50%. Using biomass to provide heat, and in some cases heat and power, is therefore becoming an increasingly viable alternative.

During 2007–08 most enquiries to the BEC were linked to the production or use of woodfuel. Burning biomass from woodlands that are regenerated and managed sustainably helps to prevent further rises in atmospheric CO_2 from burning fossil fuels. Also, producing woodfuel from woodlands not previously in active management can open new income streams for the woodland owner or manager, and have positive effects on biodiversity and timber quality within the woodland. For the end user, woodfuel can compete with oil and even gas in terms of price per kilowatt hour (see table). Biomass boilers are generally expensive to buy but this may be offset by national or regional grant schemes – the subject of another frequent enquiry.


Chipper producing fuel from slab wood


A satisfied woodfuel user

The BEC has also dealt with numerous enquiries from wood-processing companies trying to reduce costs of both waste management and energy by using sawdust and off-cuts to generate their own heat or to produce fuel pellets or briquettes for sale. In addition to providing information via the website and enquiries services, BEC works with Regional Development Agencies and the Forestry Commission's woodfuel officers at local and regional levels – attending shows, giving seminars and producing information sheets. BEC has already developed a strong reputation among other organisations, and has advised the Carbon Trust, the Renewable Energy Association, Defra, the Energy Saving Trust and regional woodfuel producer groups.

For more information, visit
www.biomassenergycentre.org.uk

Cost comparison of fuel types, March 2008 prices*

Fuel	Price	Price per kWh
Heating oil	50p per litre	4.9p
Mains gas	2.5p per kWh	2.5p
Woodchip (30% moisture content)	£70 per tonne	2.0p

BIOMASS Energy Centre

* Updated regularly on the BEC website.