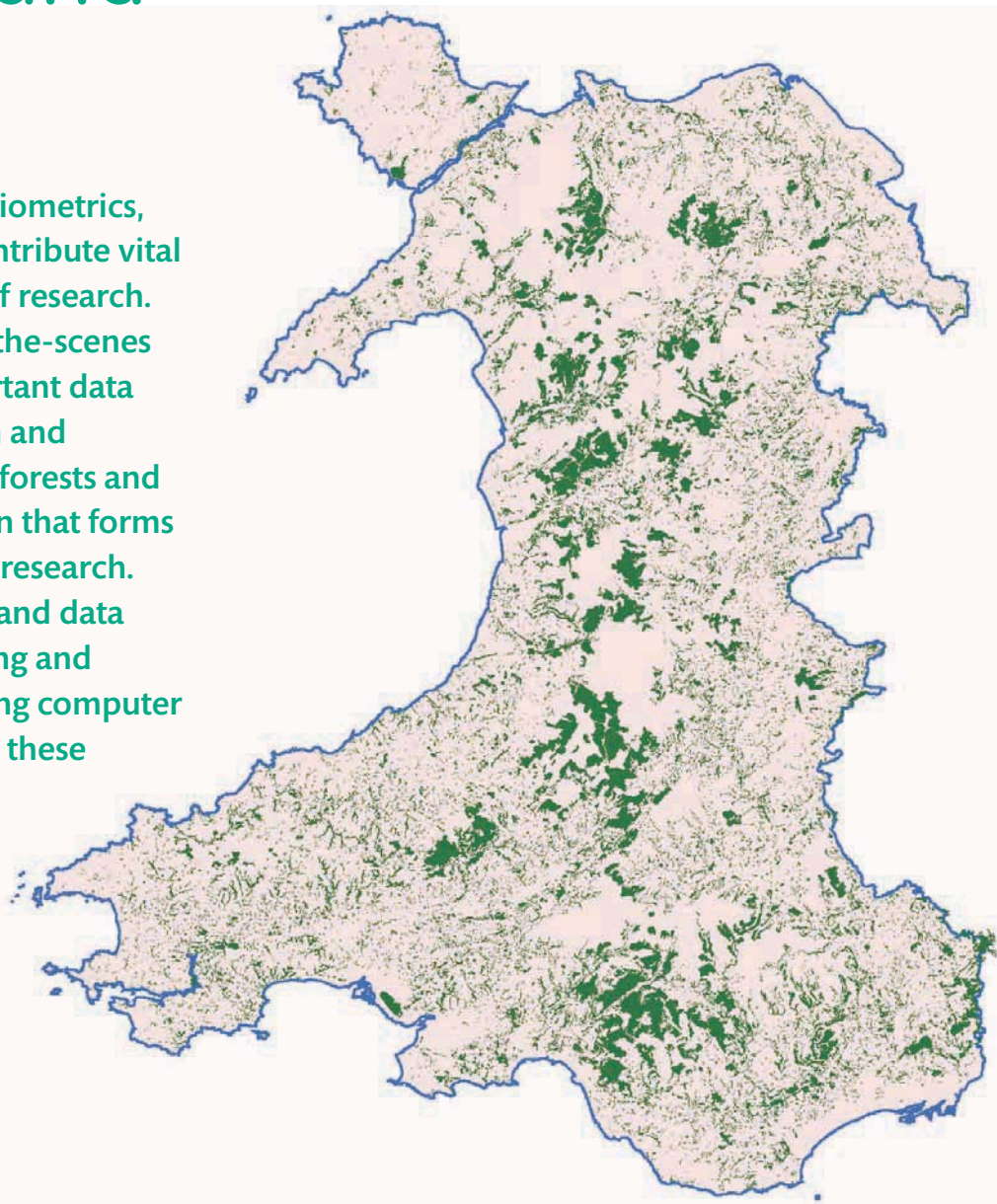


Biometrics, Surveys and Statistics

Our teams working on biometrics, surveys and statistics contribute vital support to many areas of research. Often playing a behind-the-scenes role, they provide important data such as the size, location and composition of Britain's forests and woodlands – information that forms the foundation of much research. From statistical analysis and data management to surveying and measurement, developing computer software and modelling, these roles are crucial for ensuring our woodlands are able to contribute effectively to today's key issues of climate change, biodiversity, economic viability and social value.



Woodland surveys

Considerable work this year has focused on the National Forest Inventory and the Production Forecast, both key Forestry Commission outputs that support policy and the forestry industry. We used recent aerial photographs to assess the locations and types of woodland and, for the first time, were able to plot woods as small as half a hectare. The woodland map for Wales has been

completed (above), and those for Scotland and England will be available in autumn 2009. These woodland maps will be followed up by carefully designed field sampling to collect more detailed information on Britain's woodlands.

Production forecasting

Having identified the species, measured the trees, and assessed their age, we then use computer models to estimate the size and growth rate of all Britain's forests. Knowing when trees are due to be harvested, we use another set of models to estimate the potential amount of timber. One important task this year has been to simplify and increase the efficiency of these models and provide more options for forest management, as forests are being used in more complicated and diverse ways. The models will benefit forest managers and planners, who will find them easier and quicker to run when assessing production scenarios.



Statistical analysis and support

Our teams provide essential help to colleagues on statistics, database management, software development and geographic information systems, as reflected in the scientific outputs and practical tools described elsewhere. In addition, we also take forward the science of statistical analysis in its own right. For example, recent research explored experimental and survey data to find relationships between seedling growth, deer browsing and vegetation within woodland ecosystems. The aim of this work was to advise foresters on how to minimise the effects of deer browsing during woodland establishment.

We carried out two studies: a detailed experiment at one site and a survey of different woodlands at another site. We then applied statistical models to the results to predict the risk of browsing from site characteristics such as the vegetation cover and the numbers and type of deer observed in the area. The findings have helped to improve understanding of the complex interaction between deer browsing and woodland vegetation.

Biomass energy

As a sustainable source of renewable energy, woodfuel is an increasingly important forest product. In response to the growing interest in renewable fuels, the Biomass Energy Centre (BEC) was launched in 2006 and is managed by Forest Research on behalf of the Forestry Commission, the Department for Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change (DECC). It provides an independent and authoritative source of information and advice on all aspects of bio-energy. In the past year, we have added the European technical specifications for solid biomass to the BEC website, and a Biomass Environment Assessment Tool from Defra and the Environment Agency. Interest in the website and BEC enquiries service has grown quickly over the last twelve months, with a total of over one million page hits and 3000 enquiries on a wide range of subjects associated with the production and use of biomass fuels. Visit www.biomassenergycentre.org.uk



Ecology

Our ecologists undertake applied research to provide an ecological basis for the sustainable management of forests, woodlands and associated land uses. Recent projects feature conservation and management of woodland species (including alien and invasive vertebrates) and genes; management of wooded and open habitats within forests, and the impacts of herbivores upon them; development of a landscape ecology approach to wooded, rural and urban landscapes; and the synthesis and use of ecological knowledge, including biodiversity indicators. Our research is conducted for policy makers, forest and land managers in Britain and the European Union.

Landscape connectivity

Our landscape ecology research focuses on validating the principles of landscape connectivity – the degree to which the landscape allows or hinders species movement – and developing tools to support forest restoration policies. We recently completed two collaborative projects on landscape connectivity for the Department for Environment, Food and Rural Affairs (Defra) and partners: a literature review considering 'Which landscape features affect species movement and dispersal?', carried out with the Centre for Evidence-Based Conservation at Bangor University; and testing 30 methods of assessing landscape connectivity, in collaboration with the Centre for Ecology and Hydrology (above right: group discusses landscape measures for the conservation of Black Grouse). Following this analysis, we recommended a connectivity indicator to assist biodiversity reporting. This has now been approved

for application as part of the UK contribution for European biodiversity reporting in 2010. The contract reports are available from the Defra website; for more information on FR's work on this topic visit

www.forestresearch.gov.uk/landscapeecology

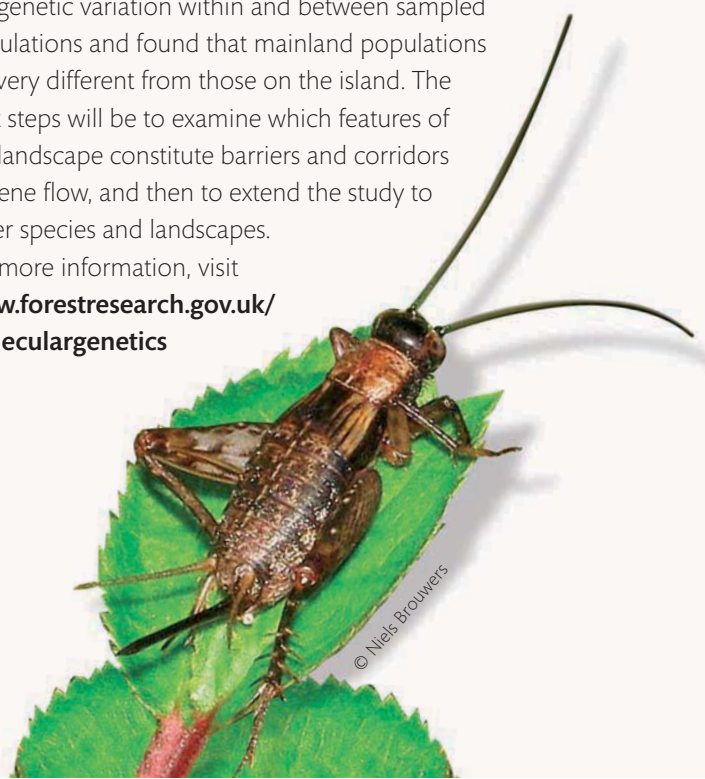


Molecular genetics

Some land use policies assume that the creation of 'corridors' between different habitat patches ensures genetic connectivity, but there is little data to support or refute this. A recent research project has brought together our expertise in both molecular population genetics and landscape ecology to test this idea. We carried out a study on the Isle of Wight using the wood cricket (*Nemobius sylvestris*, pictured below) as a model woodland species. The island has a patchwork of fragmented forests separated by a range of possible barriers to gene flow. We developed microsatellite markers to determine the genetic variation within and between sampled populations and found that mainland populations are very different from those on the island. The next steps will be to examine which features of the landscape constitute barriers and corridors to gene flow, and then to extend the study to other species and landscapes.

For more information, visit

www.forestresearch.gov.uk/moleculargenetics



Deer management

Deer are often regarded as an iconic element of British wildlife, but they can have detrimental impacts on our natural heritage, including biodiversity, and on the sustainability of land management. It would be useful to be able to predict how deer populations will respond to future changes in climate and land use, and how their population sizes and health are related to environmental conditions. Our work for the Deer Commission for Scotland, in collaboration with the Macaulay Institute, is developing methods to assess deer population health that will provide such understanding and can be easily and reliably recorded by deer managers. The methods are being tested on study sites with differing climatic conditions, habitat types, management objectives and animal densities. The criteria being assessed are consistency, utility and practicality. For more information visit www.forestresearch.gov.uk/deermonitoring



Alien and invasive vertebrates

We have been researching the management of grey squirrels for some years, and our current focus is the development of immuno-contraceptive methods, partly in conjunction with The Food and Environment Research Agency (formerly Central Sciences Laboratory). We have now extended our work to consider other possible vertebrate threats to woodland biodiversity and timber production, and a scoping study has identified several newly established or potentially expanding species. We are examining evidence for the degree of threat from these, starting with the risk of potential expansion of the edible dormouse (*Glis glis*, pictured above), and the development of monitoring and management techniques for wild boar (*Sus scrofa*) in woodland.

Environmental and Human Sciences

The past year has seen an increasing number of projects spanning the range of disciplines within environmental and human sciences. This is a reflection of both customer-driven demand and our researchers' concern to produce outputs highly relevant to forestry stakeholders. Our research projects are widely varied, from developing a tool to model air quality and human health before and after greenspace establishment, to providing best-practice guidance on how and when to harvest stumps and roots for bioenergy. Here, we highlight some examples of recent work.

Forest carbon and greenhouse gas balances

This year, we carried out a review entitled *The Carbon and Greenhouse Gas (GHG) Balance of UK Forests*. With input from a multidisciplinary team of researchers, the review summarises key information on carbon stocks and fluxes, and the fluxes of other greenhouse gases in UK forests, and how they are affected by forest dynamics, management and operations. It examines key information on forest carbon pools, looking in turn at trees, debris and litter, and soil carbon, and also discusses the carbon stocks and fluxes related to harvested wood products and the potential of wood substitution. The review considers all available information on the fluxes of the three important greenhouse gases from forest soils – carbon dioxide, methane and nitrous oxide – and shows available

information on the fluxes arising from forestry operations. GHG emission data were incorporated into calculations to model GHG emissions and carbon balances of example forest management cycles. For further information, visit www.forestresearch.gov.uk/carbon



Forest soils and biodiversity

This year we completed the UK's contribution to Biosoil, a project co-funded under the European Union (EU) Forest Focus Regulation to examine the feasibility of systematically monitoring forest soils and biodiversity at a European scale. For Great Britain, this involved the detailed soil sampling and chemical analysis of 167 forest plots distributed across Scotland, England and Wales. We submitted the data to the EU at the end of December 2008. This provides a very valuable baseline for evaluating the current condition of forest biodiversity and soils, including soil carbon stocks. It will also enable the assessment of any future changes to forest soils and biodiversity. For further information, go to www.forestresearch.gov.uk/biosoil



Woodland heritage services

In 2008, we launched the Woodland Heritage Services Group, offering specialist advisory services to managers of heritage projects involving woodland. The Group features a wealth of archaeological and ecological knowledge, plus technical expertise in modern remote-sensing surveys and mapping, backed up by a solid understanding of woodland management. The Group advises customers on heritage protection during forest operations and in the development of management plans. All aspects of the historic environment are included: from advice on individual veteran trees and archaeological features (e.g. WWII storage depot pictured below), to operational practices for historic landscapes. The Group can also carry out light detection and ranging (LiDAR) surveys to identify archaeological and other features beneath the woodland canopy, and has carried out several successful surveys this year. For further information, see

www.forestresearch.gov.uk/woodlandheritageservices

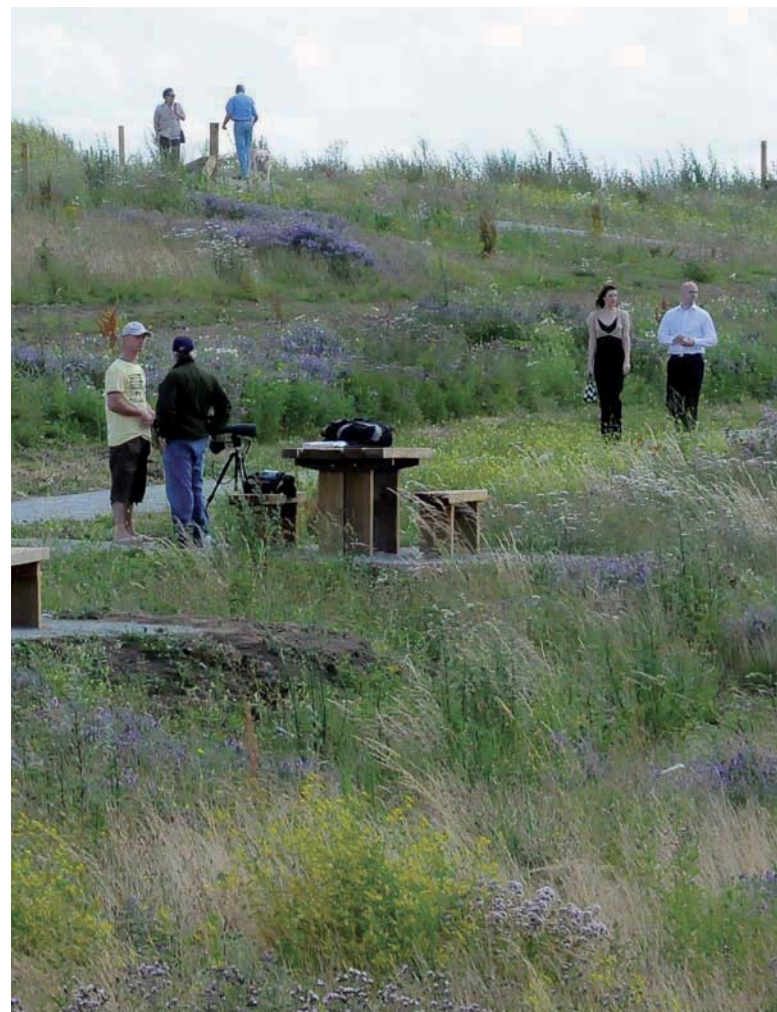


Greenspace impacts and sustainability

We have developed an interdisciplinary approach to monitoring and evaluating the impacts and sustainability of greenspace. Named Methuselah, the strategy uses primary data collection, such as interviews and site management records at a network of sites, and national datasets. We carried out field tests of Methuselah at a sample of regeneration sites to assess their accessibility for leisure and recreation, the types of visitors using the sites and whether existing records could be used more effectively to demonstrate their impacts. With further development, Methuselah will help the Forestry Commission and others to evaluate the impacts and outcomes of regeneration activities from social, environmental and economic perspectives.

For more information, go to

www.forestresearch.gov.uk/methuselah



Forest Management

Our forest management researchers are responsible for research and development covering the sustainable management of the forestry-wood chain. A strength of this group is the extent of its international collaboration, for example between tree-breeding researchers and colleagues in Canada. This has helped us to improve methods for tissue culture and cryopreservation of Sitka spruce, as well as increasing our knowledge of the Sitka spruce genome. Also this year, we have provided guidance for forest managers confronted with meeting varied demands plus the need to adapt forests to predicted climate change. Here, we offer a taste of this work.

Guidance on stump harvesting

There is increasing interest in using forest biomass as an alternative energy source for power plants. As around 25% of the mass of a tree can be in its stump and roots, attention has turned to the possibilities of stump harvesting as a source of biomass. In a preliminary study in south Scotland, just under 70 per cent of the stumps on one site could be harvested. However, the carbon benefit of using stump wood to offset fossil fuel consumption must be balanced against risks such as loss of soil carbon after stump removal. Other potential drawbacks include increased soil erosion, soil and water acidification, and reduced stream water quality and soil fertility. To help manage these risks, we have issued interim guidance on site selection and good practice for stump harvesting.

We are also undertaking experimental work to provide improved data on the longer-term effects of this new practice. For more information visit

www.forestresearch.gov.uk/stumpharvesting



Short rotation forestry

Short rotation forestry can be used to produce biomass from fast-growing tree species. These could include native species such as ash and non-natives such as eucalyptus (below) which has grown well in arboreta and privately funded trials. Over the past year, interdisciplinary work has progressed to field experiments to fill important knowledge gaps. We are establishing a network of new trials in Scotland and England to examine the viability of short rotation forestry and collecting data from relevant existing plantings. Taken together, these sources will provide best practice guidance on short rotation forestry, including its carbon balance, economic viability and environmental impacts.



Tree establishment

Many factors influence the success of tree establishment and need to be taken into account when planting trees. Until now, existing knowledge has been contained in many technical and scientific publications that may not be easily available to a forest manager. Therefore, we have developed a new tool to make this simpler – the



Establishment Management Information System (EMIS). This integrates existing knowledge on the factors influencing tree establishment in upland forests to provide site-specific best-practice guidance. The user inputs site information to calculate the environmental variables that affect species choice and EMIS identifies appropriate management practices.

We will update EMIS regularly to include new research findings. For example, EMIS will include recent EU research on forest management to reduce the use of herbicides in Europe's forests. A full publication can be found at www2.clermont.inra.fr/cost-e47/

Improved management of native woodlands

A major aim of current national forest policy is to conserve and expand Britain's native woodlands, not least because of their key contribution to biodiversity. As woodland development can be divided into a series of distinct structural phases, a sustainable forest should, in theory, contain a proportion of each phase. Each phase is characterised by features such as the amount of young seedlings, the number of big trees and the occurrence of deadwood. We have recently improved the current description of these phases for Scotland's native pinewoods. This will allow us to define more accurately the existing structure of a specific forest, and to identify appropriate silvicultural techniques that will take the forest towards a more favourable state. An example is given at www.forestresearch.gov.uk/glenaffricplan



Tree Health

Research into tree health has the dual function of underpinning authoritative advice about a wide range of established tree disorders, and assessing the risks of newly detected or listed quarantine pests and pathogens. Information about our recent research findings is available on the Forest Research website. Heightened concern about how introduced organisms and climate change are affecting tree health makes these webpages a popular source of information. Here, we highlight our advice services and some key areas of recent research.

Pests and diseases – new and old

This year Forest Research entomologists and pathologists responded to over 1200 enquiries sent into the Tree Health Advisory Service, answering information requests and identifying pests and pathogens. This included on-site visits for disease diagnosis and safety assessments of potentially hazardous trees. Many enquiries were about horse chestnut (*Aesculus hippocastanum*) because of the highly visible impact of leaf miner (*Cameraria ohridella*) and bleeding canker disease. We have developed a real-time polymerase chain reaction diagnostic tool for faster and more reliable detection of the pathogen *Pseudomonas syringae* pv *aesculi*, which causes the bleeding cankers. See www.forestryresearch.gov.uk/bleedingcanker

We also provide scientific support to underpin the Forestry Commission's Plant Health Service. Most recently this included phytosanitary work on pine lappet moth (*Dendrolimus pini*, pictured above right) in Scotland; interception of timber infested with quarantine pest pinewood nematode (*Bursaphelenchus xylophilus*); and contributing to pest risk analyses for pests including

Phytophthora ramorum (cause of sudden oak death), oak processionary moth, and the ash dieback pathogen *Chalara fraxinea*.



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Acute oak decline

We have been investigating the causes of the increasing numbers of native oaks with extensive stem bleeding leading to acute decline. On some sites many trees are affected and die within just 3–5 years of the first symptoms. Samples from affected trees have shown that the bleeding (pictured below) is frequently associated with the presence of bacteria, particularly those within the genera *Serratia* and *Brenneria*; trees compromised by the bleeding lesions may also then be attacked by beetles. We have inoculated oak saplings to determine whether bacteria are the immediate cause of the bleeding. It may be several months before these tests yield results, but molecular analysis of *Serratia* shows it to be very similar to a species of bacterium recently found causing bleeding and dieback on some Mediterranean oak species. For more details, see www.forestryresearch.gov.uk/oakdecline



Stump treatment

Heterobasidion annosum, which causes root and butt rot, is another serious pathogen of commercial conifer forestry; in Europe estimated losses exceed €800 million per year. However, plantations can be treated to prevent infection by applying chemical or biological control agents to stumps created during thinning or clear-felling. We are testing a biological stump treatment based on the fungus *Phlebiopsis gigantea* (Rotstop®), which could be effective on both spruce and pine stumps, unlike the current UK-registered treatment (PG Suspension), which is approved only for use on pine. We have also developed computer software to aid foresters in judging when stump treatment is needed to control *Heterobasidion*, by evaluating the level of risk based on soil type, climate and tree species. See www.forestresearch.gov.uk/rootandbuttrrot



Increasing impact of red band needle blight

Red band needle blight (*Dothistroma septosporum*) is an economically important and serious disease affecting several coniferous species, especially pines (pictured below). Its spread and severity has continued to increase this year on Corsican and lodgepole pine in England and Scotland, and it has now been found also on Scots pine at several sites. Our research shows that both mating types of the fungus are present in Britain, with initial studies suggesting considerable genetic diversity. The ability of the pathogen to change and adapt, combined with favourable climatic conditions, is a likely driver of the current epidemic, increasing the distribution and host range of the pathogen. It also highlights the risks of invasive pathogens to Britain's plantation forests, including our native pine species. More information is available at www.forestresearch.gov.uk/redbandneedleblight

