COFORD ANNUAL REPORT 2009

COFORD

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COFORD's activities are funded by the Irish government under the National Development Plan.

Chairman's report

Michael Lynn

The year under review, 2009, was difficult for the wood processing sector in Ireland, as demand fell off and processors were forced to seek new markets in Great Britain and further afield. COFORD also faced an agenda of change – following the announcement in Budget 2009 that the Government intended to move the work and staff of COFORD to the Department of Agriculture, Fisheries and Food. During the year the council and I spent a good deal of time seeking further clarity on the nature of the changes, and in particular how they would impact on the work of COFORD and its ability to continue to provide essential information and outputs for the wider forestry sector. By year- end the situation had become clear: the well-respected COFORD brand was to be maintained, the forest research programme was to be administered directly by the Research Division of the department, but with continuing input by the council on scope and funding, and the vital role of the Council in supporting the development of the forest sector would continue.

Development was indeed an increased focus of the Council. The three groups dealing with the afforestation programme, roundwood demand and roundwood supply, all had a productive year. Beginning with the afforestation group - chaired by Donal Whelan of the Irish Timber Growers Association – it was tasked with identifying constraints to the national planting programme and identifying ways to overcome them. It published a series of six papers in October dealing with key aspects of the afforestation programme, under the banner *Forestry 2030*. The papers were widely distributed among the forestry sector and in policy circles, and it was worthwhile to see that they had a resonance with the forestry aspects of the *Renewed Programme for Government* which came later in the year. One of the central arguments in the papers, the need to bring the afforestation programme back to the 10,000 ha per level and beyond, was reflected in a 10,000 ha per year target in the government programme. In scoping and drafting the papers the Afforestation Group was able to call on scientists working in the national forest research programme, the COFORD executive, as well as other experts in the COFORD sphere. All in all the exercise was an example of how research-based information can be used to support strategic objectives of the forestry sector.

Roundwood supply and demand are critically important issues for the forest sector on the island of Ireland. The Supply Group, under Mike Glennon of Glennon Brothers, made substantial progress in addressing its objectives of quantifying potential roundwood supply and how to mobilise it in a cost effective way. The main output was the updated and revised forecast of roundwood supply from private sector forests, published by COFORD during the first half of the year. Processors and growers had a direct input to the framing of the forecast and its presentation. Such processes are essential to get buy-in from all parties, and for the data to be understood and correctly interpreted. Work progressed in the group on a comprehensive all Ireland roundwood supply forecast, which will be available in the first half of 2010. As in the case of the afforestation, the group was able to call on the assistance of a COFORD funded project, in this case FORECAST, and the work of the Forest Service, to provide the actual forecasts.

Roundwood demand forecasting was led by Willie Fitzgerald of Enterprise Ireland. It established current and likely future demand for roundwood for sawmilling and board manufacture in the Republic and Northern Ireland based on survey and market information. Information on wood energy demand will be developed for the island as a whole in early 2010, in cooperation with the Sustainable Energy Authority of Ireland.

We plan to bring together the supply and demand forecasts in mid 2010 and to progress further on addressing ways to reconcile demand and supply dynamics in the context of infrastructural, sales and other issues.

This report also outlines the service provision, information transfer and forest research functions in the COFORD sphere. These were provided within a budget of just over €4 million. Given the annual €1.9 bn scale of the forest sector it is a modest investment, but one that has a demonstrated value for both the private and public sectors. I am confident that the role of the COFORD research and development programmes and of the council will grow in significance, and that the forest industry will play an important part in the overall economic recovery.

Director's report

Dr Eugene Hendrick

COFORD's activities in 2009 covered the funding of the national forest research programme 2007-2013, information transfer and the services to the forestry sector and public outlined in this report.

The forest research programme covered all of the thematic areas, with the exception of forest recreation, where a call for proposals was postponed owing to curtailment of the planned expansion of the forest research budget under the NDP. Work in the other areas led to a number of significant outcomes, including the forecast of roundwood production for the private forest sector. The forecast was rolled out in a series of workshops where accompanying software and GIS-based tools were demonstrated and made available. National reporting on forest carbon stock change, including the 2008 report under the Kyoto Protocol, were made to the EPA and the United Nations Framework Convention on climate change using the systems developed in the CLI-MIT programme. Without the investment made by COFORD in climate change research, the ability to report on carbon stock change would be greatly diminished, leaving the level of forest sequestration underreported, and thereby increasing the cost burden for compliance with national greenhouse gas emission targets.

The interaction of forest cover with water quality and yield are of continuing interest to practitioners and policy makers. On the policy side, COFORD staff and researchers in the funded programme were closely involved in developing the Programme of Measures and Standards for forests and water under the Water Framework Directive. COFORD recognised the need for continued investment in the research in this area by joining with the EPA to fund a long-term programme of work on forest and water interactions at the catchment level. A consortium led by UCD, and involving UCC and NUIG was awarded the work, which is reported on under the HYRDOFOR project. The work will carry forward some existing sites, such as Burrishoole, Co Mayo where detailed assessment of silt and phosphorus dynamics in a clearfelled forest catchment have been underway since 2004, in coloration with Coillte, the Marine Institute and the EPA.

Continuity of tree and forest growth data and records of environmental variables are of great utility and importance in relation to growth and yield modelling, and in assessing the interaction of forests with the environment. The forest sector in Ireland has a well-documented series of trials and forest growth plots, some of which date back to the 1970s and earlier, most of which are based in the Coillte estate. As outlined in the report, this valuable resource is being maintained and documented under the auspices of the NATFOREX project at UCD, in collaboration with Coillte and other parties. The project is also tasked with validating and archiving several decades' worth of data in electronic format, and will be made available to the wider research community.

COFORD staff attended all six meetings of the UN Framework Convention on Climate Change, including the Copenhagen Conference, served with Sustainable Energy Ireland and other agencies on the Bioenergy Working Group. COFORD worked closely with industry and agencies to develop a national wood fuel quality assurance scheme, and continued its involvement with Teagasc and SEI in Bioenergy 2009. As the report outlines we also compiled the national catalogue of seed stands and worked on the British and Irish Hardwoods Improvement Programme, as well as EUFORGEN (European Forest Genetic Resources Programme). We also undertook the Joint Forest Sector Questionnaire which compiles wood harvest, use and trade data, on behalf of EUROSTAT and other bodies, and the Joint Wood Energy Enquiry on behalf of the UNECE/FAO Timber Section.

Outsourced services on woodenergy.ie and woodspec.ie continued to attract significant traffic, despite the economic recession. Both are important areas for the future of the forest sector in Ireland and

Finally, COFORD was proud to have been a sponsor of the Meitheal Adhmaid exhibit at the Electric Picnic in September. The exhibit was based around innovative use of wood structures and forms, with interpretative material outlining the environmental value of wood as a carbon store and its role in sustainable construction. It attracted great interest, and based on feedback was highly effective in raising awareness of wood as the building material of the future.

Forest Sector Development

As the representative forum for the forest sector, the COFORD council has expanded its involvement in addressing development issues. Three council groups have been established to address specific development issues. Outlined below are the topics, objectives and outputs of the groups.

1. Supply side production forecasting and needs

Chair: Mike Glennon, Glennon Brothers, with membership drawn from Coillte, Forest Service, Irish Timber Council, Irish Timber Growers Association, Northern Ireland Forest Service and Teagasc

Objectives

- determine the level of roundwood and forest harvesting residue supply potentially available on the island of Ireland on an annual basis from 2009 to 2029.
- identify constraints and needs (including access to and within forests, harvesting capacity and competence, and the regulatory framework) to optimise wood harvest, and ways to address constraints.

Working arrangements and timeframes

- *Initial focus on wood supply forecasting* - at its first meetings in 2008 the group focussed on wood supply issues and agreed timetables and contents:
  - By the end of July 2009, publication of a private sector roundwood production forecast on a county-by-county basis for privately owned forests in the Republic, to 2029, based on the COFORD-funded FORECAST project.
  - By mid 2010, publication of an all-island wood production forecast to 2029 based on Coillte, Northern Ireland Forest Service and Republic of Ireland private sector forecasts, and taking into account wood reuse and recycling levels.
- *Constraints and needs* - the group will address constraints and needs (including access to and within forests, harvesting capacity and competence, and the regulatory framework) to optimise wood harvest, and ways to address constraints. It may commission work on issues such as harvesting and transport capacity needs, review and follow up of findings of the COFORD-funded OptiLog project.

Status and outputs

- The roundwood forecast for the private sector has been agreed and was published by COFORD in 2009 - *Roundwood production from private sector forests 2009-2028. A geospatial forecast*. Henry Phillips, John Redmond, Máirtín Mac Siúrtáin and Anita Nemesova (www.coford.ie/iopen24/roundwood-production-from-private-sector-forests-20092028-p-966655.html).
- GIS and other software tools have been developed to access the forecast (see FORECAST project) and have been released to the public domain in a series of workshops. Further information on the tools is available from forecast@ucd.ie.
- The all-Ireland forecast is expected to be completed by the end of May 2010.
- Constraints and needs have been outlined and will be addressed further in 2010.

2. Demand side forecasting

Chair: Willie Fitzgerald, Enterprise Ireland, with membership drawn from Coillte, the Irish Timber Council and Sustainable Energy Ireland.

Objectives

- determine the likely level of demand for roundwood, sawmill coproducts and harvest residues on the island of Ireland on an annual basis from 2009 to 2029.
- identify policy and market issues that are likely to impact on demand and seek ways to identify synergies between different demand streams.

Working arrangements and timeframes

- Focus on establishing level of future demand - the group focussed on setting out a framework and a reporting timetable, envisaged as the end of 2009/early 2010, to establish:
  - likely levels of demand for roundwood, sawmill coproducts and residue streams from forest harvesting and recovered wood, over the period to 2020, taking into account findings on the supply side,
  - the ability to source this material on the island of Ireland and the level of imports of raw material and finished product that may be required to meet future needs,

- working relationships with the Bioenergy Working Group convened by the Department of Communications, Energy and Natural Resources which is examining woody biomass supply potential and matching supply to policy needs.

Status and outputs

- A roundwood demand model has been developed for the boardmilling, sawmilling and wood energy sectors.
- Preliminary results were presented at the National Forestry Conference in 2010.
- The group will report by mid 2010.

3. Scientific and technical constraints on the attainment of the national afforestation programme and sustainable forest management

Chair: Donal Whelan, Irish Timbers Growers Association, with membership drawn from Forest Service, None-so-Hardy Nurseries, Irish Farmers Association, Northern Ireland Forest Service, Coillte and Teagasc.

Objectives

- identify scientific and technical issues, such as environmental designation, land availability and suitability, land valuation and others that constrain the attainment of the national afforestation programme and sustainable forest management.
- identify, through a series of COFORD position papers based on research and related outcomes, the background to and validity of constraints and ways to effectively address them.
- identify communication channels and means to effectively communicate the COFORD position on the constraints identified and addressed.

Working arrangements and timeframes

- Focus on identifying and prioritising constraints:
  - the group identified and prioritised the most pressing constraints on the attainment of the afforestation programme and sustainable forest management,
  - the group examined relevant parts of the COFORD portfolio and identified areas where existing and past research findings could address the constraints. The work included an review of relevant COFORD research underway and completed, and set a timetable for completion of position papers by the end of 2009.
- Position papers and communication channels:
  - at subsequent meetings the group reviewed the position papers and decided communication channels and means to effectively communicate them.

Status and outputs

- The group completed its work by addressing the objectives through a series of six papers, formally launched in October 2009, under the *Forestry 2030* banner, and covering the following topics:
  - Irish forestry and the economy.
  - Climate change and Irish forestry.
  - Irish forestry and renewable wood energy.
  - Afforestation - enhancing biodiversity in the Irish countryside.
  - Recreational value of Irish forests.
  - Irish forestry and the environment - a catchment-based approach.

The papers were posted on the COFORD web site at the end of 2009 (www.coford.ie/iopen24/defaultarticle.php?cArticlePath=127_525). They were widely distributed among the industry, policy makers and other decision makers.

Research Programme 2009

COFORD's research programme is broadly grouped into three main thematic areas: establishing and growing forests, harvesting and products; and policy and public goods. Each area is addressed by a number of programmes and projects.

Establishing and growing forests

Establishing and growing forests are core activities of forest management, central to which is the concept of sustainability. Sustainable forest management (SFM) is the underlying principle by which forest management is practised in many countries throughout the world. Since the concept was first introduced in 1992 at the Earth Summit in Rio, SFM has been a key driver of forest research and development programmes. SFM has required a re-examination of the value of forests and the goods and services they provide; also to rebalance the economic, environmental and social aspects of forest management for a more sustainable future.

The projects outlined are concerned with making forest management more sustainable in Ireland, e.g.

- rebalancing the species composition of the forest estate towards broadleaves and mixed species stands to create greater variety in both timber products and enhancement of biodiversity;
- better understanding of the timber yields from private forests so that a sustained yield can be achieved;
- sustaining an experimental infrastructure from which we derive much of our scientific knowledge that underpins policy and management decisions;
- developing new technologies for multi-resource inventories;
- developing planning tools for redesigning forest plantations established on environmentally sensitive sites.

These outputs will provide the necessary guidance and methodologies which will ensure that practices are appropriate for the sustainability of forests and to ensure that they are in harmony with other land uses and the wider landscape.

Forest Reproductive Material

The original objective of the national afforestation programme was to create a resource that would yield a sustained supply of timber to partly satisfy the country's needs and reduce dependence on imports. Initially this led to the establishment of plantations of several fast-growing exotic conifers, especially from western North America. However, recent years have seen a rapid rise in the use of native species, particularly broadleaves, in both commercial afforestation and in the Native Woodland Scheme. Whichever species is used, it is important that planting stock should be well adapted and genetically suited to the site on which it is planted. Attempts to rectify the planting of unsuitable or poorly adapted forest reproductive material is expensive, and the returns on such crops will be far below expectations. Forest owners and managers recognize that the costs associated with using the most appropriate and proven forest reproductive material are small compared to the costs of forest establishment and management. Securing forest reproductive material that is well adapted to Irish climatic and edaphic conditions is fundamental to maintaining the sustainability of the forest resource. COFORD funds the monitoring, testing and evaluation of Irish forest reproductive material through a number of national and international projects.

PROJECTS

ASHGEN: Identifying the scale of suspected hybrid ash (*F. excelsior x F. angustifolia*) in Ireland

BIHIP: British and Irish Hardwoods Improvement Programme

BIRCH/ALDER: Selection and improvement of Irish birch and alder

BROADPROV: Testing and comparing sources and stands of Irish ash, beech and oak

EUFORGEN: European Forest Genetic Resources Programme

QUALIBROAD: Improving the uniformity and quality of broadleaf planting stock

SEEDSTANDS: The national catalogue of seed stands

Silviculture

Forest policy changes made in the 1980s to diversify the species composition of the forest estate resulted in a significant expansion in the area of broadleaved tree species. From a very low base 20 years ago, broadleaves have now reached almost 30% of the annual afforestation programme. This has presented Irish foresters with a challenging situation, as broadleaves are more demanding in terms of site requirements; and are more costly to establish, maintain and subsequently manage than conifers, which have formed the greater part of the afforestation effort to date. Issues such as matching of species to site, planting pure or mixed crops, compatibility of species, shaping, tending and more recently thinning, have tested foresters' silvicultural skills for some time. While much has been learned from practical experience, research has contributed. The BROADFORM and GBREVIEW projects, both of which combine scientific and practical approaches, have provided much needed guidance for forest managers and owners. Experience and experimentation with broadleaves in Ireland is currently being reviewed in the GBREVIEW project. The findings will be published in 2010.

PROJECTS

BROADFORM: Silviculture of new broadleaved plantations: shaping and thinning

GBREVIEW: A review of *Growing Broadleaves*

Forest planning and management

Sustainable Forest Management (SFM) as the basis of the National Forest Standard requires that management decisions are based on an evaluation of economic, social and environmental indicators. The PLANSFM programme - *The planning and implementation of sustainable forest management* - addresses the need for improved access to information and decision support systems required for the sustainable management of the national forest estate. It also addresses the need for access to the results of previous forestry research trials and experiments, bringing added value to the existing data and ensuring the continued maintenance and assessment of existing, relevant experimental sites. The long-term goals of the PLANSFM programme are to support the forest industry through the provision of improved tools to support sustainable forest management, the provision of better quality information about the forest, the best options for sustainable management of the forest using this information, and the provision of forecasts of timber and non-timber outputs at local and regional levels.

In addition to the suite of projects in the PLANSFM programme, COFORD also funded the CLUSTER and FORECAST projects that are addressing issues concerning timber supply from private forests.

PROGRAMMES AND PROJECTS

PLANSFM

FORESTSCAN: Terrestrial laser scanning technology for multi-resource forest inventories

NATFOREX: Establishing a national resource of field trials and a database for forest research and demonstration

PRACTISFM II: PractiSFM - implementation, communication and optimisation

STANDMODEL: Development of dynamic yield models for conifers, broadleaves and mixtures.

TREEMODEL: Development of single tree volume models and stem profile models

WESTFOREST: A GIS-based multi-objective decision support system for the optimal management of forests on sensitive sites

CLUSTER: A cluster based approach for identifying farm forest resources to maximise potential markets

FORECAST: Geospatial forecasts of private sector timber supply

ASHGEN

Identifying the scale of suspected hybrid ash (*F. excelsior* x *F. angustifolia*) in Ireland

PROJECT TEAM

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Muriel Thomasset, Trinity College Dublin and Teagasc

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COMPLETION DATE: June 2010

BACKGROUND

Ash imported from 1993 to 2000 have produced poorly growing plantations in a substantial number of cases. This project investigates whether the planting stock was true common ash (*Fraxinus excelsior*) or natural hybrid material involving another continental species (*F. angustifolia*). These plantations are now seeding. The project is investigating the origin of the imported trees and their interbreeding capacity, as the dispersal of hybrid seed into the landscape may give rise to a wild population that would interbreed with native stock, resulting in genetic pollution of native ash germplasm.

OBJECTIVES

The overall objective is to provide a set of tests that can confirm the hybrid nature of ash that is present in suspect stands in Ireland and their potential to interbreed with indigenous ash.

The specific objectives are:

- to examine suspect ash stands in Ireland using known morphological criteria;
- to examine suspect ash stands in Ireland using known molecular criteria;
- to assess the potential threat of confirmed hybrid material to introgress with native stocks of ash.

PROGRESS

Two sites, one in Dublin and one in Meath, have been chosen for intensive study as well as material from France where natural hybridisation of ash occurs. Several tasks have been completed and data are being analysed. Completed studies include a comparison of flowering time (phenology) and the sex ratio of trees in suspect 'hybrid' plantations and native ash trees. Our studies have shown that flowering period of suspect hybrid ash in plantations can overlap with native trees and that seeds are produced in these plantations. By a paternity analysis of the seeds, we aim to determine whether the seeds were produced by pollen from within the stand of imported trees or by pollen from native trees around the stand. Similarly, we are examining seeds on native trees in hedgerows near these plantations to see if they were sired by pollen from the imported trees. DNA has been isolated from parent trees and statistical analyses of the morphological data, combined with the genetic data is underway to determine the paternity of the seeds collected in the suspect hybrid stands. This will also indicate the level of gene flow from plantation to native trees and from natives to plantation trees.

Seeds collected from suspect hybrid trees have been stratified and are now in germination tests to compare the embryo size and plant development from these seeds compared to native ash. To determine those characters which may be diagnostic for hybrid ash we have studied F1 hybrid ash trees which were produced from controlled crosses. The parameters measured were the density of stomatal cells and leaf morphology traits. In addition, DNA has been extracted from parent and F1 hybrid trees and a molecular analysis is in progress.

Work is underway to develop a 'bar code' approach to genotyping ash using molecular markers for potentially adaptive characters which could distinguish *F. excelsior* from *F. angustifolia* and hybrids; the genes involved affect foliar morphology, drought resistance, bud flushing, and dormancy.

A set of guidelines have been drafted as an aid to identify hybrid ash. The features of hybrid ash are:

- Brown buds are associated with hybrid trees but black buds may are also found.
- Narrow leaflets, about 2 cm wide with a spear form, usually bearing between 7 to 15 conspicuous marginal teeth are typical of many hybrids. Common ash bears at least 20 very small teeth and frequently up to 30.
- Leaflet numbers on sun-exposed branches can be as low as 5, but more typically 7, although some branches can exhibit more leaflets; common ash exhibits frequently 9 to 13 leaflets.
- Tendency to produce leaf and bud whorls of three on the same plane especially on slow growing branchlets and twigs. This is also associated with a round, plump

terminal bud in hybrids. Common ash typically has two opposite leaves with a 'snake head pointed bud'.

- Flowering time in hybrid individuals usually starts earlier, (December-January); common ash tends to flower in mid February to March, or even April depending on climatic conditions during the year.

ACTIVITIES PLANNED

- Sequencing of a comprehensive sample of Irish provenances, continental *F. excelsior* and *F. angustifolia* and hybrid populations using expressed sequence tags (ETS) and Internal Transcribed Spacers (ITS) to provide a potential 'bar code approach' to identification.
- Analyses of paternity determination for progeny collected in hybrid plantations.
- Submit a scientific paper for publication on the characterization of F1 hybrid ash.
- Prepare a set of guidelines to aid in the identification of hybrid ash in a leaflet form, and guidelines on how best to mitigate and manage the problem in plantations.
- Determine the viability of seeds from Irish hybrid plantations.
- Complete the morphological analysis of Irish plantation material to compare with putative hybrid zone material from France.
- Complete the genetic fingerprinting (genotyping) of chloroplast markers for two plantations.

OUTPUTS

Posters

Muriel Thomasset, Gerry Douglas, Trevor Hodkinson. 2008. *Hybrid alien ash in Ireland and its potential for interbreeding with native ash.* Postgraduate Ecology Forum conference 10-12 March 2008 at Trinity College Dublin. Conference book, page 40.

Juan F. Fernández-M., Muriel Thomasset, Trevor R. Hodkinson, Nathalie Frascaria-Lacoste, Gerry C. Douglas. 2008 *Identifying the scale of suspected hybrid ash* (F. excelsior × F. angustifolia) *in Ireland and its potential for genetic pollution of indigenous ash.* Climate Change and Systematics, 1-3 September 2008 at Trinity College Dublin. Conference book, page 24.

Muriel Thomasset, Gerry Douglas, Trevor Hodkinson. 2008. *Hybrid alien ash:* F. excelsior × F. angustifolia *and its potential for interbreeding with native ash under current and future climatic conditions*. Climate Change and Systematics, 1-3 September, 2008 at Trinity College Dublin. Conference book, page 29.

Juan F. Fernández-M., Muriel Thomasset, Trevor R. Hodkinson, Nathalie Frascaria-Lacoste, Gerry C. Douglas. 2008. *Identifying the scale of suspected hybrid ash* (F. excelsior × F. angustifolia) *in Ireland and its potential for genetic pollution of indigenous ash*. Agricultural Biotechnology International Conference August 24-28 2008, University College Cork. Poster 1.18 Book of abstracts, page 8.

Communications

'*Keeping Irish ash pure*' 2008. ScienceSpin No. 31 p10.

M. Thomassett. Seminar day for first year postgraduate at Trinity College Dublin, 25 March 2008: Presentation: '*Hybrid alien ash in Ireland and its potential for interbreeding with native ash*.'

M. Thomasset, T. R. Hodkinson, G. C. Douglas. 2009. *Assessing the potential for introgression of imported ash with native ash* (Fraxinus excelsior L.) Irish Ag. Forum (in press).

G.C. Douglas, M. Thomasset, T.R. Hodkinson. 2009. *Phenology of alien hybrid ash* Fraxinus excelsior × F. angustifolia *in Ireland*. Presentation at Treebreedex meeting Noble Hardwood Trees Breeding Italy (in press).

Report

Muriel Thomasset. 2009. Transfer Report from MSc to PhD Programme at TCD. *Hybrid alien ash: Fraxinus excelsior × F. angustifolia in Ireland and its potential for interbreeding with native ash*.

BIHIP

British and Irish Hardwoods Improvement Programme

PROJECT TEAM (Irish representatives)

Michael Carey (Forestry consultant), Sycamore group chairman
Pat Doody (Coillte), Ash group vice chairman
Gerry Douglas (Teagasc), Sycamore group member
John Fennessy (COFORD), Oak group chairman*
Derek Felton (Forestry consultant), Oak group member
Ted Horgan (Forestry consultant), Spanish chestnut group member
Elaine O'Connor (Teagasc), Birch group member

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COMPLETION DATE: Long term improvement programmes, that will continue for the foreseeable future.

BACKGROUND

The British and Irish Hardwoods Trust (BIHT) was created in 2009 but has its origins in the British Hardwoods Improvement Programme (BHIP), which was formed in 1991. It is an informal association of landowners, nurserymen, forestry consultants, timber merchants and researchers in Ireland and the UK. Work is carried out through species groups for ash, birch, cherry, oak, Spanish chestnut, sycamore and walnut. The aim is to improve the form and quality of the species selected through reduced rotation length, increased volume, enhancing resistance to pests and diseases, and to ensure a broad genetic base in order to maintain resilience to future climate change. The method used is traditional selection and breeding. It gained charitable trust status about five years ago in the UK, and in Ireland in early 2009.

OBJECTIVE

The programme operates through individual species groups with a central executive co-ordinating the programme. The objective is to improve the quality and productivity of the most important broadleaved species in Britain and Ireland by continuous improvement through conventional breeding programmes.

PROGRESS

Plus tree selections are almost complete in most species, while earlier progeny/breeding seedling seed orchards in oak, cherry and ash are being assessed at regular intervals.

The first series of oak seedling seed orchards, of which there are eight, including one in Ireland, were measured during 2007/8. Results were published during 2008.

Limited seed production has commenced in the ash seedling seed orchards, and they are now due for roguing.

The birch indoor clonal orchards are producing adequate seed to supply demand in Scotland. Similar indoor orchards are being developed at Kinsealy by Teagasc. Commercial quantities of seed will be produced over the next couple of years.

A limited quantity of cherry seed became available from the BIHIP programme in 2009.

The collection of sycamore and Spanish chestnut selected clonal material for establishing seed orchards was also completed in 2009.

During 2008/09 the Irish element of the British and Irish Hardwoods Trust was established in Ireland. The purpose of the trust is to raise funds to finance the full development of the programme. During 2009, genetics advisor Dr David Boshier, Research Coordinator at BIHIP, worked on the development of breeding strategies for a number of the species, including ash and cherry. The development of the oak programme strategy is expected to be completed in early 2010.

ACTIVITIES PLANNED

A full review of BIHIP will take place in early 2010. The outcome of the review is expected to be published during 2010 and consideration of its implementation will be an important component of the annual general meeting to be held in the autumn.

The Management Committee will meet in Northern Ireland in May 2010, hosted by the Agri-Food and Bioscience Institute at Loughgall, Co Armagh.

OUTPUTS

Plans are well advanced for a new database on all BIHT plus trees and field trials identified in the programme across Ireland and the UK, It will provide a permanent record of this valuable breeding material for the first time. Plus trees will be listed by species, location, quality, sex, dimensions, and ownership. It will be continually updated as new plus trees are identified.

BIRCH/ALDER

Selection and improvement of Irish birch and alder

PROJECT TEAM

Dr Ellen O'Connor, University College Cork*
Oliver Sheridan, Teagasc
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COMPLETION DATE: December 2010

BACKGROUND

In recent years the demand for native species has risen in accordance with increased use of broadleaves in afforestation. The birch improvement programme (*Betula pendula* and *B. pubescens*) began in 1998 with a view to providing additional native species with timber potential to the Forest Service schedule of acceptable species. The improvement of alder (*Alnus glutinos*a), a species included in the Forest Service schedule, was initiated in 2005. In the recent COFORD review[1], alder and birch were confirmed as native species of high potential for improvement in the Irish context.

OBJECTIVES

The overall objective of the research is the development of a sustainable supply of improved, adapted and healthy seed within the framework of the EU Forest Reproductive Material regulation. The specific stepsare:

- Locating the best plus trees as a basis for the improvement programme;
- Establishing seed orchards, and clone banks;
- Establishing progeny trials to assess the genetic value of plus trees.

PROGRESS

Location and collection of new material for the breeding programmes is ongoing. In 2009, grafts from 16 new birch and 26 alder plus trees were successfully established.

Clones of 81 alder genotypes, collected in 2006 and 2007, were used to establish a clone bank at Teagasc Research Station, Kinsealy. The birch clone bank was extended using recently collected clones.

The breeding values of the birch and alder plus trees are being tested in field trials. Two alder progeny tests, using seed collected from the 2006 plus trees, were established in 2008 and a third was established in 2009 in Sligo. Trials are monitored for growth and survival; quality assessments will be introduced at a later date. Over the winter of 2008/2009, height, diameter and quality assessments were carried out at two progeny/provenance birch trials that had been established in 2001. Results indicate significant differences between families (Figure 1).

Indoor seed orchards for both birch and alder were established (Figure 2). The alder seed orchard is based on clones of selected plus trees. The birch seed orchard was mainly based on selections within the progeny trials, based on early results.

ACTIVITIES PLANNED

The best birch trees from the best families, based on the latest data from the progeny trials, will be used to update the seed orchards.

The flowering and pollen release dates of the seed orchard material will be recorded to ensure that the flowering period does not overlap with that of the clones outside. The number of male catkins, and thus pollen contribution, from each clone will be noted.

In 2010, the seed from individual clones in the seed orchard will be collected to determine the contribution of each clone to the overall production of seed.

The alder trials will be assessed for growth and survival and monitored for pests and diseases in 2010.

OUTPUTS

Hemery, G., Clark, J., Aldinger, E., Claessens, H, Malvolti, M., O'Connor, E., Raftoynnis, Y., Savill, P. and Brus, R. Growing scattered broadleaved tree species in a changing climate – risks and opportunities. *Forestry Advance Access* published on 24 December 2009. doi:10.1093/forestry/cpp034.

Active participation in BIHIP birch group.

[1] Cahalane, G., Doody, P., Douglas, G., Fennessy, J., O'Reilly, C. and Pfeifer, A. 2007. *Sustaining and developing Ireland's forest genetic resources - an outline strategy.* COFORD, Dublin.

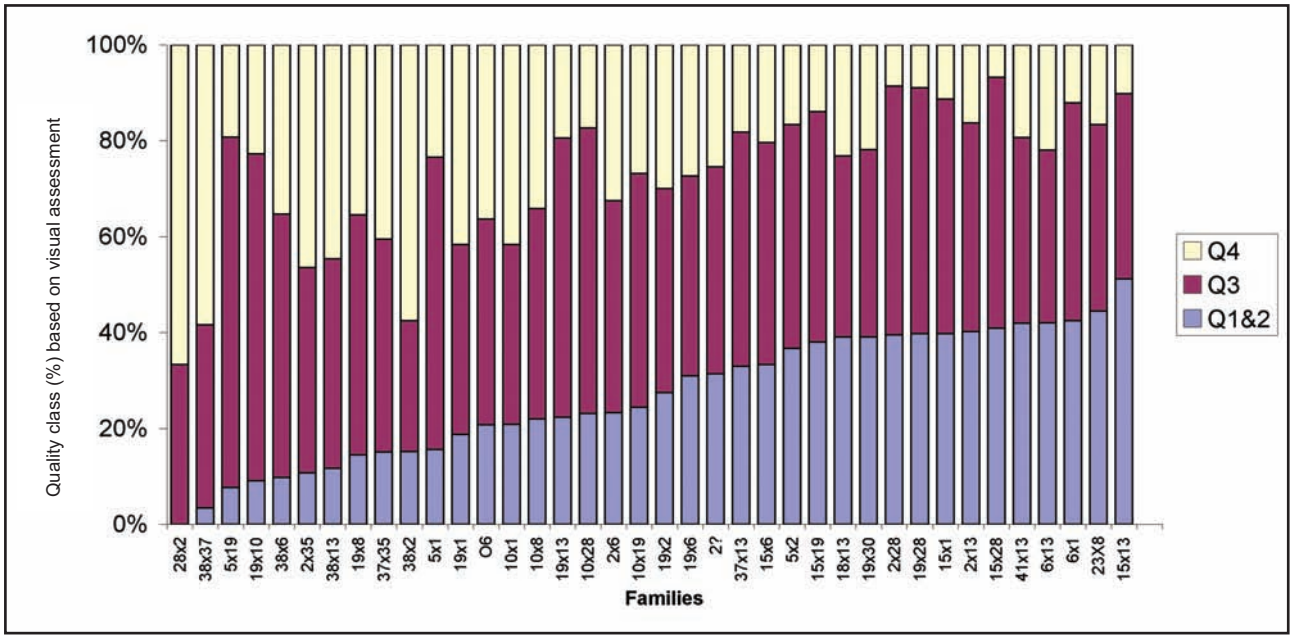

Figure 1: The proportion of different quality values within birch families at age eight. (Q1&2 = very good and good; Q3 = moderate; Q4 = poor quality).

Figure 2: Indoor alder seed orchard at Teagasc Research Station, Kinsealy.

BROADPROV

Testing and comparing sources and stands of Irish ash, beech and oak

PROJECT TEAM

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COMPLETION DATE: April 2010

BACKGROUND

Ash (*Fraxinus excelsior*) is one of the most commonly planted broadleaves. The stem quality of many ash stands is variable, but whether this is due to genetic differences in seed source or other biotic factors is not known. Currently most of the ash originates from hedgerow or parkland trees, because there are few ash seed stands, and ash plantations may not consist of local material. (A seed orchard of phenotypically selected individuals has recently been established but is not yet in production.)

Beech (*Fagus sylvatica*), although not a native species, has been planted in Ireland since the 1600s at least and plays a role in broadleaf forestry in Ireland. In the past, seed price rather than suitability to Irish climatic conditions determined the source of most imported seed, which resulted in low survival and poor quality stands.

Oak (*Quercus petraea* and *Q. robur*) are important native species that occupy a significant proportion of the planting programme. While it is Forest Service policy to use home-collected seed, there are good and bad native sources. For this reason it is necessary to identify good seed sources, but also to identify those to be avoided.

OBJECTIVES

- to establish a series of trials comparing the growth and stem form of a range of ash seed sources, including Irish roadside trees, Irish seed stands and several continental seed sources.
- to establish a series of beech field trials comparing the growth and stem form of selected home-grown seed sources with continental seed sources.
- to establish a series of field trials to test the productivity and quality of a range of both registered Irish oak seed stands and 'source identified' Irish seed sources.

PROGRESS

Ash seed was obtained from 18 sources including eleven from Ireland (two each from Denmark, Germany and the UK and one from the Netherlands). Seed was stratified and sown in March 2008 in containers in a heated glasshouse. In July plants were moved outside. Due to close spacing in the containers, some plants overtopped others resulting in a wide range of plant sizes at the end of the growing season. One trial was planted at Camolin forest, co Wesford, and the second at the Manch estate in Co Cork.

Beech seed from 17 sources, including 12 home-collected as well as one source each from the Netherlands, Denmark, Belgium, Germany and the UK was sown in containers in a heated glasshouse in March 2007. Plants were removed from the containers and lined out in a nursery bed due to difficulties with sites combined with the lateness of the season. In December 2008 trials were established at Camolin, Co Wexford, and at the Manch estate, Co Cork.

Seed from 11 registered Irish oak seed stands and 10 'source identified' stands were sown in containers in a heated glasshouse in the spring of 2008. Plants were moved out of the glasshouse in July and hardened-off. As with the ash material, the close spacing of the cells in the trays resulted in the more vigorous plants overtopping the other individuals, resulting in a wide range of plant sizes. In December 2008 trials were established at Camolin, Co Wexford, and at the Manch estate, Co Cork.

ACTIVITIES PLANNED

Survival and height assessments will be carried out at all trials in early 2010 and a project report will be prepared. A project plan covering the future management of the trials will be prepared.

Trials at the Manch estate, Co Cork.

EUFORGEN

European Forest Genetic Resources Programme

PROJECT TEAM

National Co-ordinator – John Fennessy, COFORD*
EUFORGEN National Co-ordinators:

- Conifers – Alistair Pfeifer, COFORD
- Scattered Broadleaves – Elaine O'Connor, University College Cork
- Stand-forming Broadleaves – John Fennessy, COFORD
- Thematic Networks (Forest Management) – Noel Foley, Forest Service
- National Focal Point (EUFGIS Project) – Cathal Ryan, Forest Service

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COMPLETION DATE: This is an ongoing programme on gene conservation at European level. Phase IV commenced on 1 January 2010 and is scheduled to end on 31 December 2014.

OBJECTIVES

In 1994, the European Forest Genetic Resources Programme (EUFORGEN) was established as an implementation mechanism for Resolution S2 (Conservation of forest genetic resources) adopted by the first Ministerial Conference on the Protection of Forests in Europe (MCPFE) in 1990. EUFORGEN is coordinated by Bioversity International and has participants from over 30 European countries. The programme operates through networks in which policy-makers, scientists and managers from participating countries agree work programmes, exchange information and identify needs and priorities to enhance pan-European collaboration on forest genetic resources. In Ireland the programme is serviced by COFORD in co-operation with the Forest Service.

PROGRESS

In early 2009, Irish representatives met to review progress with the EUFORGEN programme and to decide whether Ireland should continue membership during Phase IV. It was agreed that Ireland should continue as an integral part of EUFORGEN.

As Phase III of EUFORGEN came to an end in December 2009, a Steering Committee Meeting was held in Greece in mid June 2009 to discuss the outcomes from the current phase and to consider future plans for EUFORGEN. At the Steering Committee Meeting updates were provided on progress made by the EUFORGEN Networks during Phase III and whether there was a need to continue into Phase IV. Due to the many factors affecting forest genetic resources, especially climate change, it was decided that EUFORGEN should continue and had an important role to play into Phase IV. At the meeting a speaker from the Canadian Forest Genetic Resources Information System (CAFGRIS), Dr Judy Loo, provided information on the structure and status of gene conservation of tree species in Canada. CAFGRIS provides information on native tree species biology and ecology as well as on threats to the species (e.g. alien invasive species and developing environmental change). Summarised data are also available as text and graphs for public use. More informtion is available at Canada's National Forest Information System (NSIF) website (https://cfsnet.nfis.org/cafgris,index.html).

In spring 2009, the EUFGIS project (Establishment of a European Information System on Forest Genetic Resources), an EU-funded project began its third year of activities, with a series of training workshops for national focal points. An important element was an introduction to the pan-European minimum requirements and data standards for dynamic gene conservation units of forest trees. This programme is expected to conclude in late 2010.

OUTPUTS

During Phase III, EUFORGEN had continued to operate through one thematic and three species networks – Forest Management, Conifers, Scattered Broadleaves and Stand-forming Broadleaves.

In 2009 the Stand-forming Broadleaves Network Meeting was held in Antalya, Turkey (31 March – 2 April) at which representatives from 27 countries participated. At this meeting the common action plans for scattered broadleaves were progressed and the meeting reported on the development of common action plans in a number of member countries. Progress on the network's work programme for phase III was also evaluated and tasks to be completed before the end of the phase were highlighted.

It concluded with an agreement that network members will finalize working plans for the completion of the programme in Phase III of EUFORGEN with:

- publication of guidelines on genetic aspects of forest management,

Participants of the EUFORGEN Stand-forming Broadleaves Network meeting in Turkey visiting a stand of Kasnak oak (*Quercus vulcanica* L.) at the Isparta Forest Conservancy.

- include relevant policies and practices related to gene conservation and forest management in the summary report to be developed by all networks and published at the conclusion of Phase III,
- the network will also prepare a chapter on policy tools to promote the use of high quality forest reproductive material in the summary report as agreed to be prepared by all networks and published at the conclusion of Phase III.

It was also agreed that the network will review climate change strategies in European countries with a view to developing a comprehensive set of recommendations for the use of forest genetic resources in Europe in the light of this change.

ACTIVITIES PLANNED

The EUFORGEN Steering Committee decided to continue the programme into Phase IV (1 January 2010 – 31 December 2014). The meeting also decided to change the way EUFORGEN operates. During the new phase, activities will be carried out through smaller working groups coming together and focusing on specific tasks. Each working group will consist of approximately ten members and will be established by the Steering Committee, which will also identify and define the task to be addressed, will set deadlines for completion and will direct the group on expected outputs for each working group. The Steering Committee is scheduled to meet in early 2010 to develop the programme for Phase IV.

QUALIBROAD

Improving the uniformity and quality of broadleaf planting stock

PROJECT TEAM

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COMPLETION DATE: December 2009

BACKGROUND

The planting of broadleaf species in Ireland has increased in recent years; they now account for more than 30% of the planting programme. Consequently, there has been a renewed focus on improving the yield and quality of broadleaf planting stock in the nursery. The main focus of the QUALIBROAD project was to address these issues for broadleaf species of importance in the forestry programme in Ireland. The development of new seed pretreatments and seed storage protocols, and the effects of post germination aspects (cloches, fertilisation, mini-plugs) of nursery culture on seedling growth, yield and quality were examined during the early years of the project. The seed research element of the project focussed on common alder (*Alnus glutinosa* Gaertn.), birch (*Betula pendula* Roth and *Betula pubescens* Ehrh.), ash (*Fraxinus excelsior* L.), and pedunculate oak (*Quercus robur* L.). Most of this research was completed in 2007. In 2008, research on ash seeds was continued and new research was initiated on the seeds of spindle tree (*Euonymus europaeus* L.), rowan (*Sorbus aucuparia* L.) and blackthorn (*Prunus spinosa* L.), most of which are important for the more diverse species mix in new plantings. Research on the use of the exponential fertilisation method as a means of culturing oak seedlings in the nursery was conducted in 2008 and 2009.

OBJECTIVES

- To improve seed germination in spindle, rowan and blackthorn.
- To grow oak seedlings to plantable size in a single season using the exponential fertilisation method.

PROGRESS

Seed research

The effects of seed moisture content, warm treatment duration and chilling on the germination response of spindle and rowan seeds were investigated. Although the data have not been fully analysed yet, it appears that spindle seeds require very long periods of chilling to effectively release dormancy (much longer periods than recommended in literature). The germination response can be enhanced by using seed moisture content levels lower than the fully imbibed state. Some preliminary work commenced on blackthorn, focussing mainly on developing methods to break dormancy (especially the hard outer 'seed coat'), but no results are available yet.

Nutrition research

In collaboration with Prof. Douglass Jacobs of Purdue University, Indiana, the use of exponential nutrient loading to improve the quality of pedunculate oak seedlings, as well as its impact on the leaching dynamics was examined. Exponential nutrient loading of pedunculate oak seedlings shows potential as a means of producing nutritionally superior seedlings at Ballintemple nursery in one year. The exponential fertilisation technique involves giving seedlings incrementally increasing fertiliser rates that match their growth during nursery production. In addition, loading involves application of high fertiliser rates towards the end of the season (levels that exceed seedling growth demands) and allow them to store nutrients for use after planting. Results of the 2009 study at Ballintemple nursery indicate that exponentially loaded seedlings receiving 1,500 kg N ha^{-1} during the abnormally wet summer reached final heights near target specifications (40 cm). In addition, these seedlings had superior stem and root nutrition compared to seedlings reared under conventional fertilisation (180 kg N ha^{-1}). These seedlings are likely to perform better after planting than conventionally produced stock. The fact that mean seedling height reached 40 cm during an exceptionally wet summer also indicates that 1-0 oak

Fertiliser trial (centre bed) at Ballintemple nursery in 2009.

Seedlings given 1,500 kg N ha^{-1}.

seedling production is possible in Ireland and that lower exponential rates may provide similar results in drier summers.

OUTPUTS

O'Reilly, C. 2009. *Enhancing seed germination in broadleaf species in bare root nurseries.* Invited oral presentation at: Innovation and New Horizons in Tree Nursery Stock Production and Forest Restoration – from Research to Business. IUFRO Conference, Rome, 12 March 2009.

O'Reilly, C., De Arip, N., Doody, C., O'Leary, D., Doody, P. and Thompson, B. 2008. Increasing the yield and quality of broadleaf planting stock through higher N fertilisation in the nursery. *Irish Forestry* 65: 5-16.

Doody, C. and O'Reilly, C. 2009. *Long periods of warm pretreatment enhance germination in common ash.* Poster presentation at Innovation and New Horizons in Tree Nursery Stock Production and Forest Restoration – from Research to Business. IUFRO Conference, Rome, 12 March 2009.

Schmal, J.L. 2009. *Exponential Nitrogen Fertililization of Quercus Robur Seedlings in County Carlow, Ireland.* M. Sc. (Forestry), Purdue University, West Lafayette, Indiana, USA.

Schmal, J., Jacobs, D.F. and O'Reilly, C. 2009. *Exponential fertilisation of pedunculate oak (*Quercus robur *L.) seedlings: quality assessment, nutrient budgeting, and leaching dynamics.* Poster presented at Spring Research Symposium, Purdue University, Indiana, April 2009.

SEEDSTANDS

The national catalogue of seed stands

PROJECT TEAM

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COMPLETION DATE: The national and EU seed stand listings are reviewed and updated on an annual basis and a new updated listing at national and EU level is produced at the end of each calendar year.

BACKGROUND

On becoming a Member of the European Union in 1973, the Irish State was obliged to comply with a number of Council Directives on the Marketing of Forest Reproductive Material. These Directives were updated in 1999, and new regulations came into force across all member states from 1 January 2003. In compliance with the regulation, Ireland is required to draw up a national register of the basic material of the various species approved on its territory. This is the responsibility of the regulatory authority, the Forest Service, which with COFORD carries out the annual update of the National Catalogue of Seed Stands.

OBJECTIVE

To comply with the EU Directive on the marketing of forest reproductive material as well as to monitor and satisfy national forest reproductive material (FRM) requirements, where possible, from well adapted, productive and suitable forest reproductive material from home sources. Where home sources are not available, national needs are satisfied by suitable overseas material.

PROGRESS

The main progress during 2009 was the identification of stands for the production of forest reproductive material of the main commercial conifer species, especially Sitka spruce, Norway spruce and to a lesser extent lodgepole pine. Stands were also registered in Douglas fir, Japanese larch, western red cedar and Scots pine. One stand of pedunculate oak in private ownership was also registered. In recent years, supply of forest reproductive material for lodgepole pine was provided from seed orchards; however, these are in decline and production of seed is low. As an interm measure, until new orchards are established, suitable stands of known origin will be selected and used as seed sources for lodgepole pine. During 2009 one seed collection area for the species was registered.

In recent years, seed stands have been thinned to increase seed production. Oak stands at Kilcooley and Donadea and a beech stand at Kilbor were thinned in 2009.

It should be noted that 2009 was particularly poor for tree seed production in Ireland, especially in the broadleaved species.

As outlined in the previous annual report, since the 1970s an active Sitka spruce breeding programme has been ongoing in Ireland. From an original selection of over 550 plus-trees, 86 have been proven in field trials to have superior growth and quality characteristics. These are retained at Kilmacurra, and are the basis for selected Sitka spruce now available, They are classified as 'tested' material. A number of hedged orchards have been established at the Coillte Aughrim nursery. These were added to in the 2007, 2008 and 2009 lists.

ACTIVITIES PLANNED

Continue review and updating of the national catalogue in line with current demands for forest reproductive material and related matters.

OUTPUTS

The national and EU listings were completed on schedule at the end of 2009. The current area of seed stands is shown in Table 1.

Table 1: Current area of seed stands as at 31 December 2009.

		Number of stands	Area (ha)
BROADLEAVES			
Alder	*Alnus glutinosa*	11	113.3
Ash	*Fraxinus excelsior*	8	155.8
Beech	*Fagus sylvatica*	18	80.3
Birch	*Betula pubescens*	6	26.0
Pedunculate oak	*Quercus robur*	45	780.0
Sessile oak	*Quercus petraea*	44	1381.3
Spanish chestnut	*Castanea sativa*	3	8.6
Sycamore	*Acer pseudoplatanus*	4	7.0
MIXED SPECIES			
Mixed species		3	52.8
CONIFERS			
Corsican pine	*Pinus nigra* var. *maritima*	2	63.1
Douglas fir	*Pseudotsuga menziesii*	21	203.6
European larch	*Larix decidua*	4	19.7
Hybrid larch	*Larix x eurolepis*	1	2.9
Japanese larch	*Larix kaempferi*	16	68.7
Lawson cypress	*Chamaecyparis lawsoniana*	1	3.3
Lodegepole pine	*Pinus contorta*	15	138.1
Monterey pine	*Pinus radiata*	9	21.7
Norway spruce	*Picea abies*	36	347.3
Scots pine	*Pinus sylvestris*	19	158.2
Sitka spruce	*Picea sitchensis*	73	610.9
Western red cedar	*Thuja plicata*	5	14.9
Yew	*Taxus baccata*	3	33.1
TOTAL		**347**	**4290.6**

BROADFORM

Silviculture of new broadleaved plantations: shaping and thinning

PROJECT TEAM

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COMPLETION DATE: January 2010

BACKGROUND

Approximately 32,000 ha of broadleaves have been planted during the period 1990-2007 (Forest Service 2008). The demand from forest owners and the wider industry for advice on broadleaf tending and thinning, especially for ash but also for other species, has increased in recent years, as demonstrated by the increase in number of enquiries to Teagasc Forestry Development Officers. The introduction of the *Tending and Thinning of Broadleaves* grant in 2009 as part of the Woodland Improvement Scheme increased the awareness by forest owners of the need for management interventions in order to realise the full potential of their broadleaf crop. An ultimate aim of this project is to provide owners, and the wider industry, with science-based best practice knowledge on the tending and thinning of broadleaves.

OBJECTIVES

- To secure, maintain and monitor existing broadleaf silvicultural trials and demonstration sites established by the COFORD-funded BROADFORM project;
- To report on the final measurements of a concluded poplar trial;
- To establish a new alder tending trial;
- To disseminate broadleaf silvicultural best practice to practitioners.

PROGRESS

Poplar

Due to external factors at two of the poplar sites, analyses of stem form are ongoing and a complete report will be submitted to COFORD when the analyses have been concluded. A COFORD Connects note based on the most recent data will be published in 2010.

Alder tending trial

The objective of this trial is to investigate the effect of thinning intensity on Potential Crop Tree (PCT) growth rate. A 1.4 ha trial located at Kilbride Woods, Arklow, consisting of three treatments in a Latin Square Design, has been established (Figure 1). The three treatments are:

- Light thin (1 competitor removed per PCT);
- Heavy thin (2 competitors removed per PCT);
- Control (no competitors removed).

Baseline measurements have been captured. The Light and Heavy tending treatment plots have been tended. Data to enable the calculation of volume to 5 cm diameter of each thinned stem have been captured.

Figure 1: Tree numbering, DBH assessment, heights and PCT marking at Kilbride Woods alder tending trial.

Ash tending trial

A new ash tending trial (Figure 2) has been established in Co Mayo that is envisaged to become part of a larger trial as more sites become available. The objective of the trial is to investigate the effect of two thinning intensities on PCT growth rate.

ACTIVITIES PLANNED

- Continue expanding, managing and monitoring the existing broadleaf tending and thinning experiment and demonstration sites.
- Continue disseminating broadleaf silviculture knowledge to practitioners and industry.
- Complete analyses of the poplar data and submit full report to COFORD.

OUTPUTS

Ash tending demonstration days

Two ash tending demo days were held with approximately 200 attendees at each. The first was held on 20 May at The Rower, Inistioge, Co Kilkenny. Dr Ian Short and Toddy Radford also presented at the Forest Service in-house training held directly after the event. The Teagasc "*Silvicultural Guidelines for the Tending and Thinning of Broadleaves*", written by Dr Ian Short and Toddy Radford, was launched at the demonstration day. The second demonstration day was held at Four Mile House, Co Roscommon, on 22 October. Extraction methods for small-scale tending/thinning operations were also demonstrated. There was also a stop to discuss chainsaw health and safety issues.

Presentations

Dr Ian Short and Toddy Radford were invited to present the tending and thinning of broadleaves at the *Small-Scale Harvesting* demonstration day held at Teagasc Ballyhaise College on 27 May. The Irish Farmer's Association also invited them to present the silvicultural guidelines at the IFA Forestry Section meeting on 18 June where the IFA county forestry representatives were present.

Short, I. and Radford, T. 2008. *Silvicultural Guidelines for the Tending and Thinning of Broadleaves*. http://www.teagasc.ie/forestry/docs/research/¬Teagasc_silvicultural_guidelines_Broadleaves.pdf.

Short, I. and Radford, T. 2009. *The 2-Stick Method for Marking Trees.* http://www.teagasc.ie/forestry/docs/research/Teagasc%202-stick%20method%20¬tending_thinning_broadleaves.pdf.

Figure 2: Newly established ash tending trial, Co Mayo.

GBREVIEW

Review of '*Growing Broadleaves*'

PROJECT TEAM

Editorial Committee:
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Prof. Padraic Joyce, University College Dublin
John Fennessy, COFORD*
Working Group:
Dr Ian Short, University College Dublin
Dr Nuala Ni Fhlatharta, Teagasc
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COMPLETION DATE: December 2010

BACKGROUND

COFORD published '*Growing Broadleaves*' in 1998 to provide foresters, landowners and students with silvicultural guidelines for the establishment and management of broadleaves in Ireland. However, this focused only on five species. In the interim, much knowledge has also been gained through experience and further contacts with colleagues in the UK and elsewhere. To reflect these changes and to expand the range of species, a full review of the original publication is underway.

OBJECTIVES

The objective is to review and update *Growing Broadleaves.*

PROGRESS

Several meetings of the Editorial Committee took place during 2009 and agreement was reached on the new structure for the book. Early in 2009 final drafts were distributed to the Working Group and their observations, comments and suggestions were invited. Towards the end of 2009 these recommendations were considered by the Editorial Committee. A draft has been sent for external review.

ACTIVITIES PLANNED

Publication of the revised *Growing Broadleaves* is planned for 2010.

FORESTSCAN

Terrestrial laser scanning technology for multi-resource forest inventories

PROJECT TEAM

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COMPLETION DATE: April 2012

BACKGROUND

Ireland is a high cost economy, and this is reflected in the delivered-in price of wood. Research and development aimed at reducing costs, and thereby increasing competitiveness in roundwood production, is the key driver behind this project. Effective planning and decision-making in modern multi-purpose and sustainable forest management requires up to date and accurate data in order to evaluate the range of potential options for the future management and utilisation of a forest.

OBJECTIVES

The three main objectives of the study are:

- An investigation of the basic principles of terrestrial laser scanning technology and its applicability to (multi-resource) forest inventories.
- An evaluation of existing data analysis software for forestry applications. Development of new software, for a range of applications, will be investigated.
- A cost-benefit analysis for the introduction and use of this technology over a range of potential inventory applications

PROGRESS

Research continued with two stands of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) of different ages at Clonmel and Kinnity scanned early in the year. Measuring different aged stands addresses the effect of size and density of the stand on estimating diameter and height using the laser scanner (Figure 1). Trees in the stands within a 15 m radius of the laser scanner were scanned before and after removing the lower branches (up to a height of 3 m). Sample trees of different diameters were felled and prescribed measurements taken from the felled trees. The

Figure 1: Data collected from the scanning device (foreground) is uploaded to a computer. The resulting point cloud data is processed to arrive at stem diameter distributions.

resulting point cloud data were extracted using FARO Scene software, and were processed with AutoStem software to derive dbh, tree height and number of stems for estimating basal area, volume and stand density. The results were compared with the manually measured parameters (i.e. obtained after felling the trees).

Generally, tree diameters in the scanned forest are estimated from the point cloud data with acceptable accuracy, except in the upper stem due to the occlusion by branches, and in the lower stem (i.e. the first 1.5 m) due to interference from ground unevenness and the irregular shape of the lower stem. The number of trees per plot and the diameters of a number of trees were under-estimated in some cases due to occlusion of the stem by other trees in the stand. Pruning did not significantly improve diameter estimation. The position of trees within the plot (i.e. distance from the scanner) did not show a significant effect on the accuracy of diameter estimation.

In the autumn, PTR and TreeMetrics initiated a second phase of measurement and scanning operations in the Clonmel plots. This will provide a second set of sample plot data representing two full growing seasons between Phase 1 and Phase 2 measurement and scanning operations. These data will be used to study the use of terrestrial laser scanning technology in forest crop growth/yield monitoring.

Martin van Leeuwen completed his Masters thesis entitled: *On the use of laser range-finding techniques for forest inventory studies*. It includes interesting work on the concepts of branch recognition algorithms and the complexities involved in attempting to train software to recognise real branches on the tree and exclude artefacts.

ACTIVITIES PLANNED

- Other plots in different terrain, broadleaved stands and stands which are ready for clearfelling will be identified to be measured during the second phase of scanning.
- Scanning will be done in the previous plots to monitor annual growth by measuring and scanning plots before and after growing seasons.
- Scanned data wil be processed and analysed.
- Paper writing and presentations at workshops and international conferences (e.g. Silvilaser 2010 in Germany).
- Identify stands which were previously scanned with aerial LiDAR and ready to be harvested will be scanned by terrestrial LiDAR for comparison.

OUTPUTS

Mengesha, T. and Nieuwenhuis, M. 2009. *Retrieving forest parameters using laser scanning technology* [Poster Presentation]. The 9th international conference on LiDAR applications for assessing forest ecosystems. Texas A&M University, College Station, Texas USA

Van Leeuwen, M. 2009. *On the use of laser rangefinding techniques for forest inventory studies.* Unpublished MSc thesis, University College Dublin, Ireland.

Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and Implementation of Sustainable Forest Management.* Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.

Harper, C. and Nieuwenhuis, M. 2009. *PLANSFM - Planning and implementation of sustainable forest management* [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

NATFOREX

Establishing a national resource of field trials and a database for forest research and demonstration

PROJECT TEAM

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COMPLETION DATE: October 2013

BACKGROUND

Past forest research activity has resulted in an extensive network of experimental trials on many aspects of silviculture and forest management. These trials have provided scientific data to assist in developing best forest practice and have also acted as demonstration areas for communicating research results. The NATFOREX project aims to create a national database of trials established before November 2007. It will give a useful inventory of intact and closed trials with the associated data, and silvicultural and management treatments tested. It will also facilitate reviews of knowledge gained to date and help to show areas where new trials may be required. In addition, important extant trials will serve as demonstrations of good forestry practice.

OBJECTIVES

To identify, maintain and manage a national network of field trials for the study of silvicultural and forest management treatments. Specifically to:

- evaluate the relevance of existing trials in the Coillte experimental plot network and in the research sections of other organisations;
- decide on the reliability of existing data and on the benefits of further data collection;
- carry out necessary maintenance on field trials earmarked for retention;
- collect new data in retained trials where required;
- integrate the findings and data from the trials into a public online database;
- identify information gaps;
- decide on the need to establish new trials.

PROGRESS

To date, more than 300 field trials and experiments have been visited (Figure 1). A total of 158 field reports have been reviewed, summarised and entered into in a database. Where there were originally about 1,500 experiments listed on Coillte's network, this number has now been reduced to about 980 and this figure is expected to reduce significantly as more inspections are undertaken and reports are made available. Work has begun on the transfer of non-metric data, collected prior to 1971, onto Excel for metrication and storage. Data presentation has been designed to be similar to that of other databases including the NoLTFoX database.

Essential maintenance and assessment work continues on a range of experiments. In the past year 55 trials received attention, ranging from growth measurement to thinning

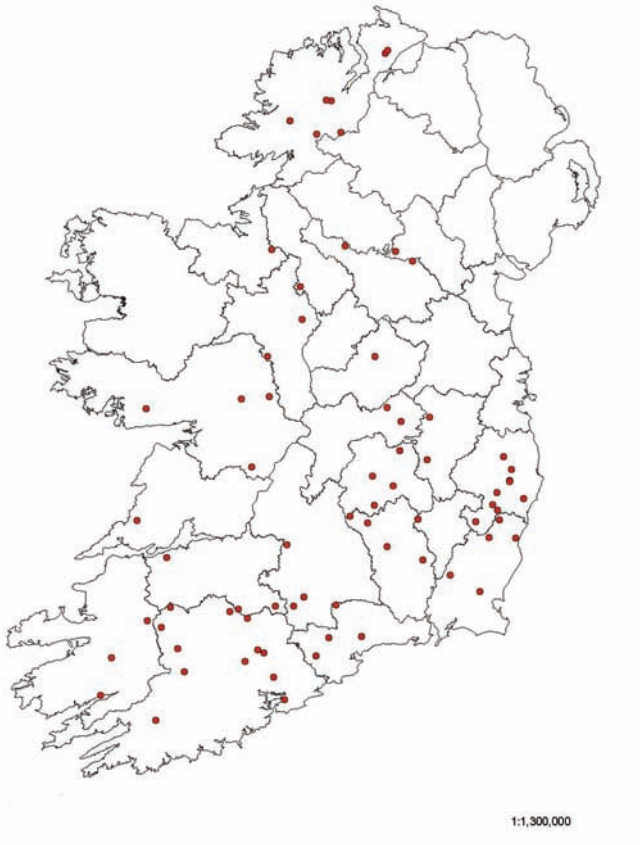

Figure 1: Map of sites visited to date.

to pruning, to scrub clearance, to final crop selection. Data from some of these trials were analysed to get a clearer view on their current status.

Trial sites from Donegal to Cork and Galway to Wicklow have been inspected in the field. A common factor has been the poor quality of the maintenance of the experiments on the ground. This has had an impact on the ability of these trials to perform to their full potential. .

ACTIVITIES PLANNED

- Decision on the retention of intact trials based on the field managers' reports, the quality of the existing data and the statistical soundness of the experimental design.
- Continued digitising of data from experiments that are closed.
- The database for the website (www.natforex.com) will be completed.
- The project management group will make a second field visit, this time to the midlands and West.
- Reporting on field trials will be completed.
- A distinction between trials which are valuable for their data output only, and those still intact and capable of producing valuable data will be made.
- Criteria for the retention of intact experiments will be drawn up.
- Criteria for the inclusion of the data from closed trials will be drawn up.
- The selection process for retained trials will begin.
- Work on selected trials including the compilation of Management Plans will begin.
- Further efforts will be made to include non-Coillte experiments in the work.
- The project group will work with a recently appointed statistician on the authenticity of experimental design and the reliability of experimental data.

OUTPUTS

- Project website www.natforex.com
- COFORD Annual Report www.coford.ie/iopen24/pub/natforex2008.pdf
- Information on NATFOREX was made available at an EFI conference held in Dublin Castle in September 2009.
- Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and Implementation of Sustainable Forest Management*. Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.
- Harper, C. and Nieuwenhuis, M. 2009. PLANSFM - *Planning and implementation of sustainable forest management*. [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

PRACTISFM II

PractiSFM: Implementation, communication and optimisation

PROJECT TEAM

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COMPLETION DATE: December 2013

BACKGROUND

The Irish National Forest Standard, published in 2000, applies to all forest in Ireland. Since its implementation, private forest owners and managers are required to evaluate forests for economic, social and environmental sustainability through the quantification and qualification of multiple resources. Such requirements place additional demands on data collection methods, beyond the traditional, timber-orientated forest inventory. For private woodland owners in Ireland, the lack of reliable, up to date and affordable forest inventory data providing information related to their own properties represents a considerable obstacle in the assessment, monitoring and implementation of Sustainable Forest Management (SFM). The original PractiSFM project resulted in a prototype multi-resource inventory protocol and decision support system. The PractiSFM2 project will build on this success to operationalise the system and to enhance its usefulness in terms of improved forest management and the provision of a reporting capacity to provide the forestry sector with up to date information on planned outputs from private woodlands.

OBJECTIVES

- Field testing and validation of the PractiSFM system with the help of management companies.
- Further development of the existing system in co-operation with management companies.
- Development of a communication system, enabling the uploading of PractiSFM management plan information into a central database.
- Introduction of a wider range of management options that move towards flexible, user-defined management strategies.
- Development of an optimisation component to the PractiSFM system.
- Implementation of the completed system in the private forest management sector.

PROGRESS

The PractiSFM (PSFM) system (Figure 1) was introduced to three management companies Greenbelt, FEL and PTR. Field testing and validation of the system has begun. This involves a forester carrying out data collection based on the current inventory protocol. Office-based personnel will input and process the data and generate management options with the current PSFM programme. The outcome will be a critique of the multi-resource inventory protocol and the PSFM programme.

The project participants have joined the COST Action PF0804 *Forest Management Decision Support Systems*. This will facilitate networking across a range of disciplines in the development of decision support systems (DSS) and will also highlight the methods used to optimise such systems, and the development of appropriate communication platforms.

Frank Barrett submitted his PhD thesis: *PractiSFM – a multi-resource inventory protocol and decision support system for the sustainable management of privately owned forests in Ireland.*

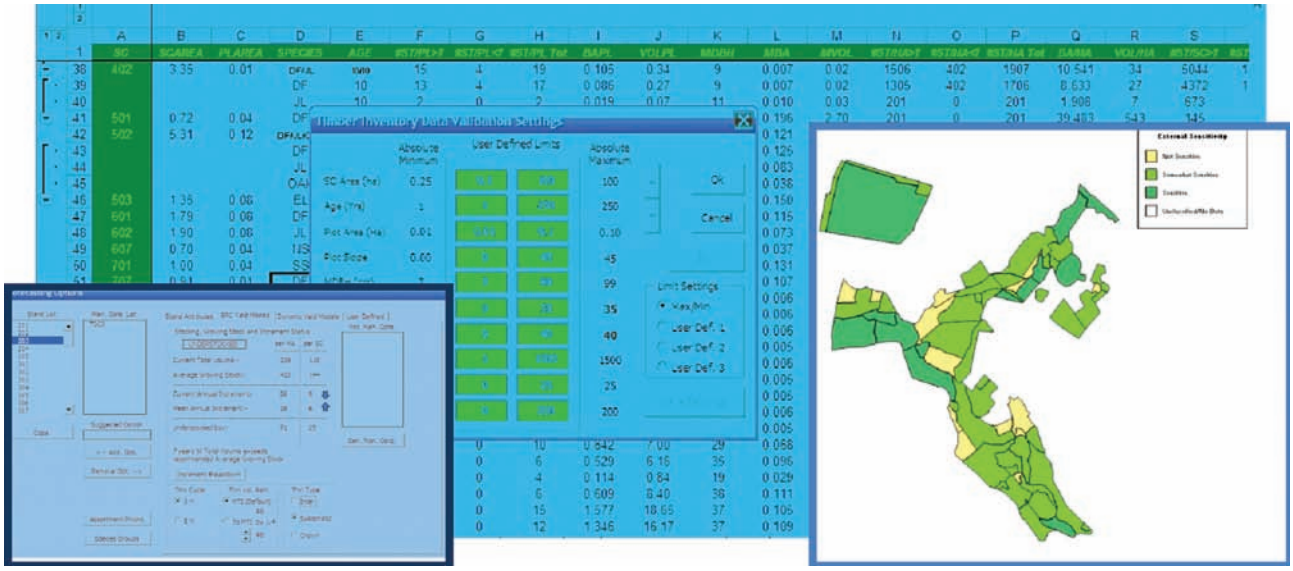

Figure 1. Composite image derived from PractiSFM software.

ACTIVITIES PLANNED

- Continue and expand field testing of the inventory protocol and the DSS.
- Initial feedback from the professionals using the system will be used to develop a SWOT analysis of the current system and identify changes required to improve it.
- Meetings with FSC and PEFC Irish representatives to define what level and format of information will be necessary to include in the DSS to meet certification requirements.

OUTPUTS

Barrett, F. and Nieuwenhuis, M. The PractiSFM multi-resource inventory protocol and Decision Support System: a model to address the private forest resource information gap in Ireland. *Irish Forestry* (in press).

Barrett, F. and Nieuwenhuis, M. 2009. *A Decision Support System Linking Forest Policy with Sustainable Forest Management Planning in Private Forest in Ireland*. In: Grossberg, S.P. (Ed). Forest Management. Nova Science Publishers, New York. Pp 61-84.

Barrett, F. 2009. *PractiSFM – a multi-resource inventory protocol and Decision Support System for the sustainable management of privately owned forests in Ireland*. PhD thesis (volumes I and II). University college Dublin.

Nieuwenhuis, M. and Barrett, F. An application of PractiSFM - a multi-resource decision support system for the planning and implementation of sustainable forest management. *Journal of Forest Science* (submitted).

Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and Implementation of Sustainable Forest Management*. Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.

Harper, C. and Nieuwenhuis, M. 2009. PLANSFM - *Planning and implementation of sustainable forest management* [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

STANDMODEL

Development of dynamic yield models for conifers, broadleaves and mixtures

PROJECT TEAM

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COMPLETION DATE: December 2012

BACKGROUND

Better resource information is one of the key needs for investment decisions. Growth and yield models, including those developed under the DYNAMIC YIELD project, are an important component of any decision-making framework. Models developed to date cover Sitka spruce, lodgepole pine, Norway spruce, Douglas fir and Scots pine. These have an operational interface called GROWFOR, which is licensed by COFORD and which is now in use by Irish foresters. The models are also incorporated into Coillte's volume forecasting systems. Given the increase in the use of both broadleaves and mixtures under grant-aided afforestation, further models need to be developed. The STANDMODEL project is currently developing new dynamic yield models for ash and Japanese larch and is examining ways in which growth and yield in mixtures can be modelled.

OBJECTIVES

- Produce new dynamic yield models for Japanese larch (thinned and unthinned) and ash (thinned) and integrate these into the existing Irish Dynamic Yield Model User Interface.
- Investigate the potential for generating growth forecasts for species mixtures using existing model combinations.
- Investigate the potential for utilising National Forest Inventory plot data in validating and strengthening existing dynamic yield models and in generating new ones.
- Develop additional functionality for the Irish Dynamic Yield Model User Interface in the form of:
  a) user-defined assortments;
  b) optimisation/goal seeking capability;
  c) facility to cater for mixtures .

PROGRESS

Members of the project team attended the meeting of COST ACTION FP0603: *Forest models for research and decision support in sustainable forest management* where they met other researchers working in the area.

During the year, 40 validation plots of Japanese larch were established nationwide and standing data were collected. The 40 plots were selected across geographic and age strata. In each plot, 7 volume sample trees were selected, felled and measured (Figure 1) and recorded for use in the independent validation of the Japanese larch model. The purpose of this work is to provide independent stand and stem volume verification data for Japanese larch, once a dynamic model has been produced for this species.

Over the last 10 years, 100 Japanese larch plots have been maintained nationwide and have been used as a data source for the development of a new dynamic yield model for Japanese larch, which will be added to the GROWFOR package when completed. Just like for the other species currently available through GROWFOR, it is necessary to

Figure 1: Sectional measurement of a Japanese larch sample tree, Virginia Forest, Co Cavan.

independently validate any model produced with data not used in the development of the model. It is suggested in some publications that, after successful validation, all data from the original dataset and the validation data set should be combined to produce the final model. This means that no data are ignored in the final model.

The 100 plots established in ash stands in 2007/2008 were maintained and data were collected in the dormant season 2008/2009.

User-defined assortments for Scots pine and lodgepole pine were uploaded onto GROWFOR. Additional work on the development of user-defined assortments in Sitka spruce and Norway spruce was begun.

ACTIVITIES PLANNED

- Data for the 100 ash plots will be collected in the dormant season 2009/2010.
- Work will continue on user-defined assortments in conjunction with Dr Lance Broad.
- Collaboration with SCION Research Institute in New Zealand on the development of models similar to those used in GROWFOR.

OUTPUTS

Recent Developments in Irish Stand and Stem Modelling under the COFORD STANDMODEL and TREEMODEL Projects. Presentation to ITC Technical Group, Portlaoise, 14 July 2009 by Paddy Purser

Dissemination of the project at a course on Bayesian Nonparametric mixture modelling, NUIG, 14 December 2009 by Andrew McCullagh

Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and Implementation of Sustainable Forest Management.* Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.

Harper, C. and Nieuwenhuis, M. 2009. *PLANSFM - Planning and implementation of sustainable forest management* [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

TREEMODEL

Development of single tree volume models and stem profile models

PROJECT TEAM

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COMPLETION DATE: December 2011

BACKGROUND

The National Forest Inventory has collected tree and stand measurement data at over 1,800 permanent sample plots across the country. Investigations to determine the suitability of these data for updating dynamic yield models are required. Work associated with the National Forest Inventory has derived very accurate Sitka spruce tree volume equations that have an application not only in deriving stand volume estimates, but as a cost-effective mensuration tool. Further work is required in this area, extending to other species, as is research on deriving wood supply indications from the national inventory and other data sources.

OBJECTIVES

- Produce stem profile models for Sitka spruce, Norway spruce, Douglas fir, lodgepole pine, Japanese larch, Scots pine and ash, and validate these with newly collected stem data.
- Describe the different inventory tools available for collecting data necessary for stem profile model development.
- Develop recommendations for the integration of stem profile models into everyday inventory and management practice.

PROGRESS

A range of stem profile data from 280 Japanese larch stems were collected in 2009. These data, representative of a broad range of tree ages, sizes and geographic locations, were added to the national database containing sectional stem measurements and will be available for other COFORD projects.

A literature review was completed. As part of the compilation of an Inventory Equipment Database, some initial work has been completed, with the recently purchased Masser RC3H. A paper on stem profile modelling has been completed and is being prepared for submission for publication.

ACTIVITIES PLANNED

- Initial work on stem profile modelling of Japanese larch and ash.
- The integration of the new single models into practical inventory systems.
- A database of measurement equipment available for use in inventory will be prepared.
- A short guide/handbook.

OUTPUTS

- The validated Sitka spruce stem profile model has been produced. Stem profile models for Norway spruce, lodgepole pine, Scots pine and Douglas fir have also been produced. A fully validated MS Access database of all stem data has been produced. A rudimentary querying system for the above models has been produced.
- A research paper: *Stem profile modeling of the main coniferous tree species in Ireland as a tool for standing volume estimation* has been prepared.
- *Recent developments in Irish stand and stem modelling under the COFORD STANDMODEL and TREEMODEL projects.* Presentation to ITC Technical Group, Portlaoise, 14 July 2009 by Paddy Purser.
- Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and implementation of sustainable forest management.* Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.
- Harper, C. and Nieuwenhuis, M. 2009. *PLANSFM - Planning and implementation of sustainable forest management* [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

WESTFOREST

A GIS-based multi-objective decision support system for the optimal management of forests on sensitive sites

PROJECT TEAM

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COMPLETION DATE: August 2012

BACKGROUND

There are many forests planted on western peatlands of Ireland.Their sustainable management is a complex issue. The range of critical environmental and social constraints that needs to be taken into account, as well as the age distribution of the stands, add to the factors to consider in making decisions about the future of these forests. Decision support tools to facilitate the management of stands, based on catchment sensitivity, soil type, National Heritage Areas, amenity provision, economic potential and social acceptability, merit investigation. This applies particularly to forests established on peatlands and other environmentally sensitive areas, where felling and reforestation decisions need to take into account a wide range of economic, social and environmental factors.

OBJECTIVES

The project aims to develop:

- a GIS system that contains spatial, contextual and qualitative information on restrictions applicable to western peatland forests (WPFs).
- a matrix of the known impacts and restrictions associated with the range of potential forest management practices and land use changes.
- a decision support system (DSS) for the sustainable management and redesign of WPFs.
- an optimisation module for the DSS to evaluate different courses of action.
- a forest management plan for WPFs, based on the optimal DSS prescriptions, drawn up in the context of arrangements with the Forest Service, and compatible with an integrated land use policy.

PROGRESS

In order to create a robust decision support system, the study area needed to be as multifaceted as possible, covering environmental, social and economic issues. To this end, two study areas were identified: Nephin Forest and Glennamong Forest in Co Mayo (Figure 1). These areas are near to one another, approximately 16 km from the town of Newport in Co Mayo. The main soil type in Nephin Forest is blanket peat, with patches of mineral soil

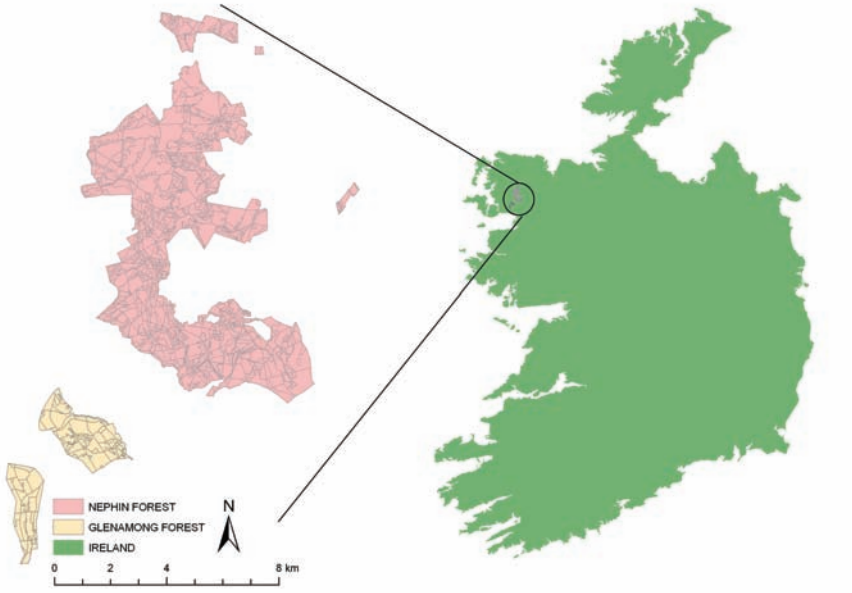

Figure 1: Glennamong and Nephin Forest location.

derived from quartzite, while Glennamong has peat soils over schist and gneiss. Current management focus in Nephin is concerned with timber production in conjunction with a strong emphasis on biodiversity conservation in less fertile areas. Glennamong forest is less focused on timber production due to fisheries restrictions.

A breakdown of land use type for each area is listed in Table 1. Coillte has provided GIS coverage of these areas, consisting of inventory data as well as soil and water data from the EPA. These data will serve as the initial building blocks for the creation of the DSS. Additional study areas may be added as the project proceeds, to ensure that the resulting DSS can be applied to any medium to large scale forest management planning situation.

As part of the gathering of information, team members have joined the COST Action FP0804 *Forest Management Decision Support Systems* (FORSYS). This Europe-wide action aims to define a framework for decision making for sustainable multifunctional forest management. The forum will provide a platform to source information and learn from experiences from others who are developing DDS for forest management.

Table 1: Land use types in Glennamong and Nephin forests.

	Forest area (ha)	
Land Use Type	**Glennamong**	**Nephin**
Bare marginal	7	25
Bare plantable	28	37
Bare upland	0	474
Broadleaf high forest	0	29
Windthrown	0	0
Conifer high forest	665	3,544
Dead	0	1
Felled	0	113
Mixed high forest	0	4
Miscellaneous	0	0
Swamp	1	7
Undeveloped	23	128
Water	0	62
Total	**724**	**4,426**

ACTIVITIES PLANNED

- Completion of literature review.
- Development and review of GIS methodologies.
- Sourcing of additional data from international sources.
- Creation of DDS matrix.
- Attend the conference of the Association of American Geographers, April 2010.

OUTPUTS

Brian Clifford has been accepted to present a paper at the AAG (Association of American Geographers) annual conference 2010. The meeting will be held in Washington DC, 14-18 April 2010.

Nieuwenhuis, M. 2009. *COFORD's PLANSFM Research Programme: Planning and Implementation of Sustainable Forest Management.* Presentation to the COFORD Council, AFBI Field station, Hillsborough, Co Down, 24 July 2009.

Harper, C. and Nieuwenhuis, M. 2009. *PLANSFM - Planning and implementation of sustainable forest management.* [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

CLUSTER

A cluster-based approach for identifying farm forest resources to maximise potential markets

PROJECT TEAM

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COMPLETION DATE: August 2009

BACKGROUND

Private individuals or institutions own over 330,000 ha of forest, 46% of the total forest cover, and 5% of the land area of the Republic of Ireland. Recent studies have indicated that the private forest resource has the ability to significantly contribute to the national and rural economies. Current net roundwood production from privately owned plantations was 118,000 m^3 in 2008, but has the potential to increase to 2.95 million m^3 in 2028. However, the full potential of the private forest resource is not being realised in Ireland, with a significant gap between potential supply and actual output. Although it is the intention of over three-quarters of private forest owners to thin their forests, only 13% of farm forest plantations in Ireland are currently thinned (Maguire 2008). Results from recent research raise doubts whether projections for timber supply from the private forests in Ireland will be realised due to the suitability of areas to be harvested with excessive roading requirements, windthrow risk and poor ground conditions the main constraints. A large number of small and fragmented plantations providing low volumes, coupled with the high cost of harvesting and timber haulage are all significant obstacles to be overcome by the sector.

OBJECTIVES

The aim of this research is to use a cluster-based approach that will aid the development of private forestry in Ireland, specifically to:

- identify large concentrations of private forestry in defined geographic locations.
- evaluate a methodology for improving timber forecast volumes from plantations to derive a cost-effective and efficient methodology.
- enable the rapid assessment of timber resources in a defined local area.
- utilise the outputs from the research for the establishment of forest grower producer groups who may wish to collaborate in the sale and harvesting of forest products and in the grouping of forest operations to achieve economies of scale.

RESULTS

Cluster analysis located 16 viable concentrations or clusters representing 42% of private grant-aided forests (88,143 ha). A study area in Mayo, Sligo and Roscommon around the town of Ballaghaderreen in Co Roscommon was chosen to evaluate the immediate potential output from thinnings. Only forests older than 12 years of age were selected for study, as these had immediate thinning potential. A field-based sample survey of 935 ha was conducted, comprising of 92 forest owners. On average, plantation sizes were small (5.14 ha), with 47% of stands less than 8 ha. The majority of stands assessed were within close proximity to the national road network with 52% of the forest area surveyed having a forest road in place.

Thinning has only been carried out in 11% of stands occupying 30% of the forest area. Thinning operations have been confined solely to pure stands of Sitka spruce. Sitka spruce is the dominant species occupying 75% (705 ha) of the area. North coastal lodgepole pine occupies 14.5% (134 ha) of the area. Broadleaf high forest comprises 3% of the forests surveyed. Sitka spruce was the most productive species with an average weighted yield class across all stands of 24 $m^3\ ha^{-1}\ yr^{-1}$. North coastal lodgepole pine planted pure and in mixture had an average yield class of 12 $m^3\ ha^{-1}\ yr^{-1}$, south coastal lodgepole pine had an average of 14 $m^3\ ha^{-1}\ yr^{-1}$. Coniferous crops such as Japanese larch, hybrid larch and Norway spruce occurred to a lesser extent, with an average yield class of 14 $m^3\ ha^{-1}\ yr^{-1}$. Across all coniferous species, yield classes in excess of those listed in the Forestry Commission tables were observed.

On average, Sitka spruce stands reach a threshold basal area for thinning, 34 $m^2\ ha^{-1}$ at 14 years of age. Average standing volume per hectare across all species was 188 $m^3\ ha^{-1}$. Total standing volume for all stands (4,597 ha) is 840,698 m^3 with 365,990 m^3 available as small sawlog, 324,796 m^3 as pulp and 149,913 m^3 as large sawlog (Table 1). Overall Sitka spruce was the most productive species in the area, and accounted for 90% of the total standing volume (754,146 m^3). Findings show that 71% of the surveyed area is suitable for thinning based on an

Table 1: Total standing volume for stands greater than 12 years old (4,597 ha).

Age class	Pro. area (ha)	Net area (ha)	7-13 cm	14-20 cm	>20 cm	Total
1-5	68	58	0	0	0	0
11-15	1,450	1,116	102,886	46,649	2,270	151,806
16-20	1,684	1,339	144,136	153,897	49,784	347,817
21-25	1,302	1,028	73,667	160,528	97,160	331,355
26+	60	45	4,106	4,915	698	9,720
Total	4,564	3,586	324,796	365,990	149,913	840,698

examination of basal area windthrow risk. A further 10% of the forest area was deemed past thinning stage.

Total estimated volume production for the 4,597 ha over the period 2009 to 2028 is 2.06 M m^3. The unsmoothed forecast indicates peaks and troughs in the forecast from 2009 to 2028 (Figure 1). Spikes in timber output in occur throughout the forecast period. The smoothed forecast gives a better indication of the long-term increase in timber output, increasing from an average of 25,000 m^3 in 2009 to 200,000 m^3 per annum by 2028 (Figure 1). Large sawlog makes up the bulk of harvest material with 76% of total volume, small sawlog makes up 17%, and pulpwood 7%.

The study illustrates the potential from timber output from small-scale forest plantations through clustering the geographic concentrations of forests. The study will provide a template for developing local level forecasts and should encourage co-operation between growers and industry to achieve economies of scale in harvesting.

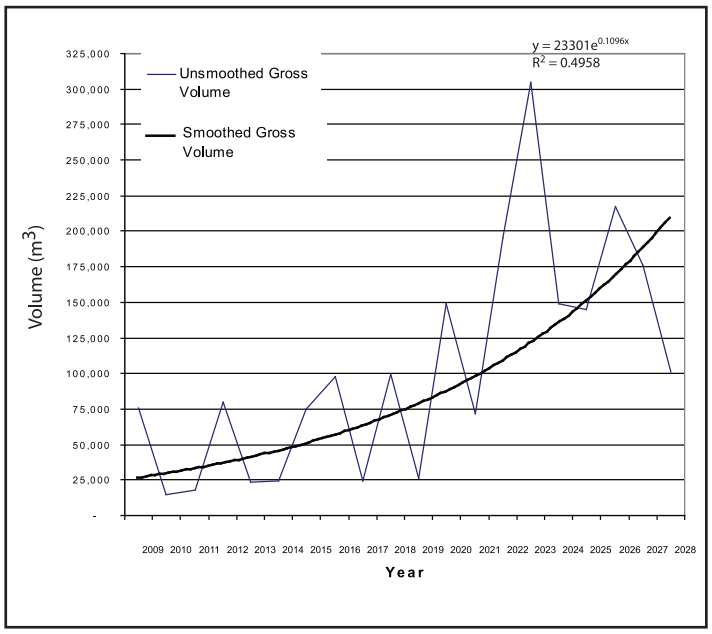

Figure 1: Forecast of production smoothed and unsmoothed for stands ready for thinning from the cluster study area over the period 2009-28.

OUTPUTS

Farrelly, N., Clifford, B. and Green, S. 2008. Unlocking Farm Forest Potential. *TResearch* 3 (1): 22-25.

Farrelly, N., Clifford, B. and Green, S. 2008. Using GIS Cluster Analysis to Quantify Timber Production from farm forestry plantations. *Irish Timber and Forestry* 17 (5): 30-33.

Farrelly, N. 2008. *Fuelling Your Future – The Growing Forest Resource.* Proceedings from the Teagasc/COFORD/SEI Wood Energy Conference, Westport 10 September 2008. www.coford.ie/iopen24/pub/westport1.pdf

Clifford, B., Green, S. and Farrelly, N. 2008. *A cluster-based approach for the identification of private forest resources.* 2nd Annual Irish Earth Observation Symposium, Opportunities for Earth Observation in Ireland, 6-7 November 2008.

Farrelly, N., Clifford, B. and Green, S. 2008. Forest Focus Unlocking Farm Forestry. *Irish Farmers Monthly* July 2008. p42-44.

Clifford, B. 2009. *A cluster-based approach for identifying thinning material for wood energy users*. Proceedings from the Teagasc/COFORD/SEI Wood Energy Conference, Wednesday 17 June 2009, Kilkenny.

Farrelly, N. and Clifford, B. 2009. *CLUSTER – A Cluster based approach to identifying farm forest resources to maximise potential markets.* Final project report, COFORD, Dublin.

Farrelly, N. and Clifford, B. 2010a. A Cluster-Based Approach to Creating Economies of Scale in Harvest Output from Small-Scale Forests in Ireland. *Small scale forestry* (in press).

Farrelly, N. and Clifford, B. 2010b. *A preliminary evaluation of the application of multi-return LiDAR for forestry in Ireland.* COFORD Connects (in press).

Farrelly, N. and Clifford, B. 2010c. *Estimating Height in Sitka spruce Stands using airborne laser scanning data (LIDAR) in Ireland.* Internal Report, Teagasc Forestry Research, Athenry, Co Galway.

FORECAST

Geospatial forecasts of private sector timber supply

PROJECT TEAM

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COMPLETION DATE: March 2012

BACKGROUND

Ireland's private forest estate is fast becoming a considerable wood and energy resource. Most of the 320,000 ha private forest estate has been established over the past two decades, with many areas now entering the first thinning stage. Recognising the need for updated and improved information on wood supply, COFORD funded the FORECAST project.

OBJECTIVES

The overall objective is to develop a reliable national GIS-based private sector wood supply forecast model. The short-term objectives relate to the provision of an interim GIS forecast to provide guidance to the forest sector as to the likely timber supply from privately-owned forests. The long-term objectives are research orientated, focusing on reliable GIS forecasting methods and internet interface development.

- To develop an interim GIS forecast on a national and catchment basis for privately owned forests (2009-2028) to replace the current private sector forecast; and
- To publish an interim private sector timber supply forecast within 12 months after consultation with interested parties.
- To analyse the possibility of generating a reliable forecast of production from privately owned forests using existing National Forest Inventory (NFI) plot data.
- To compare plot versus stand based methods for forecasting future timber production from privately-owned forests.
- To develop an internet interface for the provision of national and catchment forecasts through an easy-to-use client browser, which is fully compatible with iFORIS and ESRI products, using industry standard licence-free GIS software.

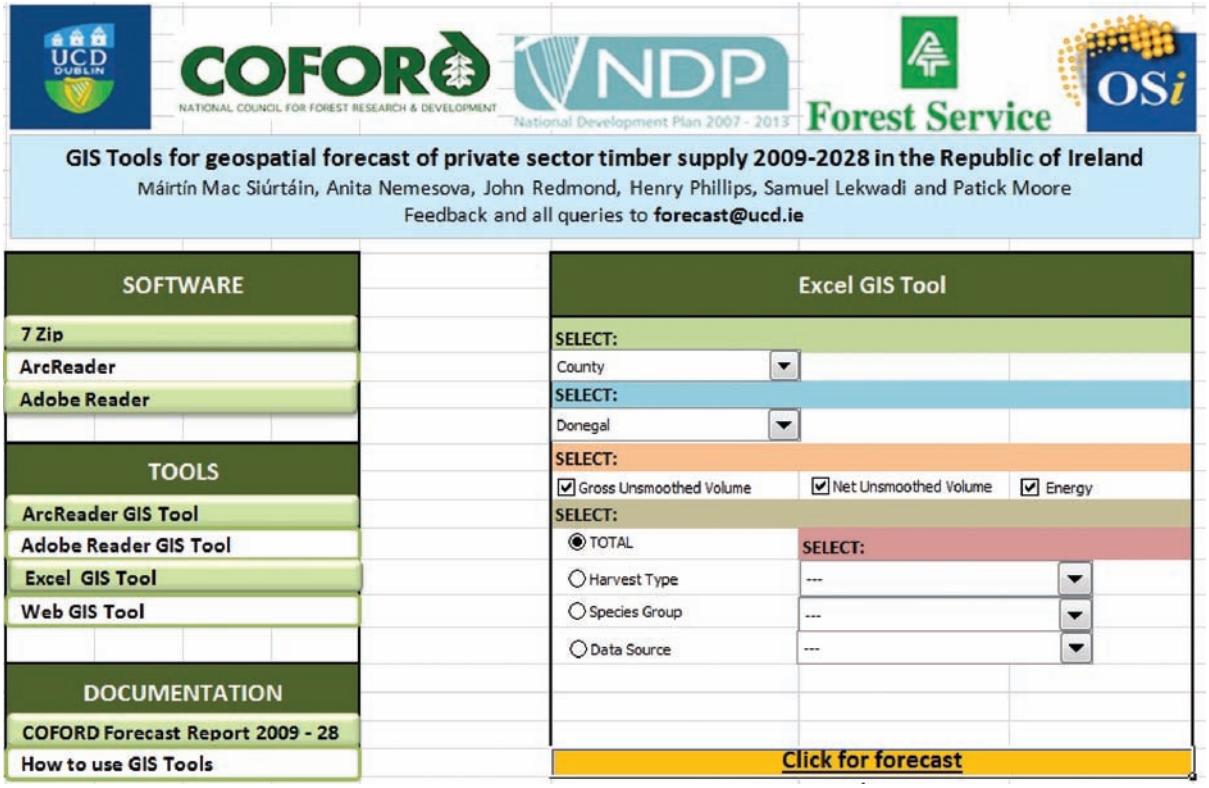
PROGRESS

The FORECAST report *Roundwood production from private sector forests 2009-2028 - A geospatial forecast* (Phillips et al. 2009) sets out the annual potential level of gross and net roundwood supply from privately owned forests, which is predicted to increase 8-fold over present levels, to reach almost 3 million m^3 by 2028. The overall net smoothed roundwood production from privately owned forests will increase from an estimated 0.38 million m^3 in 2009 to 2.95 million m^3 by 2028.

The NFI data contain no information on top height or yield class. Robust models predicting top height from mean height have been developed for all coniferous species and broadleaves, based on data contained within the Coillte permanent sample plot database. Models were also developed to predict the 95% upper and lower prediction intervals for all species. These top height-mean height models allow the NFI plot data to be populated with top height, yield class and with the precision of the estimates quantified. Source R code has been developed to facilitate realtime analysis and revision of top height-mean height models as new data are acquired.

The FORECAST team published a suite of four free web-enabled GIS Tools through an Excel interface Excel_GIS_Tool.xls. The GIS Tools enable private sector forecasts to be downloaded at national, regional, county levels as well as at 60 and 80 km radii from 42 locations; 40 of which are in the Republic of Ireland, with two locations in Northern Ireland.

All Excel formatted private sector forecasts are available directly through the Excel GIS Tool and or though an ESRI ArcReader GIS Tool in published map format (*.pmf), through Adobe Reader GIS Tool in published map format (*.pdf) and through an interactive Microsoft Access database query interface. All Excel formatted forecasts provide gross and net unsmoothed volumes (000 m^3 or m^3) by assortment plus net energy assortment (000 m^3 or m^3) and harvest areas (ha) by production year. The forecasts are further broken down by Harvest Type, Species Group and Data Source. The GIS Tools were developed in co-operation with the Forest Service and Ordnance Survey Ireland (OSi), who provided geospatial vector and raster data for the GIS Tools. Source code, developed by Spectral Signatures Ltd, facilitates interactive queries of the



FORECAST Excel GIS Tool interface.

Microsoft Access forecast database from within the GIS Tools. The GIS Tools have highlighted the importance of physical accessibility in relation to private sector forecasts.

ACTIVITIES PLANNED

Through the FORECAST project, COFORD is compiling an all-island forecast of roundwood production, which will combine private sector forecast with those from Coillte and the Northern Ireland Forest Service. This work will provide an updated roundwood production forecast for the full island and the first ever complete county forecast for the Republic of Ireland.

The research activities of the FORECAST will focus on:

- Updating geospatial private sector forecasts using National Forest Inventory (NFI) data.
- Further development of geospatial FORECAST GIS Tools and web services.
- Population of parameter estimates databases for reliable forecast estimation using the Coillte permanent sample plot and OSi lidar geospatial databases.
- Geospatial modelling of accessibility constraints on private sector forecasts.

OUTPUTS

Phillips, H., Redmond, J., Mac Siúrtáin, M. and Nemesova, A. 2009. *Roundwood production from private sector forests 2009-2028. A geospatial forecast.* COFORD, Dublin.

Mac Siúrtáin, M., Nemesova, A., Redmond, J., Phillips, H., Lekwadi, S. and Moore, P. 2009. *GIS Tools for geospatial forecast of private sector timber supply 2009-2028 in the Republic of Ireland.* University College Dublin.

Nemesova, A., Mac Siúrtáin, M., Redmond, J., Phillips, H. and Lekwadi, S. 2009. *GIS Tools for accessing timber and energy forecasts for the Republic of Ireland*. Prize-winning poster. School of Agriculture, Food Science and Veterinary Medicine, University College Dublin.

COFORD-FORCAST GIS Tool Workshops. 22, 29 September and 30 October 2009.

Presentations at the workshops and conferences:

- Forest Service, Johnstown Castle 20 May 2009.
- Bioenergy 2009, Banking on Biomass, 17 June 2009.
- FORECAST – Forestry Commission Meeting, UCD 28 August 2009.
- GIS 2009, The Guinness Storehouse, Dublin. 14 October 2009.
- Economic and Social Research Institute (ESRI). 10 December 2009.
- COFORD Wood Supply Group meeting 11 December 2009.

Input into the Forestry Degree Curriculum development at UCD: Mac Siúrtáin, M. 2009. *FORECAST GIS Tools incorporation in Forestry Degree Modules: FOR 30310 GIS and Remote Sensing, FOR 40080 GIS and Forest Inventory.* University College Dublin.

Harvesting and Products

From the earliest times forests have been used as a resource to sustain human existence. They have provided food, fuel and materials to build shelter and provide a safe environment in which to live. While our circumstances have changed from those early days, we still benefit from products that forests continue to provide. The development of new technologies and changing circumstances are providing us with opportunities for more cost-effective and efficient production and harvesting of what are often regarded as traditional forest products; and for using these in a different way. Lifestyle changes have made us aware of other non-timber products that forests can provide such as decorative foliage, wild foods and intangible benefits such as the enhancement of our environment for recreation, biodiversity etc.

The research projects described in this section are concerned with tangible products from forests. They deal with the adaptation of new technologies (GPS) to transport wood more efficiently to the mills; also the harvesting and processing of wood fuel, not a new product by any means, but a traditional forest product that is being used for the new purpose of providing carbon neutral renewable energy. Similarly, the potential for the commercial production of edible fungi, a traditional forest product in central Europe, is also being investigated as a possible new product from Irish forests.

Forest harvesting and transport

There are approximately 320 Coillte-contracted timber haulage trucks in operation in the country. The overloading that occurred in the past has been significantly reduced, making the sector one of the most compliant across the entire haulage industry. As a result, payloads are smaller, but haulage costs have increased,mainly due to the cost of road diesel. Furthermore, as the maximum gross vehicle weight (g.v.w) for 5-axle trucks is due to revert from the current 42 tonnes to 40 tonnes, this will also impact on revenue per kilometre. Taking these factors into account it is imperative that maximum legal payloads are hauled 100% of the travelling time, in order to maintain and build competitiveness in a sector that impacts significantly on the delivered-in price of roundwood. The basis for the LOADSENSOR project was therefore to develop and test the most appropriate, affordable and accurate on-board weight systems for optimising payload weights for in-forest loading and remote load monitoring.

PROJECT

LOADSENSOR: Evaluation of airbag pressure sensors / gauges as load weighing devices for use on timber haulage trucks

Wood energy

Diminishing supplies of fossil fuel, allied to the urgent need to drastically reduce emissions of greenhouse gases, are driving a world-world move to renewable energy sources. At the end of 2008 the EU agreed the Climate and Renewable Energy Package, which sets legally binding targets to be achieved by 2020, to cut greenhouse gas emissions by 20%, to establish a 20% share for renewable energy, and to improve energy efficiency by 20%. At national level a series of renewable energy policies and targets in heat, power and CHP will result in solid biomass demand of over 4 million tonnes by 2020. Further policy development is taking place under the Renewable Energy Development Group of the Department of Communications, Marine and Natural Resources.

Forestry has a central role to play in meeting future demand for solid biomass. Over 200,000 ha of new forests have been established since 1985, many of which have already entered the thinning stage, and are already being harvested for wood energy. Developing a wood fuel energy supply from Irish forests needs a concerted long-term programme of research, development and demonstration, focussed on matchingwood fuel supply and quality to end-user demands; for example, heating needs wood with a moisture content below 40%, with well graded chips, while large scale power generation can accept higher moisture contents and a wider range of fuels from sawdust to chip. COFORD has funded a national programme of R&D and demonstration in the wood energy area – FORESTENERGY – since 2006.

PROJECT

FORESTENERGY: Harvesting and processing forest biomass for energy production in Ireland

Non-wood forest products

Until relatively recently, forests were mainly viewed in the context of the quantity of wood produced. However, today forests are seen as multi-functional, sometimes with a higher value placed on the non-wood products and services.

In Ireland the opportunities created by forests for amenity, recreation and nature are among the main criteria by which most people judge the value and benefits of the national forestry development programme. There is a substantial and growing interest in the use of forests for many different activities including recreation, education and general well-being. Economic growth, development of efficient transportation networks, and other factors have led to an increase in demands for open space and the recreation associated with forested land. However, there are other products of value in the forests such as foliage, fruit, fungi and berries, and these may also have an important economic value for the forest owner.

Ireland's forests are predominantly plantations, mainly grown for wood. However, they also provide many other goods and services. As the country becomes more urbanised, the significance of these services is likely to grow. With the expansion of farm forestry, the need to develop income sources from these forests are of the highest priority and developing the full potential of the other products apart from wood production is of paramount importance.

PROJECTS

FARMFUNGI: Production of edible fungi in the farm forest

FORESTFUNGI: An assessment of wild edible fungal production in selected forest sites, and an evaluation of the commercial potential of harvesting

LOADSENSOR

Evaluation of airbag pressure sensors/gauges as load weighing devices for use on timber haulage trucks

PROJECT TEAM

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COMPLETITION DATE: April 2009

BACKGROUND

This project arose as a result of a recommendation in the Forest Industry Transport Group (FITG) Code of Practice for Timber Haulage, launched in December 2004: *COFORD in collaboration with the forest industry to undertake research and evaluation of load cells and mobile weighing devices*. Trucks vary in configuration, sensors can be placed at different locations. The most common truck configurations are the 5-axle configuration (42 tonnes g.v.w) and the 6-axle configuration (44 tonne g.v.w). All trucks and trailers are now air suspension as opposed to spring leaf suspension, which provides a higher design gross vehicle weights (d.g.v.w).

OBJECTIVE

- To test the cost-effectiveness and accuracy of using load-weighing devices fitted to the truck air suspension system.

PROGRESS

A vendor has been sourced to retro-fit the on-board weigh systems to both tractor unit and trailer. In addition to monitoring payload weights on-site, it is important to be able to monitor weights in transit and indeed remotely in real-time.

General Packet Radio Service (GPRS) is a packet-based, wireless communication service for passing data over mobile phone networks. It has become known as 'always-on data connection' for GSM mobile phones. It sends packets of data collected by the equipment on the truck, back to base in real time. It can also be used for voice communication between the vehicle and base.

Thus, by simply incorporating the GPRS network for data transfer, we can develop the technology so that trucks can be monitored in real-time and any discrepancies in loading, unloading and indeed overloading can be established and marshalled correctly.

Research has shown that for payload control, the high quality AirWeigh system incorporates a unique air sensor principle which measures the load in the trailer's air suspension system. This works in conjunction with fifth wheel loadcells for even higher precision weighing results (Figure 1). The AirWeigh system can be fitted easily and is installed within one working day. The system can measure to within ± 1.5% which implies optimizing the full revenue per payload weight. For in-cab monitoring, the indicator is fixed in place (Figure 2). For out of the vehicle and on-site weighing, the wireless pad can also be used (Figure 3).

The team is proposing a working and research relationship with GPS vendors (BlueTree) from the completed GPSTRACK project to develop the on-board payload real-time information with their R COM tracker. This software will allow the COFORD-funded GPSTRACK and LOADSENSOR projects to connect well to provide an overall answer to real-time GPS tracking and on-board weigh systems for the haulage industry.

ACTIVITIES PLANNED

This project is ongoing. Timber haulage was a pre-requisite but due to the adaptability of the haulage sector today, timber trucks can interchange their workload between timber haulage, general haulage and bulk haulage. Final activities include finishing off the trial, completing the final report for COFORD, presenting and circulation of findings to the FITG, submitting a peer reviewed paper and a COFORD Connects note.

Figure 1: Jost fifth wheel load cell.

Figure 2: In-cab indicator.

Figure 3: Freeweigh wireless pad.

FORESTENERGY

Harvesting and processing forest biomass for energy production in Ireland

PROJECT TEAM

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COMPLETION DATE: June 2009

BACKGROUND

Concerns over climate change, security of energy supplies and sustainable forest management have directed international policy towards supporting the development of renewable energy from wood fuel. The EU plans to produce 20% of energy requirements from renewable sources, with Ireland's overall target 16% by 2020. At a European level, it is expected that almost 65% of the renewable energy target will come from biomass, most in the form of wood. The Irish Energy White Paper and Bioenergy Action Plan for Ireland set out the framework for meeting these targets in Ireland. Sustainable Energy Ireland has mounted a successful campaign to encourage private individuals and commercial firms to install wood fuel boilers, thus creating a demand for wood fuel in the form of wood pellets and dry wood chip.

Three peat-fired power stations are gearing up to fulfill their obligation to co-fire peat with 30% biomass by the year 2015. The Forest Service has had two calls for grants for companies to buy wood chipping equipment.

Wood for energy is a relatively new assortment in Irish forestry and much knowledge remains to be gained. Ireland has a ready-made wood fuel resource in the large areas of farm forests planted over the last 25 years, which now require thinning to achieve production potential. Forest ownership is fragmented and knowledge of harvesting and storing wood for energy limited. The Forest Energy project, commenced in 2006, and renewed annually, aims to develop cost-effective supply chains by adapting commercially used methods from Europe to Irish conditions.

OBJECTIVES

- Demonstration of harvesting, extraction and wood fuel processing equipment in Ireland;
- Production and quality assessment of both wood chip and firewood products;
- Assessment of optimum storage systems to promote maximum seasoning at lowest cost;
- Investigation into moisture content/climate relationships with the view to developing a moisture content reduction model based on simple climatic indicators;
- Chemical composition of wood samples;
- Organisation of dissemination activities including public demonstrations, articles, workshops, presentation of results and display of wood fuel sample materials.

PROGRESS

Harvesting trials in softwood and broadleaf first thinnings

A range of harvesting methods was employed to carry out first thinning in broadleaf plantations, with both wood chip and firewood produced. The generally smaller size of broadleaf stands, the small average tree size, the close spacing and the threat of damage by large machines have led to the opinion that small scale harvesting methods are more appropriate for broadleaves. All broadleaf thinning was carried out in accordance with guidelines on line and selection around potential final crop trees. Felling was generally by chainsaw, though a harvester producing delimbed lengths was trialled at one site. All roundwood was produced to standard 3 m lengths to facilitate transport, and processing into firewood. Extraction by forwarder, grapple, ATV and horse were trialled. Different firewood processors were trialed using the 3 m lengths to produce standard length firewood logs. Woodchip was produced on two sites by felling whole trees into lines and terrain chipping and chip forwarding using the Silvatec chipper and forwarder. All operations were time studied and production was monitored. Production costs to the forest road were calculated for each production system.

Results indicate that the lowest cost method of thinning broadleaves is the whole tree terrain chipping option at between €46/m^3 and €67/m^3. The cost of producing 3 m lengths by chainsaw and extracting to roadside by forwarder was similar, ranging from €44/m^3 to €98/m^3

on the four sites trialled, but this does not include the cost of processing the logs into firewood. The firewood processors trialed ranged in productivity from 0.53 m^3/hr to 3.3 m^3/hr, including addig production costs that ranged from €11/m^3 to €49/m^3. The harvester was more productive compared with chainsaw harvesting but not sufficiently so to offset the higher operating cost. Small-scale extraction methods, such as the tractor with grapple, quad and trailer and horse and arch were all less productive and more expensive than the forwarder. However, these methods are very sensitive to the operating cost assumed. A forest owner could employ these methods directly, with the time valued differently to a contractor. Finally, the productivity of chainsaw harvesting is very sensitive to the operator, as the production rate ranged between 0.38 m^3/hr and 0.8 m^3/hr under broadly similar site and mean tree size conditions.

Energy parameter characterisation of Irish softwoods and broadleaves

All woodfuels produced from Forest Energy first thinning sites were characterized for moisture content, ash content and gross calorific value. Wood chip was also tested for bulk density and particle size distribution. Sampling, sample preparation and test methods were all carried out according to CEN Solid Biofuel technical specifications.

Woodchip bulk density

Bulk density of wood chip, measured in kg/m^3, is an important parameter, as energy content is quantified by weight, whereas the transportation and storage of wood chip is generally limited by volume, as wood chip is a relatively low density fuel compared with fossil fuel. Bulk density is determined by the basic density of wood, moisture content and mean and range of particle sizes produced by the chipper. A total of 1207 bulk density samples were measured on fourteen sites, moisture content was sub-sampled for each bulk density sample. This allowed the relationship of bulk density and moisture content to be investigated. Figure 1 shows the measured bulk density of woodchip from Sitka spruce roundwood against the sample moisture content. There is a strong non-linear relationship, described in the graph by a polynomial function with an R^2 of 0.92.

Variations within species basic density and, to a lesser extent, the variations in particle size distribution have a confounding effect. However, the strength of the relationship between bulk density and moisture content, could allow for the development of a wood fuel quantification method for payment purposes.

The two critical variables for estimating the energy content of wood fuel are weight and moisture content. Where it is neither possible nor practical to measure weight and moisture content directly, the bulk density could be estimated easily by sampling and the total load weight be derived from the load volume and estimated bulk density. The moisture content could be estimated from a fixed relationship with bulk density described for individual species and assortments. Delivered energy content could then be estimated from load weight and moisture content estimates. There are obviously large potential errors associated with this method, but in the absence of a more accurate approach, it could facilitate trade in wood chip for energy purposes.

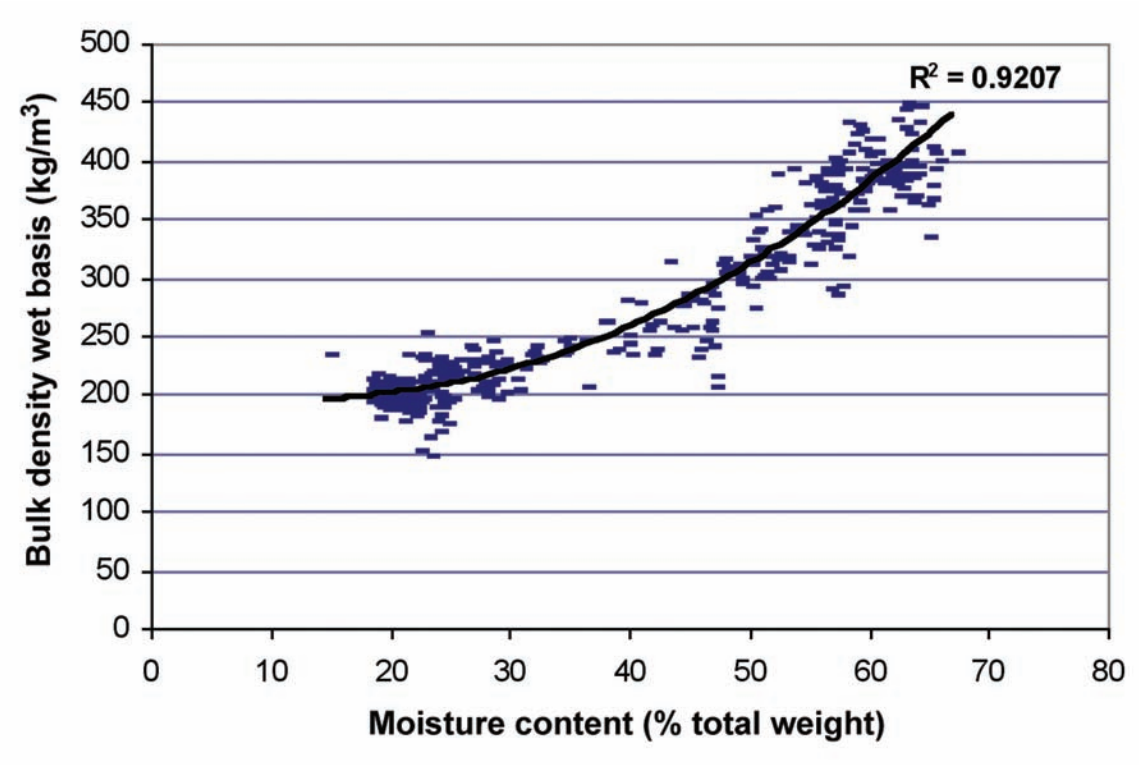

Figure 1: Relationship between bulk density and moisture content for woodchip from roundwood Sitka spruce.

Variation in gross calorific value

Over 1,100 samples from all sites were assessed for calorific value using a Parr 5200 bomb calorimeter. The general trends, which emerge are that wood is relatively homogenous in calorific value, ranging from 19-20 MJ/kg on a dry matter basis. Sufficient samples of different assortments of ash and Sitka spruce were analysed to gain further insight into variation in calorific value. Results are summarised in Figure 2, with the error bars indicating the margin of error associated with the mean at the 95% confidence level. The mean calorific value of ash is significantly lower than that of Sitka spruce. There was no significant difference between the ash roundwood (RW) and whole tree (WT) mean calorific values. Similarly, there was no significant difference between Sitka spruce roundwood and energywood assortments. The spruce whole tree assortment was significantly higher, indicating the higher calorific value associated with bark compared with wood.

Gross calorific value of woodfuels derived from forest sources vary according to species and the relative proportions of bark and wood. Gross calorific value, however, may be used to indicate the purity of the wood fuel tested, as the natural range of variation is narrow. Substantially lower or higher gross calorific values will only be caused by the presence of non-wood material.

Storage trials

In-forest and in-yard storage trial results have been previously reported. Work is on-going in developing a climate-based model estimating seasoning period for in-yard storage. Meanwhile the storage bins and load cells were relocated to Redmondstown, Co Tipperary, and reconstructed on a site provided by Coillte Panel Products. In 2010, it is proposed to undertake a storage trial of compact residue bundles.

Investigation of moisture content variation in Irish softwood and broadleaves

Moisture content of eleven species on eight sites around Ireland was assessed over 2007, 2008 and early 2009. All trees were randomly selected from Forest Energy trial sites. Additional samples were collected from a mixed softwood first thinning stand at Lismore Estate, Co Waterford. A total of 902 trees were felled, extracted, chipped. Five representative moisture content samples were collected from each tree. It should be noted that moisture content is calculated as a percentage of the total weight. Table 1 shows the mean moisture content of the eleven species sampled, at the 95% confidence interval. There was significant variation in mean moisture content between all species with the exception of alder and Douglas fir. Broadleaf moisture contents were all lower than those of softwoods. Ash is the species with lowest moisture content, averaging 40%; while Scots pine had the

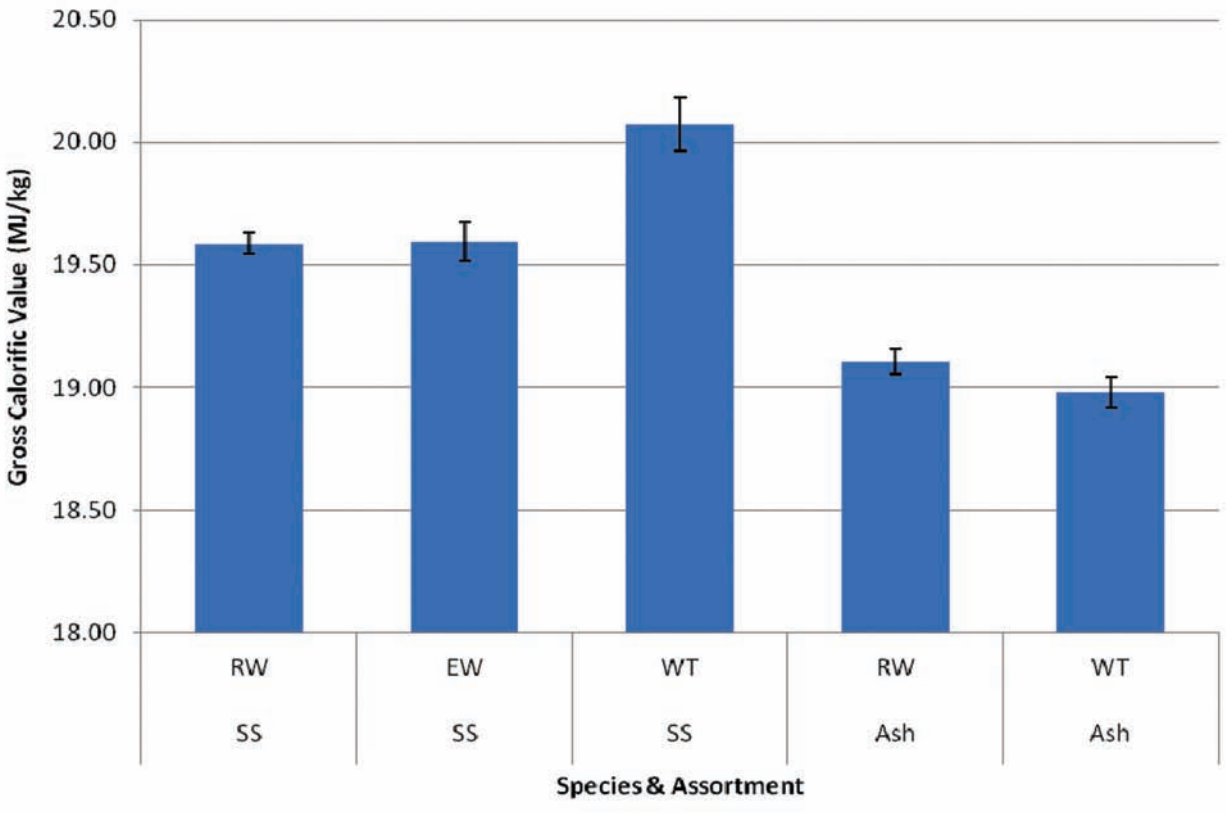

Figure 2: Gross calorific value (dry basis) of Sitka spruce and ash assortments. (For legend, see text.)

Table 1: Green moisture content (% total weight) of eleven species at first thinning in Ireland.

Species	Mean moisture content (%)	Standard deviation	95% confidence interval
Ash	40.0	3.63	0.19
Sycamore	47.6	2.74	0.33
Oak	48.4	2.36	0.22
Beech	49.8	3.28	0.58
Alder	52.6	2.69	0.33
Douglas fir	52.6	3.17	0.31
Larch	55.1	5.70	0.44
Lodgepole pine	57.0	2.93	0.53
Sitka spruce	58.1	3.58	0.28
Norway spruce	60.4	3.22	0.58
Scots pine	64.2	4.98	1.95

highest moisture content at 64.2%, albeit from a relatively small sample.

Sufficient samples of Sitka spruce, lodgepole pine, ash, oak and alder were sampled on a monthly basis to make a preliminary estimae of the variation in moisture content over the year. Results are shown in Figure 3. The bars associated with each data point represent the 95% confidence interval. All five species display a similar trend in seasonal moisture content variation. Moisture content peaks in the summer months of May to August. It falls in September and October and remains low over the winter, rising again in the spring. There is an obvious relationship between rising moisture content and the commencement of annual growth, and a similar relationship between falling moisture content and the cessation of growth in the autumn. The difference between peak month mean moisture content and the lowest mean moisture content was significant for all species. The moisture content of ash was 36.8% in April, rising to 45.6% in July. Sitka spruce moisture content in November was 55.3% and increased to 61.2% in May.

Planning a thinning to coincide with the season when moisture content is naturally low can bring significant advantages in reduced post-harvest drying, where energy is the target market for the thinning.

ACTIVITIES PLANNED

The current Forest Energy Programme is closed and reports and COFORD Connects Notes are in preparation. A further programme of joint research in wood energy, by WIT, UCD and DFE, is proposed for the period of 2010–2014.

OUTPUTS

Kent, T. and Kofman, P. 2009. *Wood Energy Supply Chains for Softwood First Thinning in Irish Forests*. Conference Proceedings: 17th European Biomass Conference and Exhibition: From Research to Industry and Markets, Hamburg.

Kofman, P. 2009. *Evaluation of Moisture Content Changes in Sitka spruce Roundwood and Energywood Assortments in Ireland: The Bin Trial*. Poster Presentation at 17th European Biomass Conference and Exhibition: From Research to Industry and Markets, Hamburg.

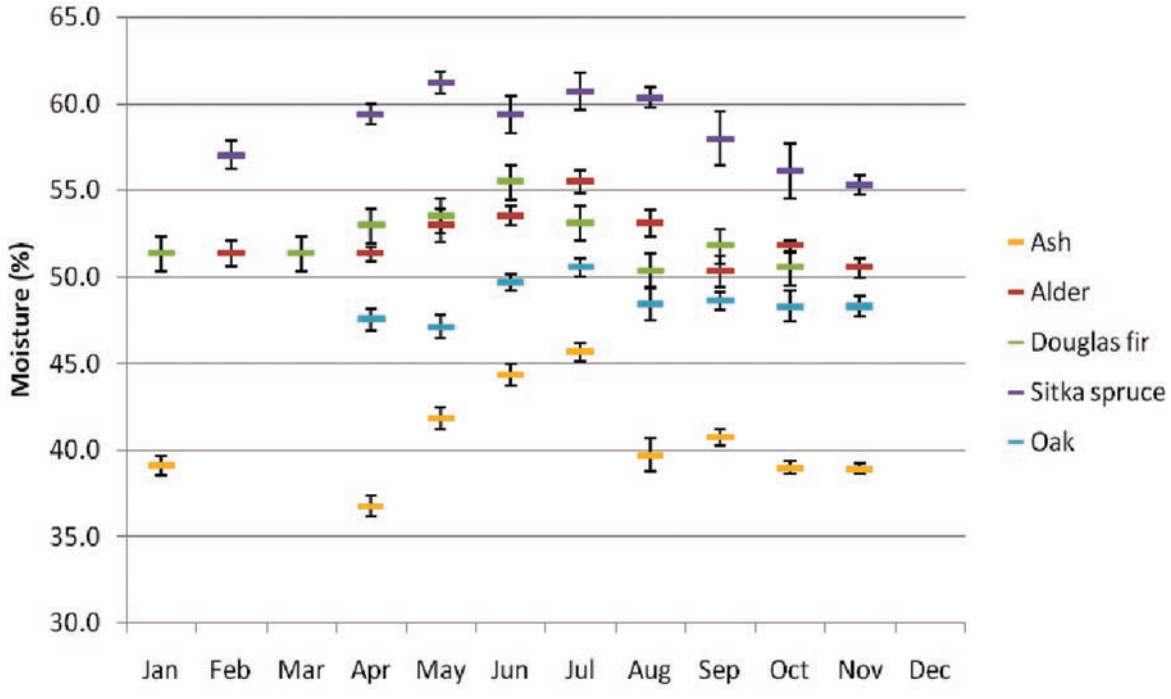

Figure 3: Monthly variation in moisture content of five species in Ireland.

FARMFUNGI

Production of edible fungi in the farm forest

PROJECT TEAM

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COMPLETION DATE: December 2010

BACKGROUND

Oyster mushrooms (*Pleurotus ostreatus*) and shiitake mushrooms (*Lentinula edodes*) are produced on a commercial scale in a number of countries. Production by traditional methods (i.e. on logs) has the potential to be integrated into farm forest enterprises, and to contribute to the financial returns from these enterprises. This is because capitalization costs are low and there is an availability of raw material for inoculation from thinnings With careful management, inoculated logs may continue to produce crops for up to six years after treatment, further reducing costs. The rationale behind this project is to assess the feasibility of this production method in a farm forest scenario in Ireland.

OBJECTIVES

- To determine whether inoculation of cut stumps and sawn logs and incubation in the forest will yield marketable quantities of oyster mushrooms and shiitake.
- To determine the influence of stump size and type, log type, size, and moisture content on mushroom yield.
- To develop a protocol for cultivation of mushrooms on logs derived from thinnings that will be applicable in farm forest enterprises.
- To determine whether a plantation of *T. aestivum*-inoculated host trees that will yield commercially viable quantities of truffles can be established on a previously unforested site in Ireland.

PROGRESS

Monitoring of the 2008 trials

Oyster mushroom/shiitake trials

Moisture contents of inoculated logs: Monitoring of the 2008 trials in Askeaton, Blossomhill and Springfield continued. Moisture contents of the logs declined somewhat in the early part of 2009 (Figure 1) at all sites. A new irrigation regime installed at Blossomhill and Springfield in March 2009 arrested and reversed this

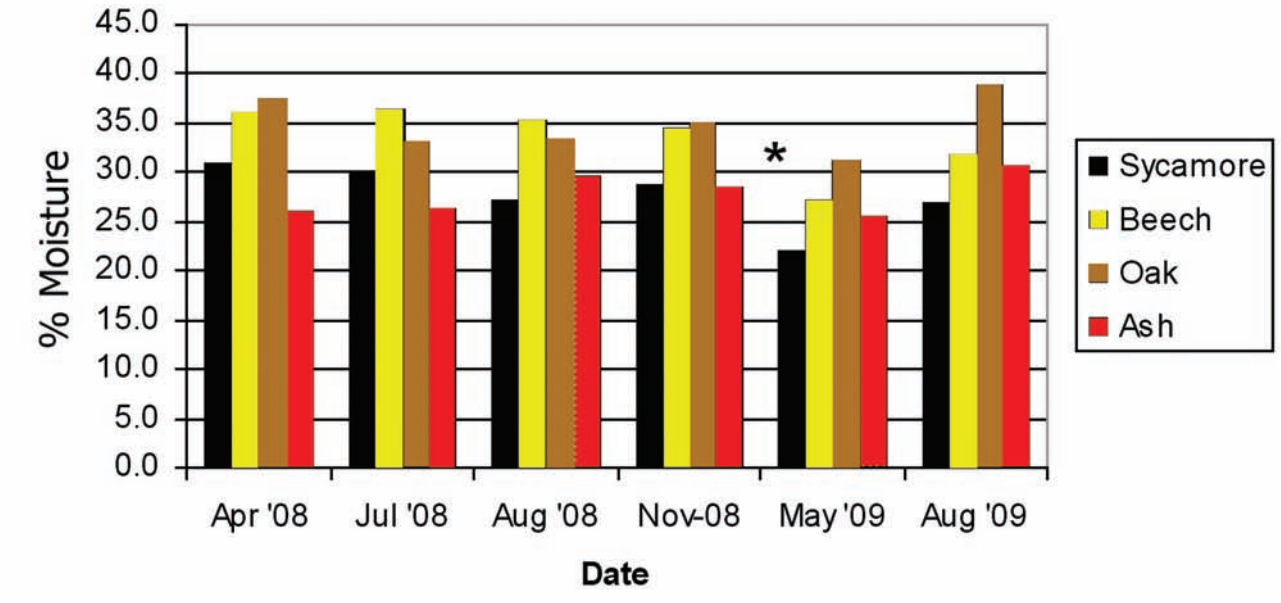

Figure 1: Average moisture content (%) of logs of different timber types at Blossomhill farm forest. Logs cut in April 2008. Irrigation installed in March 2009 (marked *).

decline (the abnormally wet summer of 2009 also helped). It was not possible to install a similar regime in the Askeaton site; this site will act as a benchmark for assessing the impact of irrigation.

Production of oyster and shiitake mushrooms

Oyster fruit bodies began appearing as early as January 2009 on sycamore stumps. Almost 50% of sycamore stumps have produced on average, 2.3 fruit bodies per stump, over the period January–August 2009. Other stump types have produced very little yet.

Logs had not produced as much as stumps up to September 2009. The main expected production period for logs would be autumn: late August –December. Expected yield would be about 2-3 kg per log. Production on logs started in September as expected, and although results have not been collated yet, production appeared to have been better than on stumps but not as good as expected. The shiitake logs have produced very little, even though induced by dipping in water. Oyster fruit bodies have appeared sporadically on all timber types, and while it is not statistically possible to say yet which timber type is most productive, it appears that sycamore is the most, and ash the least productive. The severe cold snap that started in mid-December ended all fruiting in 2009. It is expected that production on these logs will continue into 2010.

The 2009 trials

A further set of trials was set up in spring 2009. The aims of these trials were to investigate variables such as different strains of *Pleurotus* and shiitake, the use of 'home-grown' inoculum, suitability of conifer timber, influence of different inoculation rates, and continuous (i.e. year-round) inoculation. Some of the logs inoculated with a native strain of *Pleurotus ostreatus* have already produced some fruit bodies, but the main production period will be next autumn. The same irrigation regime has been applied for these and monitoring of moisture content is continuing.

The truffle orchard trial

The oak and hazel truffle orchards are being maintained manually weed-free and progress of the trees is being monitored. It is likely that excavation of the entire roots system of selected whole plants will have to be carried out in spring 2010.

ACTIVITIES PLANNED

- Continuous monitoring of the weight and moisture content of the inoculated logs and fungal development on these logs.
- Monitoring environmental conditions in each plantation.
- Analysis of how variables (such as log type, log diameter, log moisture content) influence the yield of shiitake and oyster mushrooms.
- Analysis on the influence of stump size, type and location on yields of oyster mushrooms.
- Final analysis of data and economic evaluation of in-forest fungal inoculation/production.

OUTPUTS

An interim report on the FARMFUNGI project, entitled *Fungi in farm forests*, was delivered by Tom Harrington, at the Forest Fungi in Ireland Seminar at Avondale House, Co Wicklow on 28 August 2009.

FORESTFUNGI

Assessment of wild edible fungal production in selected Irish forest sites, and an evaluation of the commercial potential of harvesting

PROJECT TEAM

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COMPLETION DATE: August 2010

BACKGROUND

At least 1100 species of wild fungi are collected worldwide for their culinary or medicinal use. In Europe, the most highly valued commercially collected fungi are truffles (*Tuber* species), ceps (*Boletus edulis* and related species) and chanterelle (*Cantharellus cibarius*), but many more species may actually be collected for consumption depending on regional preferences.

Harvesting of edible fungi in Irish forests was traditionally rather insignificant, but interest in collecting edible fungi for culinary use has increased greatly in recent years. Information is needed on the potential of edible fungi as a secondary forest product in Ireland. Such information is at present sparse, anecdotal and unpublished, in contrast to the situation in many other European countries, where collecting wild edible mushrooms is popular. The aim of this project is to obtain this information, which will provide an objective basis for assessing the commercial and recreational potential of edible fungal harvesting in Irish forests.

OBJECTIVES

- To obtain quantitative information on production of wild edible fungi in forest study sites that are representative of larger areas of forest in Ireland
- To establish a framework for long-term monitoring of the selected sites beyond the lifetime of the project.
- To extrapolate production from the study sites to larger areas of similar forest in Ireland
- To assess year-to-year variation in fungal production.
- To correlate fungal production production with environmental and habitat variables.

PROGRESS

The third sampling of the planned 3-year sampling programme was completed in autumn 2009. Forty-six forest sites, and 114 plots within them, were reselected for surveying in 2009. Each site was surveyed four times between the start of September and December. A small number of plots was lost between 2008 and 2009, mainly due to clearfelling.

Initial results indicate that in 2009 the fruiting season was spread unusually in comparison to previous seasons. Fruiting times were displaced, notably for *Armillaria* spp. which occurred in profusion at the end of September, approximately 3 weeks earlier than usual. 2009 appears slightly less productive than the 2008 or 2007 season. After a promising start, there were early occurrences of edible fungi, notably edible bracket fungi and very early winter chanterelles in August. However, with dry weather in September, fruiting ceased for a time and never fully recovered the volumes of 2008. The season ended quite early, due in part to very high rainfall in November. A small number of plots were inundated with floodwater for the first time during the three year study. Some unusual species appeared in plots for the first time in 2009, for example *Amanita vaginata* (grisette). First records of some rarer fungi were recorded from day forays also, e.g. green *Russulas* close to *Russula cyanoxantha*, such as *Russula vesca* and *R. langei.*

Additional work in 2009 included soil sampling from each plot. Environmental data collection was completed this year. Data included:

- Five soil samples from each plot;
- Assessment of ground flora cover in each plot;
- Tree numbers and girths;
- Stand history.

Armillaria mellea - honey fungus.

Boletus edulis - commonly known as penny bun or cep.

ACTIVITIES PLANNED

- Compilation of soil data and other environmental data from plots.
- Detailed analysis of the data from the three year's sampling will commence. The main aims will be:
  - To provide production estimates of edible fungal fruitbodies in dirrefent forest types
  - To extrapolate WEFF production from the study sites to larger areas of similar forest in Ireland
  - To assess year-to year variation in fungal production.
  - To examine the relationship WEFF production with environmental and habitat variables.
  - To examine the association between the different species of edible woodland fungi.

OUTPUTS

- A presentation on the project, *Forest fungi as non-timber forest product* was presented on 28/8/2009.
- *Forest Fungi in Ireland.* Woodlands of Ireland lecture, Charleville Castle, October 2009.
- *Identification of Fungi in Ireland*. National Biodiversity Data Centre, Waterford September 2009.
- Cullen, M., Fox, H. and Harrington, T. 2009. *Tuber aestivum/uncinatum in Ireland*. First Conference on the European Truffle *Tuber aestivum*, University of Vienna, November 2009. (To be published in the Austrian Journal of Mycology).
- Radio interview with Michael Lemass during identification course, Avondale 2009. www.growitcookiteatit.ie/2009
- *Eye on Nature*, 30 May 2009, Michael Viney article mentioned the Forest Fungi project.

Policy and public goods

While timber production was the original objective of the afforestation programme, today it is generally recognised that forests provide more than economic benefits to society. Social and environmental benefits, often known as public goods, have an important role in the sustainable management of our forests. Forests provide services such as employment, carbon sequestration, biodiversity, water protection and wild spaces for outdoor recreation but this contribution may not be taken into account when the economics of a forest enterprise are assessed. Our understanding of these benefits, and the underlying mechanisms by which they operate, are in many cases not fully understood or quantified. The projects reported in this section are providing deeper insights into the value of forests to society and ways to account for these externalities, in addition to providing guidance for their enhancement and future development.

Forest economics and policy

The policy arena in which forestry operates is constantly changing. The multi-functional model of forestry, delivering economic, environmental, social and cultural benefits, which has been evolving throughout Europe, represents the new paradigm. Forestry is increasingly expected to deliver public benefits including recreation, landscape, water quality, biodiversity and carbon sequestration. Furthermore, the range of tradable goods and services generated in the forestry sector has expanded beyond timber production in Ireland to include, *inter alia*, cut foliage and marketed recreational activities. Alongside this, the ongoing reform of the Common Agricultural Policy, leading to the introduction of the Single Payment Scheme and the emergence of a new Rural Development Strategy, the ongoing review of the National Climate Change Strategy, and an overall downturn in the economy will have significant implications for the future of forestry in Ireland.

The FORPOLEC programme :

- Provides an estimate of the value of all of the tradable goods of forestry, and of the direct and indirect contribution of these tradable goods and services to the national, regional and local economies.
- Addresses the valuation of the market and non-market functions of forestry, including timber, game hunting, marketed recreational activities, carbon sequestration, water quality, landscape and biodiversity impacts, as well as non-marketed recreational activities.
- Identifies strategies to encourage afforestation by farmers in the context of a changing policy environment.

PROGRAMME AND PROJECTS

FORPOLEC

FIRMEC: Modelling the economics of forestry in Ireland

FORECON: An economic evaluation of the market and non-market functions of forestry

POLFOR: Forestry in a changing policy environment

Forests and climate change

Global and regional climate change create many challenges and opportunities for Irish forestry. With their long life cycles, trees are expected to be more sensitive to large shifts in climate patterns, which are expected to be faster than those experienced in the past. Forests interact with the climate and atmosphere: on the one hand, they are vulnerable to climate change but, on the other hand, they contribute to reducing greenhouse gases in the atmosphere.

It is difficult to discuss adaptation to climate change with a forest decision maker without any comment about carbon sequestration and mitigation of greenhouse effect. Similarly, mitigation cannot be planned without an understanding of future forest vulnerability. The key objective of the CLI-MIT programme is to provide stakeholders with the tools and knowledge for formulating and achieving effective mitigation and adaptation policies. This requires a good knowledge of the impact of climate change, international and EU policy, carbon reporting mechanisms, and issues relating to forest carbon sinks. The objectives of this research programme are firmly based on the policy requirements in terms of Ireland and Kyoto reporting commitments, and government/forest policy in relation to future climate change.

PROGRAMME AND PROJECTS

CLI-MIT

CARBIFOR II: Carbon sequestration by Irish forest ecosystems

CARBWARE: Development of tools and systems for reporting on forest carbon stocks and stock change under the Kyoto Protocol and the UNFCCC

CLIMADAPT: The use of Ecological Site Classification in adapting forests and their management to climate change

FORESTSOILC: Soil carbon stock changes and greenhouse gas fluxes in Irish forests

WOODCARB: Carbon stocks and stock changes in harvested wood products

Forest biodiversity

The knowledge base on forest biodiversity in Ireland is restricted to certain forest types and taxonomic groups, although progress has been made in recent years through state funding of the National Survey of Native Woodlands and the BIOFOREST project. PLANFORBIO builds on these efforts, expanding the number of forest types in which biodiversity is understood and drafting management and monitoring guidelines for these habitats. The programme focuses on particular elements of diversity and aspects of management of importance to Irish forest policy through large scale studies of forest biodiversity. A primary aim of the programme is to address forest diversity and management, focusing on forest types that are currently being encouraged through state policies and financial incentives. These are the Irish forests of the future, and little is currently known about their capacity for biodiversity conservation.

Included in the programme are special studies of two species of great interest to Irish and European conservation and diversity: the Hen Harrier, one of Ireland's raptors associated with forested habitats, and the invasive alien plant *Rhododendron ponticum*. The aim of these studies is to develop decision-making tools for forest planning and management and draft action plans for species conservation or control.

In addition to increasing our knowledge of above-ground biodiversity, the below-ground element is also being studied in the FUNCTIONALBIO project. Fungi and soil fauna are the main drivers of decomposition and as such play a vital role in ecosystem functioning. This study, along with the other projects, significantly broadens the ecological scope of the assessment of biodiversity in Irish forests.

PROGRAMME AND PROJECTS

PLANFORBIO

FORESTBIO: Managing for biodiversity in a range of Irish forest types

HENHARRIER: Optimum scenarios for Hen Harrier conservation in Ireland

RHODO: Achieving effective rhododendron control

FUNCTIONALBIO: Functional biodiversity in forests: diversity of soil decomposers and predatory and parasitic arthropods

Forests and water

The Water Framework Directive (2000/60/EEC) requires that EU Member States achieve good ecological and chemical status for all waters within river basin districts by 2015. The characterisation study, undertaken to identify the anthropogenic pressures on water bodies, identified forestry as one of the land use activities posing a potential risk in terms of diffuse pollution. Among the pressures highlighted were increased acidification from plantations in acid-sensitive catchments, sedimentation from harvesting operations, road construction and erosion on steep catchments and eutrophication from fertilisation on steep catchments and from harvesting on peat soils.

Our knowledge of these pressures arises from scientific studies carried out since the early 1990s on the interactions between forests and surface water quality. These have given us a deeper understanding of the underlying natural processes that give rise to these interactions and have led to the introduction of Forest Service guidelines on forest operations and water quality. However, many gaps in our knowledge remain and these projects build on previous research to gain further insights into these interactions, while also investigating practical mitigation measures to address the pressures that water bodies may experience from forests and forestry operations.

PROJECTS

FORFLUX: Biogeochemistry of Irish forests

HYDROFOR: Assessment of the impacts of forest operations on the ecological quality of water

SANIFAC: Assessment and mitigation of soil and nutrient losses from acid-sensitive catchments

FIRMEC

Modelling the economics of forestry in Ireland

PROJECT TEAM

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COMPLETION DATE: January 2012

BACKGROUND

Forestry has an important and ever evolving role to play in the Irish economy. There is increasing emphasis on the role of forestry as an alternative energy source, its potential to sequester carbon and the provision of non-tradable goods such as forest recreation. However, despite the presence of generous forest premium payments and the decoupling of direct payments, the afforestation rate is in decline. Therefore given the importance of forestry, a better understanding of the relationship between policy and afforestation rates is required.

OBJECTIVES

This project assesses the actual and potential contribution of forestry to the national, regional and local economy, in terms of both tradable goods and services and in terms of public goods as well as building up the capacity to assess the impact of policy reforms on the sector and assess the impact of the forest sector on the wider economy.

- To measure the impact on farm afforestation rates on the wider economy, competing sectors in terms of land use and the external policy environment.
- To assess the impact of forestry on the regional and local economy.
- To estimate the non-market (i.e. recreational, scenic etc.) value of forests.

PROGRESS

A paper on the *Situation and Outlook for Forestry 09/10* was produced for the 2009 Teagasc Situation and Outlook Conference. This paper examined recent trends in planting and in thinning activity, as well as the state of timber markets and the consequences for afforestation rates.

A paper was submitted to the *Figures for Forests* publication in Freiburg, Germany, on using economic models to forecast the participation of farmers in afforestation. A conference paper was delivered on afforestation by farmers at the Agricultural Economics Society International conference. An Excel financial model called Forestry Investment and Valuation Estimator (FIVE) was developed which has the capacity to analyse the financial returns in terms of Net Present Value (NPV) of different afforestation scenarios by species, area, productivity, grant scheme, and other inputs. It also has the capacity to assess the economics of thin versus non-thin scenarios. A sample output from FIVE is presented in Figure 1 for a thin versus no-thin scenario for a 10 ha Sitka spruce/Japanese larch forest at age 15.

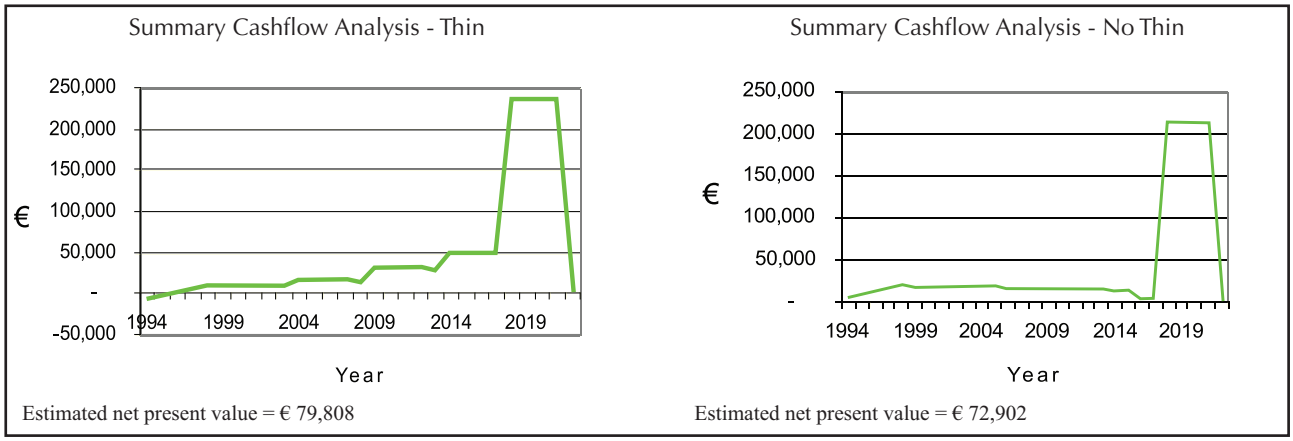

Figure 1: Financial analysis of *Thin* versus *No Thin* for a 15-year old mixed Sitka spruce/Japanese larch forest.

ACTIVITIES PLANNED

- Inclusion of forestry in the farm-level greenhouse gas emissions model.
- Derive aggregate visits and economic value estimates for potential farm forestry recreational sites.
- Because of the unusual and atypical economic behaviour that occurred at the peak of the land and property bubble over the Celtic Tiger period, it has proven impossible to develop an economic model of forestry planting decisions based upon historical aggregate data. For this reason we are using a different strategy to undertake a choice experiment survey to quantify potential farm forest planters attitudes under alternative market conditions. Linking with the Forestry Development Unit's farm advisory software, we will develop a novel survey technique of presenting income streams associated with alternative market conditions and planting type, based upon individual farms' characteristics, rather than theoretical characteristics which would be required in the absence of this software. This survey will generate a dataset of farm characteristics and planting choices which can be interrogated using discrete choice econometric tools to model farmer preferences for afforestation.

FORECON

An economic evaluation of the market and non-market functions of forestry

PROJECT TEAM

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COMPLETION DATE: June 2011

BACKGROUND

Policy decision-making in forestry needs to be well informed. This implies, amongst other things, that up to date information on the economic contribution of forestry to the national, regional and to local economies is collated. Furthermore, given that the multi-functional model of forestry, delivering economic, environmental, social and cultural benefits, is the new paradigm, this economic evaluation should include an assessment of the value of the public goods that forestry delivers, including climate change mitigation, biodiversity conservation and enhancement, water quality protection and enhancement, recreation, and landscape value. It is likely that different approaches to forest management deliver different public benefits. Thus the economic valuation associated with types of forest as differentiated by ownership, location, scale, management and species mix, needs to be assessed. This will yield strategic information by indicating the relative benefits of different types of forest.

OBJECTIVES

- Provide strategic information by indicating the relative benefits of forest management practice respectively directed at the outputs of recreation, biodiversity, landscape, water quality and carbon sequestration.
- Estimate the relative public benefits of public forestry and private forestry, including farm forestry.
- Determine the direct and indirect contribution of the tradable goods and services of forestry, including timber, game hunting, a small number of marketed leisure activities, cut foliage and forest food (i.e. berries and mushrooms) to the national, regional and local economies.
- Demonstrate the net public benefit of forestry in comparison with other land uses.
- Examine those factors which determine public benefits and determine if benefit transfer estimates from abroad would be applicable to Ireland.
- Place values in a public cost-benefit framework by comparing policy cost with the social benefits and combining this information with the private costs and benefits motivating forestry uptake over time.

PROGRESS

To date the project has focussed on examining the relative benefits of different forest management approaches to non-market forest benefits (NMFB) and on determining the direct and indirect contribution of tradable forestry good and services to the economy.

After an extensive literature review was undertaken, two focus groups were held, one in Dublin and a second in Carrick-on-Shannon, to identify the main forestry issues that are relevant to the public. This process identified five issues, with associated levels, that are meaningful to the public and policy-makers. These are: species planted (conifer, mixed, or broadleaf), the inclusion of a biodiversity reserve area (0%, 15%, 30%), harvesting methods (block or individual tree harvesting), the inclusion of recreation trails (none, basic, and a network of trails and facilities) and location (close to cities and towns; in the wider countryside and in remote upland areas).

These issues, combined with a range of potential costs, were used to describe possible management approaches to the current policy to expand forest cover to 17% by 2030. Figure 1 contains one of 72 different combinations of options. By analysing how the public rank the different options, the relative marginal importance of these forest characteristics and a range of potential costs can be identified. The data will be used ultimately to produce willingness to pay estimates for changes in the levels of individual attributes through their combination with the cost parameter estimate.

In addition to the valuation section, a number of questions related to recreational use of forests and attitudinal and socio-demographic questions have been included in the survey. Survey data will be combined with forest spatial data in a GIS to investigate how existing forests influence people's attitudes to and values of forests.

A market research company was commissioned to administer the experiment in the form of a survey of 1,000 households in Ireland. The questionnaire was piloted in

Figure 1: Sample choice set.

early December 2009 and produced positive results while providing useful information on necessary changes.

In assessing the direct and indirect contribution of tradable forestry goods and services to the economy, use is being made of the recently published Input-Output Table for 2005. The agriculture, fishing, and forestry sector has been disaggregated, as has the wood and wood products sector (into panelboards, sawmills, and other wood products).

ACTIVITIES PLANNED

- The household survey will be carried out in January and February and an analysis of the data collected will be completed by end September.
- The inter-industry distributions between the various forestry and wood sectors will be calculated. Sectoral multipliers will then be calculated and the total value of the forestry and wood products sectors to the Irish economy estimated.
- The direct contribution of game hunting, a small number of marketed leisure activities, and the cut foliage industry to the national economy will be estimated.

POLFOR

Forestry in a changing policy environment

PROJECT TEAM

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COMPLETION DATE: June 2011

BACKGROUND

The government's forest strategy, *Growing for the Future*, laid out afforestation targets of 25,000 ha per annum to the year 2000 and 20,000 ha per annum thereafter to the year 2030, with the ratio of private to public planting to be 70:30. These targets have not been met, and planting rates have fallen since 1996, reaching only 6,249 ha in 2008. Since its publication, a number of reviews of the success of the strategy have been carried out and the policy environment in which forestry operates has changed substantially. Continued reforms of the Common Agricultural Policy (CAP) resulting in the introduction of the Single Payment Scheme, changes in rural development policy and climate change measures all influence afforestation policy and practices. There is a need therefore to explore the influences of these policy measures for forestry as well as a need to understand better the decision-making environment of farmers and more specifically to influence it.

OBJECTIVES

- Compare the relative returns from forestry and a number of different agricultural systems in the light of the introduction of the Single Payment Scheme (SPS) and analyse the impact at the level of the individual farmer and the wider economy.
- Examine the implications of the forestry-related measures to be introduced under the Rural Development Regulation (RDR) in Ireland for both the sector itself (including Coillte) and the wider economy, including, inter alia, the impact of revised payment rates for afforestation and the introduction of more specific 'forest-environment' payments.
- Explore the factors influencing a farmer's decision to plant using a combination of quantitative and qualitative research methods.
- Determine the impact of these reforms and farmers attitudes on land availability for forestry.
- Identify strategies to encourage afforestation by farmers in the context of the changing policy environment.

PROGRESS

Preliminary economic comparisons of the returns from a number of agricultural systems and a forestry enterprise taking account of the introduction of the Single Payment Scheme (SFP) have been carried out. A comparison of the net present value (NPV) for cattle rearing and sheep with the NPV for Sitka spruce (YC 16, clearfell system) showed that the NPV for forestry is higher only if the farm does not participate in REPS and only 50% of farmland is afforested (stacking of the SFP). This work will be extended to examine the gross margins from various agricultural systems and the cash flows from a number of forestry enterprises and will account for changes arising from the introduction of the SPS, the Rural Development Strategy and other policy developments.

An extensive review of policies that influence land use, but specifically forestry, continues. This has included, to date, the Rural Development Programme, the Single Payment Scheme and the National Climate Change Strategy. This will continue to take into account recent economic changes in the country.

Work continued on the production of a detailed literature review of decision-making regarding land use, specifically focusing on the decision to afforest land. This had focused

on the two groups of decision-makers: group 1: public forest owners and forest companies, and group 2: farm forest owners and private estate owners. The review has shown that the former group is likely to be organisations/bureaucracies who act on a rational choice, utility maximisation basis, while for the latter group non-economic factors can be important during the decision-making process. Thus for group 1 the economic rational choice model is appropriate and factors such as land prices, timber prices, infrastructure, market development and the policy framework are important.

ACTIVITIES PLANNED

- Examine farmers' decision-making process. Using a qualitative method like for example semi-structured interviews farmers shall be asked about the reasons for their land use decisions with regard to forestry. Both farmers with and without forests will be approached as will be farmers of different farming enterprises.
- Explore the impact of these factors. With the results of the interviews, a questionnaire will be designed and issued to farmers of all farming enterprises and to farmers with and without forests. With the help of this quantitative study, structural patterns underlying the decision-making process of farmers can also be revealed.
- Examine the decision-making process of state forestry bodies and forestry companies and the factors influencing it. Meetings of discussion groups comprising a cross-section of decision-makers in state bodies and companies will be held.

CARBIFOR II

Carbon sequestration by Irish forest ecosystems

PROJECT TEAM

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COMPLETION DATE: June 2012

BACKGROUND

The overall objective of CARBiFOR II is to provide information for quantifying the influence of disturbance, land use change, soil type and forest age on carbon budgets that are relevant to the Land Use, Land Use Change and Forestry (LULUCF) reporting requirements under the Kyoto Protocol of the Climate Change Convention. CARBiFOR II builds directly on the achievements of CARBiFOR, by extending the time span of flux measurements to include an analysis of stand age, as well as the influence of disturbance caused by afforestation and thinning operations. The project will also attempt to characterize changes in biomass, decomposition, CO_2 and non-CO_2 greenhouse gas (GHG) flux associated with different soils and tree species, providing a more comprehensive assessment of the total greenhouse gas budget of Irish forest ecosystems. The project intends to study three complete chronosequences (a series of sites representing the development of forest plantations):

Chronosequence 1: Sitka spruce growing on a mineral soil;

Chronosequence 2: Sitka spruce growing on a peat soil;

Chronosequence 3: Ash growing on a mineral soil.

OBJECTIVES

- Biomass allocation and stock measurements.
- Above- and below-ground coarse wood decomposition study.
- Using ground penetrating radar to estimate below-ground biomass.
- Measuring the surface exchange of CO_2, H_2O and turbulent energy over several forest age classes using permanent and mobile Eddy Covariance towers.
- Estimation of C losses associated with thinning, associated vegetation and land use change.
- Measurement of non-CO_2 greenhouse gas emissions associated with land use change and forest stand age.
- Assessment of net GHG budget associated with afforestation.
- Project chronosequence soil characterisation and C stocks.
- Soil sampling of NFI plots and chronosequence sites.
- C inputs and parameters for Century model.

PROGRESS

Enough data have been collected to construct small tree biomass equations covering ash, alder, larch and Sitka spruce. These will be used to estimate biomass in younger forest stands where the dbh is not measurable. The height range varies from 30 cm to 11 m. These young forests often fall outside the range of biomass equations/yield models.

Photo from the top of the permanent tower at Dooary. The average dbh and height were 17.6 cm and 13.9 m, respectively, in the 20-year old stand. Snow fall in February 2009 brought air temperatures above the forest canopy to -2.7°C. Temperatures at ground level were over a degree higher because of the sheltering effect of the tree cover.

Stock estimates derived from biomass surveys of the Sitka chronosequence were used to examine age-related changes in forest increment (Figure 1). Productivity was greatest between years 16 to 18 when stand canopy competition was greatest. Annual litterfall amounts (needles and twigs) varied across the Sitka chronosequence from 0.31 (6-year old), to 2.1 (14-years), to 1.33 t C ha^{-1} (21 years). The larger amount corresponds to the period of forest development where the forest stocking is still high (two thinnings have substantially reduced the stocking of the 21-year old forest) and the growth of the tree crowns has begun to be limited by competition.

Brash, buried root bags and the trenched root experiments continue to be sampled every six months. Following mass loss and density measurements, samples have been homogenised and ground for CHN analysis, which has just begun. First results show an expected correlation between the C:N ratio and density of decay class samples. As decay progressed, both the C:N ratio and density decrease (Figure 2). Surveys of coarse woody debris stocks (CWD; Figure 3) show an abundance of abandoned logs following thinning at the 35 year old stand. This may be atypically high due to difficulties in harvesting because of a steep slope at this site.

Eddy covariance measurements have shown that the carbon sink strength of Sitka spruce forest plantations increases with age after afforestation of semi-natural grassland to a 21-year old forest stand (Figure 4). Thinning has been shown to have both neutral and negative impacts on carbon assimilation (Figure 5). The Dooary forest was thinned in 2007 (line and selection) and 2008 (selection). The results show an increase in Net Ecosystem Productivity (NEP) of the stand after the first thin due to a small reduction in gross primary productivity (GPP), coupled with a significant decrease in ecosystem respiration (Reco). The results of the second thinning show a decrease in NEP due to a reduction in both GPP and Reco.

Soil carbon dioxide (CO_2) efflux has been measured at the grassland, 6-year and 21-year chronosequence sites. The results show that CO_2 efflux decreases with forest stand age although these results are not significant ($p>0.05$). Precipitation exclusion shelters (Figure 6) have been constructed at each site to investigate the impact of changing soil water conditions on soil CO_2 efflux.

Trace gas data collected at the Dooary forest chronosequence suggest the conversion of grassland to forest increases the emissions of nitrous oxide (N_2O) to the atmosphere, while methane (CH_4) emissions tend to decrease. These results are largely due to changes in hydrology, the waterlogged conditions at the grassland site lead to anoxic soil conditions enhancing the production of methane. The lower water content at the afforested sites resulted in a decrease in CH_4 emissions but an increase in N_2O emissions.

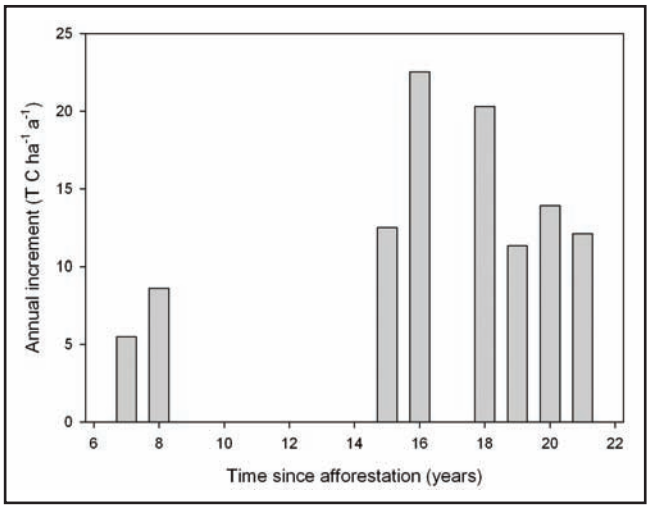

Figure 1: Increment across the Sitka spruce chronosequence at Dooary, Co Laois. Stock estimates were generated from stand surveys (on some sites since 2005) and the increment calculated as the difference between one year and the preceding one. Although thinning operations took place in years 18 and 20, the removed was added back to make stand productivity comparable with years where there was no thinning.

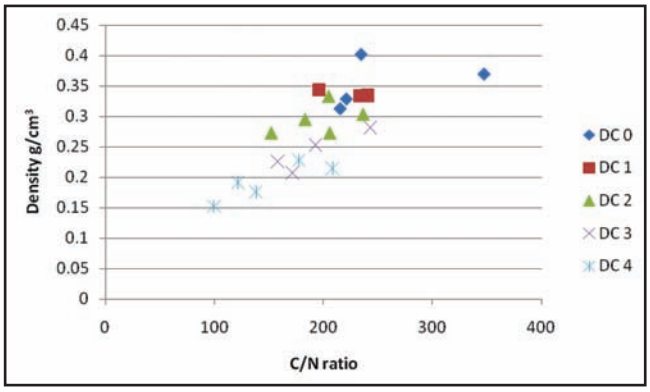

Figure 2: The relationship between C/N ratio of Sitka spruce deadwood and the basic density in different decay classes (level of decay increases from DC0 to DC4).

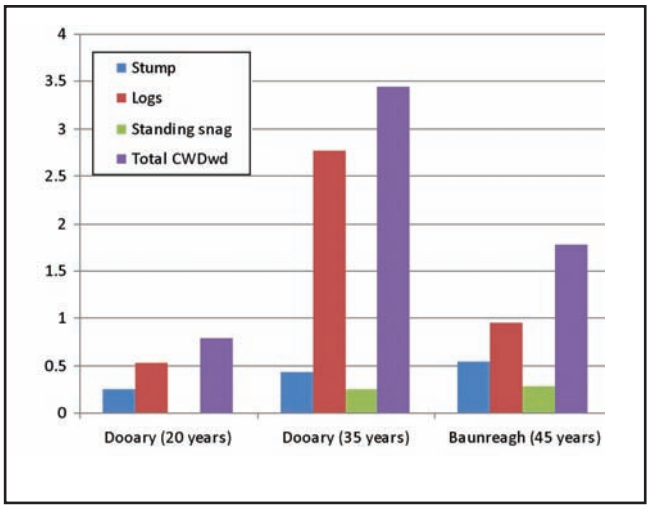

Figure 3: Above-ground coarse woody debris (CWD) stocks across a series of older Sitka spruce sites. Belowground dead roots are not included.

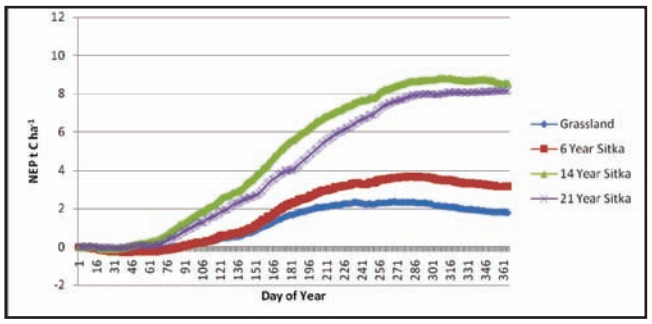

Figure 4: Net Ecosystem Productivity in 2009 of a Sitka spruce chronosequence, ranging from a semi-natural grassland (pre-afforestation) through to a 21-year old stand.

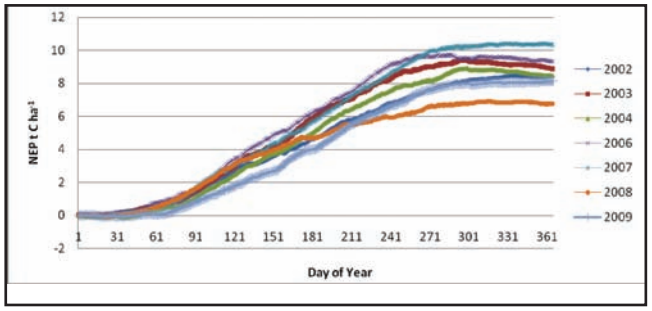

Figure 5: Inter-annual variation of Net Ecosystem Productivity of the Dooary forest, Co Laois.

Figure 6: Rain exclusion shelter located at the Dooary grassland chronosequence site.

The sampling of mineral and peaty mineral soils has been completed. These were prioritised over peat soils using a detailed sampling protocol, which was agreed with the ForesSoilC project in December 2008. Peat sampling equipment was shared with ForestSoilC. There are currently three peat sites remaining to be sampled. If these sites are not suitable, backup sites will be selected from a reserve list. The first chronosequence was sampled.

Three quarters of the sampled sites have been processed for Soil Organic Carbon (SOC). Bulk Density (BD) has been measured and calculated for over half the sites. Analysis of SOC has begun using CHN analysis. Once the SOC and BD work finishes texture analysis will begin.

Commencement of modelling will take place shortly as SOC data becomes available. The primary modelling exercise will be carried out using Century, and Yasso will also be investigated.

A peat auger at 6 m extension used to collect samples from varying depths through the soil profile.

ACTIVITIES PLANNED

- Biomass sampling of pine, larch and ash will continue in 2010.
- Surveys will be made of new chronosequence sites to establish biomass and CWD stocks.
- Above-ground CWD decomposition experiment sampling (brash bags).
- Below-ground decomposition measurements (includes decomposition bag and stump excavation).
- Continue litter collection, tree ring analysis from disk samples, ground-vegetation sampling and decaying log respiration measurements.
- The mobile eddy covariance tower will rove chronosequence 3 sites during 2010.
- Continuous soil respiration and canopy profile CO_2 measurements at the Dooary forest will continue.
- Decomposition, litterfall and fine root turnover experiments will be continued.
- Measurements of N_2O and CH_4 and soil respiration will be undertaken at chronosequence three sites in 2010.
- Continue NFI paired plot sampling and processing.
- Commence analysis of samples.

OUTPUTS

Meetings/conference attendance

COST Action FP0803. 2009. Belowground carbon turnover in European forests. Kick-off meeting to start the Action, Brussels, 25 May 2009.

ECHOES COST Action FP0703. 2009. Expected Climate Change and Options for European Silviculture. 2-3 November 2009, Thessaloniki, Greece.

ANAEE (Analysis and Experimentation on Ecosystems). 2009. Final Meeting, 24-26 November 2009, Exeter, UK.

Saunders, M., Tobin, B., and Osborne, B. 2009. *Assessing the impact of forest age on net ecosystem carbon exchange.* Irish Plant Scientists Meeting 20-21 March 2009, Trinity College Dublin.

Tene, A., Tobin, B., Ray, D., Black, K. and Nieuwenhuis, M. 2009. *Adaptability of forest species to climate change.* Ppaper presented to the Annual conference of the Association for tree-ring research, Octocec, Slovenia, 16-19 April 2009. Submitted as an article in ITF (Vol. 18, No. 2, 2009).

Wellock, M., LaPerle, C., Kiely, G., Reidy, B. and Bolger, T. 2009. *The Carbon Stocks of Peatlands under Forestry in the Republic of Ireland.* [Poster Presentation.] European Geosciences Union General Assembly 2009, Vienna , 19-24 April 2009.

Tene, A., Tobin, B., Ray, D., Black, K. and Nieuwenhuis, M. 2009. *Assessment of tree response to severe climatic occurrences.* Annual European Dendrochronology Meeting. [Poster presentation.] Majorca, 26-30 October 2009.

Albanito, F., Saunders, M. and Jones, M.B. (2009) The Irish contribution to an infrastructure for measurements of the European carbon cycle (IMECC). [Poster presentation.] AGMET meeting, Dublin, 7th December 2009.

Benanti, G., Cacciotti, E., Helmy, M., Saunders, M. and Osborne, B. 2009. *Impact of land use change on greenhouse gas emissions*. [Poster presentation.] AGMET meeting, Dublin, 7 December 2009.

Osborne, B. 2009. *Use and performance of cover crops for increasing carbon sequestration and greenhouse gas mitigation in arable ecosystems.* AGMET meeting, Dublin, 7 December 2009.

Tene,A., Tobin, B., Dyckmans, J.,Ray, D.,Black, K. and Nieuwenhuis, M. 2009. *The growth response of Sitka spruce forest stands to sever drought events*. [Poster presentation.] AGMET meeting, Dublin, 7 December 2009.

Tobin, B., Gardiner, P., Olajuyigbe, S., Saunders, M. and Nieuwenhuis, M. 2009. *Forest carbon stocks and the effect of thinning*. [Poster presentation.] UCD School of Agriculture, Food Science and Veterinary Medicine Research Day, 8 December 2009.

Publications

Luyssaert, S., Reichstein, M., Schulze, E-D., Janssens, I., Law, B., Papale, D., Dragoni, D., Goulden, M., Granier, A., Kutsch, W., Linder, S., Matteucci, G., V, M., Munger, J., Pilegaard, K., Saunders, M. and Falge, E. 2009. Towards a consistency cross-check of eddy covariance flux based and biometric estimates of ecosystem carbon balance. *Global Biogoechemical Cycles* doi:10.1029/2008GB003377.

Field study

The Dooary chronosequence sites were used to host a silviculture field day for the UCD third year forestry class in October 2009.

Project networking

- Dooary site, together with some additional work tasks, now included in a new EU funded project GHG Europe, starting January 2010.
- Forest research work included in ANAEE (analysis and experimentation on ecosystems, an EU project with preliminary funding).
- Discussions are also continuing in relation to participation in ICOS (International Carbon Observation System), its Irish equivalent IGOS-I, and LifeWatch (long-term monitoring of ecosystems).
- Dooary site now included in the EU FutMon project (long-term monitoring of forest ecosystems) as a Level 1 site.

CARBWARE

Development of tools and systems for reporting on forest carbon stocks and stock change under the Kyoto protocol and the UNFCCC

PROJECT TEAM

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COMPLETION DATE: December 2011

BACKGROUND

The Irish carbon reporting system (CARBWARE) was initially implemented in 2004 to meet reporting requirements to the United Nations Framework Convention on Climate Change (UNFCCC) on all national forest sources and sinks. Whilst this model indicates the likely contribution of forests to the national C storage (sink) potential, the system has relied on the use of generalised stand growth models to describe changes in forest carbon stocks because of the lack of national forest inventory (NFI) data. The availability of detailed NFI data and new research information now provides the opportunity to redevelop CARBWARE and improve estimates of national forest carbon stock changes. Experimental and observational research information, carried out by the CARBiFOR 2 and FORESTSOILC projects, is aimed at supporting and developing the CARBWARE reporting system.

OBJECTIVES

The overall objective is to report C stock and stock changes in Irish forests using the agreed UNFCCC format for land use, land use change and forestry (LULUCF) and the International Panel for Climate Change (IPCC) good practice guidance on LULUCF and Kyoto reporting.

Specific targets:

- Analysis of NFI and iFORIS data streams to extract relevant information in a format compatible with CARBWARE.
- Refinement and redevelopment of CARBWARE to include species specific single tree biomass models.
- Statistical sensitivity analyses to select a GPG-LULUCF compliant reporting procedure with the smallest uncertainty and error.
- The implementation of an input database to allow for QA/QC and formating of input data forCARBWARE computations.
- Development of a Windows-based software interface based on the CARBWARE model and with compatible LULUCF, UNFCCC reporting table and Kyoto output files. This software will run different scenarios and incorporate uncertainty analysis.
- Incorporation of a Harvested Wood Product (HWP) C-store reporting procedure in CARBWARE.
- Independent peer review of reporting mechanism, prior to final submissions and redevelopment if required.
- The publication of a LULUCF and Kyoto reporting manual, which complies with GPG requirements, for Irish forests.
- Implications of climate change on potential sequestration by Irish forests using a ESC yield-based model under different climate change scenarios.

PROGRESS

UNFCCC reporting

This year marked the first official submission of CO_2 sink estimates for afforestation deforestation and reforestation (ARD), under the Article 3.3 of the Kyoto Protocol. The removal of CO_2 associated with ARD activities since 1990 was 2.6 Mt of CO_2 in 2008, as determined using the newly developed CARBWARE system (Figure 1). The incorporation of new single tree growth models and NFI information into the reporting system has resulted in a significant increase in the estimate of carbon sequestration, equivalent to an extra €5 million for 2008 alone[1]. This represents a good return on research investment, considering the budget for CARBWARE is €700 k for 2007-2011.

[1] Previous projections, using old stand models, estimated an uptake of 2.1 Mt CO_2 for ARD activities in 2008. The CO_2 price is assumed to be €10 per tonne.

Growth modelling

A single tree model for six different species cohorts has been completed and is in the process of being published. These models have been designed to specifically cope with data from the NFI, which do not provide sufficient information to use stand-based models such as GROWFOR. The model has been coded using the new CARBWARE software.

Main features include:

- Single tree models can be applied to semi-natural, mixed species and uneven aged stands.
- These models can be coupled to remote sensing technologies such as LiDAR.
- The model includes a competion factor which can cope with different mortality and competition effects within one species cohort. So, for example, one model can be used for thinned and non-thinned stands of different planting densities.
- The model is dynamic since it can account the spatial and state transistions which represent stand development.
- Probalistic single tree mortality models have also been developed for the different cohorts to simulate natural mortality all forest types.

Software developement

Software code for the CARBWARE software pre-processing, growth, modification and allocation modules has been completed (Figure 1). The new reporting system adopts an activity-based approach based on a land transition matrix and forest activity information (Figure 1). The forest activity data sources for the GHG inventory is the Irish National Forest Inventory (NFI) and felling licence records compiled by the Forest Service. Additional information is supplied by Coillte. The state Forest Information Planning System (FIPS), Premium Grants Payment Scheme (GPAS) and limited felling licence records are used to derive spatial data. The reporting system includes an ongoing QA/QC system, whereby model outputs are validated against repeated NFI measurements on a 5-year rolling basis. The first repeat NFI covering $^{1}/_{5}$ of the forest area is due for completion in 2011.

Scenario analysis for the Copenhagen negotiations

Most of the CARBWARE activities were centred around providing support for the preliminary negotiations and the COP meeting in Copenhagen. The reporting and accounting of GHG emissions/reductions associated with forest management (i.e. forest planted before 1990) can be elected by Annex I countries under Article 3.4 of the Kyoto

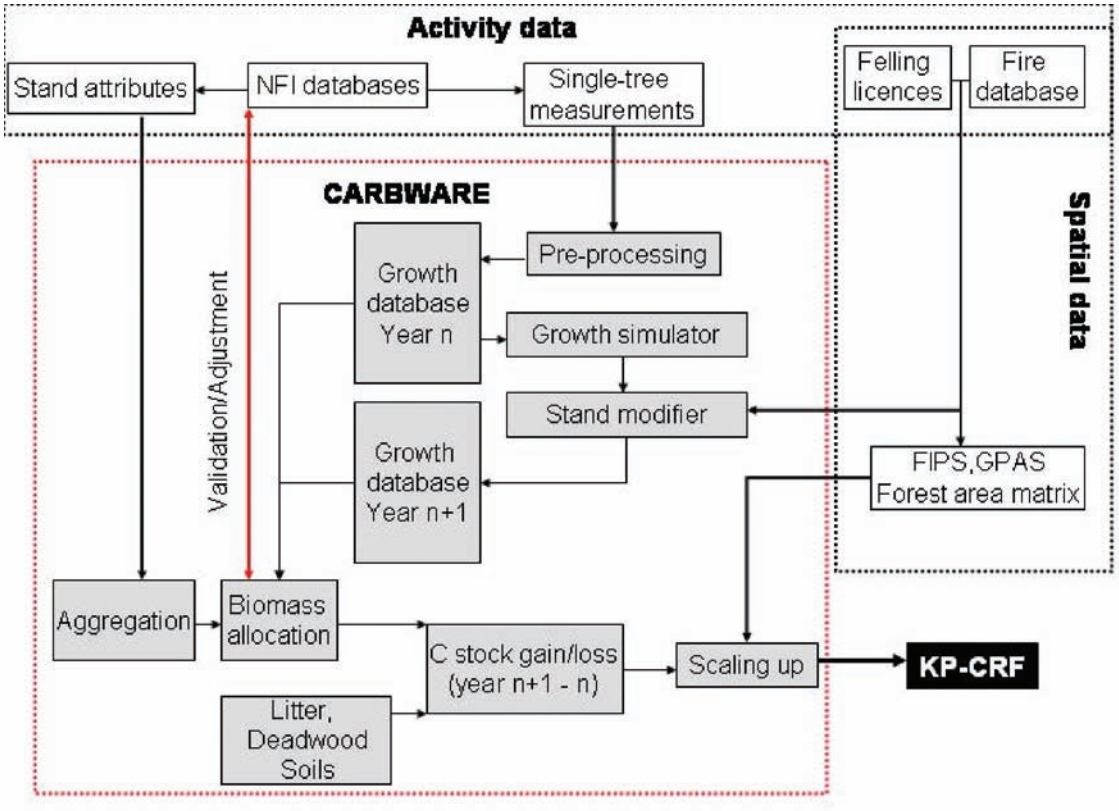

Figure 1: Schematic overview of the reporting system showing the input data streams in to the CARBWARE software and the functionality of the CARBWARE.

Protocol. Election of these activities for the first commitment period (2008-2012) was voluntary. Accounting for carbon sinks and sources by forest management, under Article 3.4, requires the factoring out of indirect human-induced effects. However, the current accounting rule for Article 3.4 forest management (i.e. baseline period gross-net accounting with a cap to limit the maximum amount of accountable sinks) does not factor out the dynamic effects of age structure resulting from activities prior to 1 January 1990 as stipulated in the Marrakech Accords COP 2001.

Historical inventory records and sub-compartment management forecast plans show that there is a shift in the age class distribution from a 'skewed' young age class distribution in 1959 to a nearly normal distribution curve in 1998 (Figure 2). However, there is a reversal towards the young age class frequency by 2006. This trend continues up to 2012, followed by a redistribution towards older age classes in the projected 2020 time series. The shifts in these age class frequency distributions are consistent with historic afforestation rates and a mean clearfell age of ca. 50 years.

The historic and projected emission/removal estimates for the pre-1990 forest show a marked decline in the removal, particularly since ca. 2000 (Figure 3). The forest C stock changes from a net sink of 1Mt CO_2 in 2000 to a net

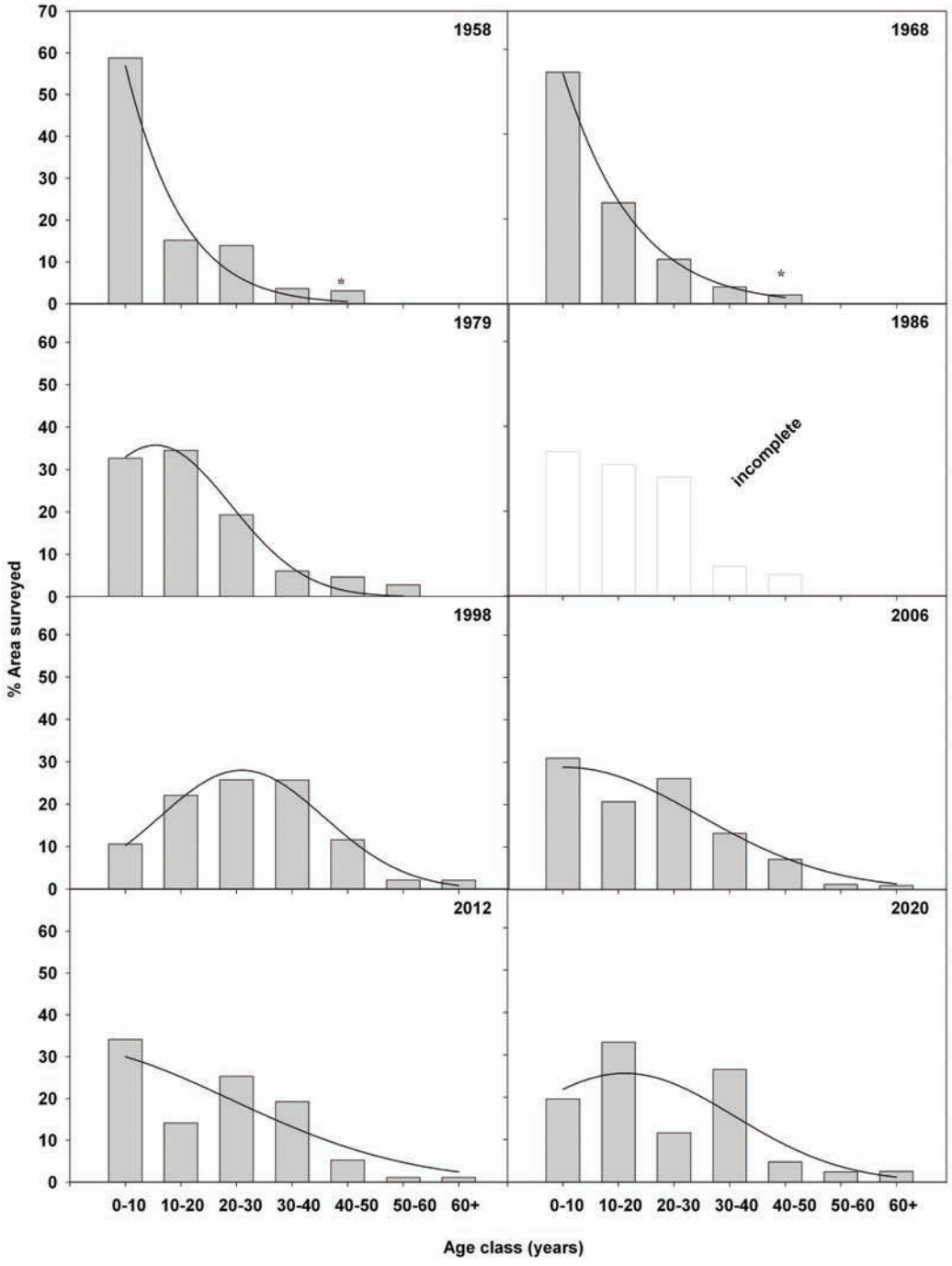

Figure 2: The age class frequency distribution based on summary statistics (grey histograms) and a fitted distribution curve (solid line) for forest planted before 1990, 89% of which are Coillte forests.

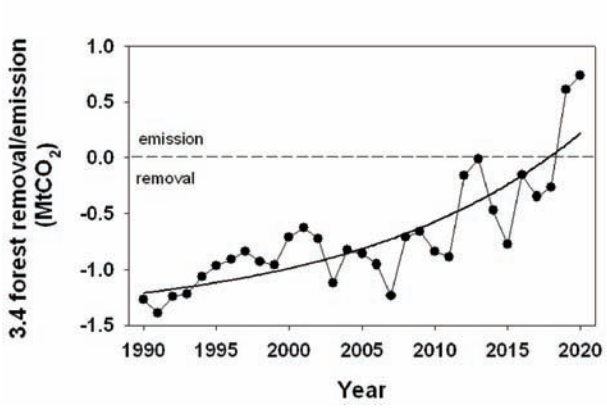

Figure 3: The total carbon stock change in all forests planted before 1990 for the years 1990 to 2020 (projected).

emission of 0.7 Mt CO_2 by 2020. The age class distribution changes are considered to influence current and projected forest emission/removals (Figure 3) in two ways:

a) A decrease in biomass increment. There is evidence of a decline in gross biomass increment between 1998 and 2020. This could be associated with a change in the mean age and age class frequency due to the lesser productivity of younger crops after clearfell.

b) A decease in the deadwood C pool, due to the residual C decomposition of harvest residues following first rotation. This C loss is carried over to second rotation crops for a period of ca. 30 years[2].

Based on a modelling exercise using sub-compartment inventory data and management forecast plans, which represents a business-as-usual scenario driven by silvicultural considerations, we suggest using a projected baseline to factor out age-class legacy effects. This involves the selection of an accounting baseline period where the population statistics are similar to accounting period values, thereby minimizing any age-class legacy effect on emissions or removals. In this case, the use of a projected baseline as the reference factors out the contribution of the legacy effect to accounting results, and would only reward the changes in forest management practices in support of climate change mitigation. Based on the CARBWARE projection, using business as usual forecast plans, the forward looking baseline for the period 2013 to 2020 would be -0.67 Mt of CO_2 (or -0.08 Mt CO_2 per year). The advantage of this accounting system is that it provides an incentive for stakeholders to either increase CO_2 sequestration potential or timber harvest at a carbon accountable cost.

ACTIVITIES PLANNED

- Inclusion of a harvested wood product module into CARBWARE.
- Completion of reporting module.
- Uncertainty analysis and scoping of Monte Carlo system for software development.
- QA/QC of data inputs into the CARBWARE software
- Assist FORESTSOILC and CARBiFOR II with statistical analysis of paired plots data for detection soil carbon stock changes.
- Updating the allocation module with new biomass equations from CARBiFOR II.
- Validation of growth models with NFI repeat inventories.
- Submission of national LULUCF and Kyoto report 2009.

OUTPUTS

Black, K., O'Brien, P., Redmond, J., Barrett, F. and Twomey, M. 2009. The extent of peatland afforestation in Ireland. *Irish Forestry* 65: 61-71.

Black, K., Byrne, K.A., Mencuccini, M., Tobin, B., Nieuwenhuis, M., Reidy, B., Bolger, T., Saiz, G., Green, C., Farrell, E.T. and Osborne, B. 2009. Carbon stock and stock changes across a Sitka spruce chronosequence on surface water gley soils. *Forestry* 85(3): 255-271.

Hendrick, E., and Black K. 2009. *Climate change and Irish forestry.* COFORD Connects, Environment No 9, COFORD Dublin.

Black, K. and Ray, D. 2009. Cost action (ECHOES) report on '*Ireland's forestry sector climate change mitigation, impacts and adaptation activities*'. ECHOES www.gip-ecofor.org/docs/37/countryreports/CountryReports_July-August-Sept2009/Echoes_Ireland_Report-DraftVersionJuly2009.pdf

Black, K., Xenakis, G., Tene, A., Nieuwenhuis, M., Saunders, M. and Ray, D. 2009. *Development of strategic adaptive climate change tools for Irish forestry*. Presentation to EFI conference, Dublin, September 2009.

Collaborations and Committees

- Management committee member of ECHOES: Cost FP0703 (Expected Climate cHange and Options for European Silviculture.)
- Member of National Steering Group on Climate change impact and adaptation.
- Member of National Steering Group on Climate change mitigation.
- Participation in workshops on LULUCF reporting issues.
- UNFCCC reviewer on LULUCF and Kyoto reporting.

[2] Black et al. (in preparation). Historic and projected carbon dioxide emission/removals for forest management under Article 3.4.

CLIMADAPT

The use of Ecological Site Classification in adapting forests and their management to climate change

PROJECT TEAM

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BACKGROUND

The project was initiated to guide forest species selection in Ireland. Climate change will impact on species selection and CLIMADAPT will provide guidance on suitability for climate scenario projections.

OBJECTIVES

- Design a forest classification system for tree species selection and yield potential in Ireland, based on the interpretation of six biophysical factors.
- Develop a knowledge base of climate change adaptation strategies, including species choice and silvicultural modifications from an interpretation of the likelihood of abiotic and biotic impacts resulting from climate change.
- Validate knowledge-based yield models for Sitka spruce and other species if data availability permits.
- Develop a web-based combined stand-scale and spatial-scale decision support tool.

PROGRESS

Data preparation: Spatial data representing the six biophysical variables have been completed for Ireland. In addition, spatial AT and MD values, based on future climate change projections for the IPCC A2 and B1 emissions scenarios, have been calculated for Ireland. These data will form the basis of assessing tree species suitability, and will provide an initial assessment of likely climate impacts and adaptation strategies for particular species-site type climate impact combinations.

Model specification: Knowledge-based suitability models have been described for 21 tree species. Models have used information from a Delphi expert group meeting in Dublin, in 2007, and from the results of an expert group discussion of tree species suitability for Great Britain in 2001. The models describe the suitability of a species in relation to each of the six biophysical variables. Suitability is defined by the most limiting factor for a particular site type.

Validation: Further validation of the knowledge-based yield predictions for Sitka spruce using Bayesian and Monte Carlo methods has revealed an additional model suitable for predicting the yield of Sitka spruce. Validation has been difficult due to the unknown impacts associated with fertilisation of many of the sites used for training and validating the model. The model is being written up for publication.

Web-application: The core model of web application has been completed and tested. This uses Java script and AJAX (asynchronous Java and xml) technologies, and links to Google™ maps and satellite imagery. The spatial data analysis module has now been completed, The large number of spatial files used by the application are currently being compiled and made ready for deployment.

User interface: The user interface has been completed and is ready for testing. The spatial module of the interface allows the user to visualise site factors that limit tree species suitability and growth. Figure 1 shows the soil fertility layer superimposed on a Google™ map backdrop. The interface also allows users to visualize climatic factors for the baseline period 1961-1990, and for future climate change projections for two IPCC emissions scenarios. The suitability and yield predicted under those conditions is also shown spatially by the CLIMADAPT tool.

PhD study: A pilot study (part of a PhD at UCD) to assess moisture stress in several tree species across a west-east transect through Ireland and the UK, has provided very interesting results. Multivariate statistical analyses showed that the density of individual tree rings increased with the warmth index - accumulated temperature (Figure 2), and the magnitude of radial growth was reduced in summers with a higher moisture deficit (Figure 2).

Next steps: Cores from Sitka spruce, Douglas fir and Scots pine will be taken from sample trees in permanent sample plots in Ireland, Wales and southern England. The choice of sites forms an increasing moisture deficit gradient from west to east, but with similar climatic warmth and soil conditions. This will allow us to test if the moisture deficit limits tree growth at sites, and how the effect varies between species that have a different moisture stress tolerance.

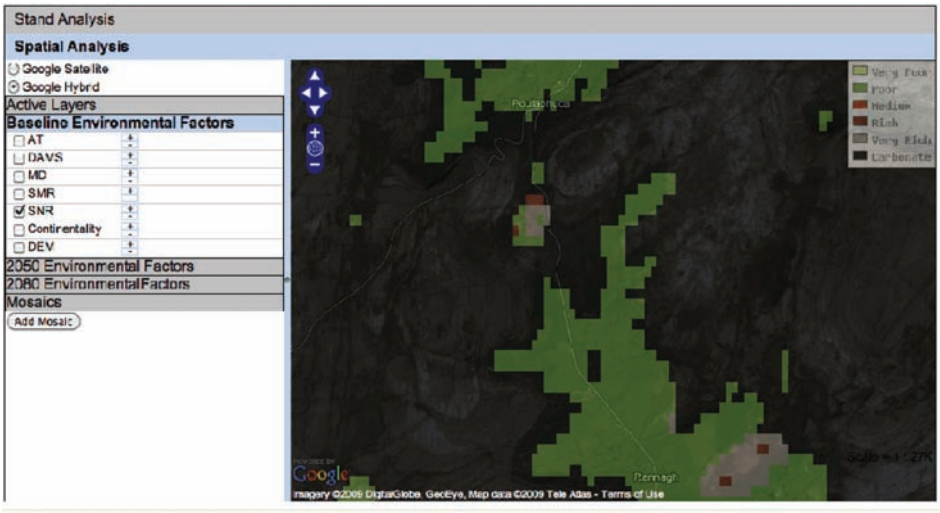

Figure 1: Visualisation of soil ferility rating of a potential afforestation site derived from the national soil map for Ireland, superimposed on a Google hybrid backdrop (composite of satellite imagery and mapping).

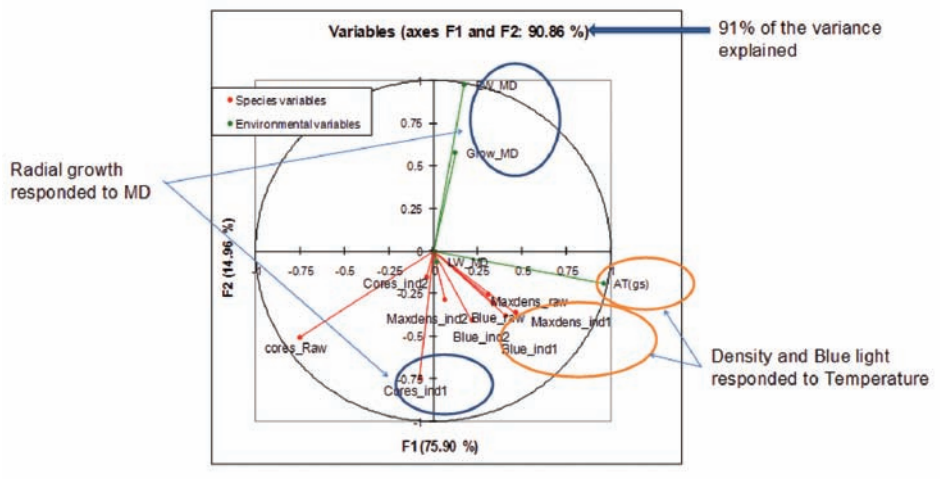

Figure 2: Canonical correlation analysis (CCA) was used to identify the major gradients of species-environment variation across the plots. Radial growth was inversely correlated to moisture deficit, whereas wood density was directly correlated with accumulated temperature.

It is hoped that the study will show whether an improved moisture stress resistance in terms of growth impacts can be useful in choosing better suited species for climate change adaptation on forest sites of increasing drought risk.

ACTIVITIES PLANNED

- Test the application with the user group in Ireland.
- Hold workshops in Ireland to demonstrate the CLIMADAPT web application.

OUTPUTS

Papers

Ray, D., Xenakis, G., Semmler, T. and Black, K. 2008. *The impact of climate change on forests in Ireland and some options for adaptation*. In: E. Hendrick and K.G. Black (Eds), Forests, Carbon and Climate Change - Local and International Perspectives. COFORD, Dublin.

Ray, D., Xenakis, G., Tene, A. and Black, K. (accepted). Developing a site classification system to assess the impact of climate change on species selection in Ireland. *Journal of Irish Forestry.*

Black, K, Xenakis, G, and Ray, D. (in preparation) Climate Change Impacts and Adaptive Strategies. *Journal of Irish Forestry*.

Xenakis, G., Black, K., and Ray, D. (in preparation) Bayesian calibration of yield class predictions for CLIMADAPT. *Forestry*.

Presentations

- Site Classification Conference, Tullamore, Ireland, June 2008.
- International Conference on climate change, Nancy, France (Poster).
- Dendro-ecology conference, Birmensdorf, Switzerland (Poster).
- Association of Tree-Ring Reasearch (ATR) Annual Meeting, Slovenia.
- EuroDendro2009 Annual Meeting, Mallorca (Poster).
- Expected Climate change impact for Environment and Silviculture (ECHOES), Thessaloniki.

FORESTSOILC

Soil carbon stock changes and greenhouse gas fluxes in Irish forests

PROJECT TEAM

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COMPLETION DATE: May 2011

BACKGROUND

Forests are a central component of the global (C) cycle and are estimated to store 77% of the C stored in vegetation and 39% of the C stored in soil. Therefore, the Kyoto Protocol includes mechanisms such as Article 3.3 for parties to use C sequestration in forests to meet emission reduction targets. Article 3.3 allows changes in C stocks due to afforestation, reforestation, and deforestation since 1990 to be used to offset emissions. Due to the rapid rate of afforestation in Ireland since 1990 Article 3.3 offers great potential for Ireland to offset emissions from other sources. In order to meet international reporting obligations Ireland must collect nationally specific data to increase the accuracy and reduce the uncertainty of the estimation of the GHG emissions offset by afforestation.

OBJECTIVES

- To use the paired plot approach to investigate the affect of afforestation on soil C stocks at 30 forest sites and to estimate forest soil carbon stocks.
- To determine the effect of afforestation and deforestation on CO_2 and CH_4 dynamics in peat soils and to develop CO_2 and CH emission factors for afforested and deforested blanket peat.
- To determine the effect of broadleaf afforestation of mineral soils on soil C stocks.
- To investigate the effect of afforestation on CO_2 and N_2O fluxes.

PROGRESS

National scale soil C stocks: The aim is to develop a quantitative assessment of the carbon (C) stocks in Irish forest soils. Following the development of sampling and laboratory protocols and some preliminary field work, 21 mineral soil sites (i.e. 21 pairs to include one forest site plus a nearby non forest site), 8 peaty mineral soil sites and 10 peat soil sites are to be sampled. The paired concept grew out of work in New Zealand.

The mineral soil sites have been divided into eight sampling groups based on soil type (brown earths, podzols, brown podzolics, and gleys) and forest type (coniferous, mixed, or broadleaf). The mineral soil forest sites are paired with a site representative of pre-afforestation site conditions.

The peat and peaty mineral (peaty gley and peaty podzol) sites are not be paired due to the level of variability in peat depth within a site.

Figure 1 shows the location of UCC sites sampled. It is important to note that UCD will be sampling the same number of sites in the northern half of the country. All UCC sites have been sampled to date. Figure 2 shows how average carbon density for three conifer gley sites changes with depth. As expected the carbon density decreases as the depth increases. Also, the total carbon density (including the litter layer) is greater in the forest compared with its paired pre-afforestation site. Figure 3 shows how the average bulk density for five low level (elevation < 150 m) blanket peat sites changes with depth. According to these data, the bulk density does not appear to increase as depth increases. This finding is contrary to some of the literature which predicts that the bulk density would increase down the profile.

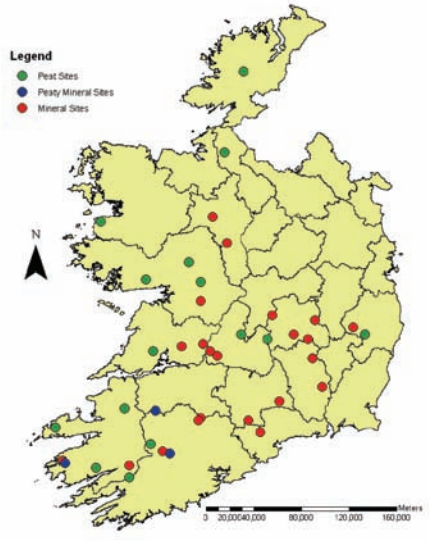

Figure 1: ForestSoilC project sampling sites.

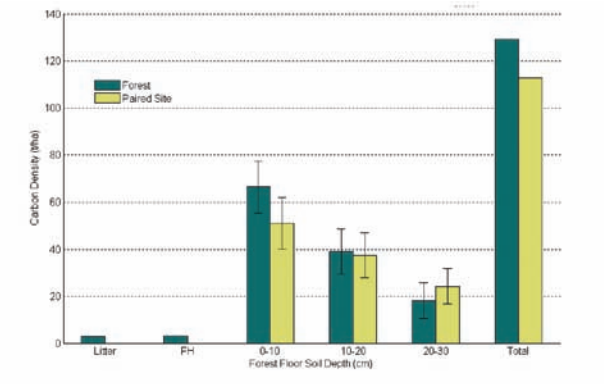

Figure 2: The average carbon density for conifer gley sites including NFI sites: 10847, 7495, and 6799.

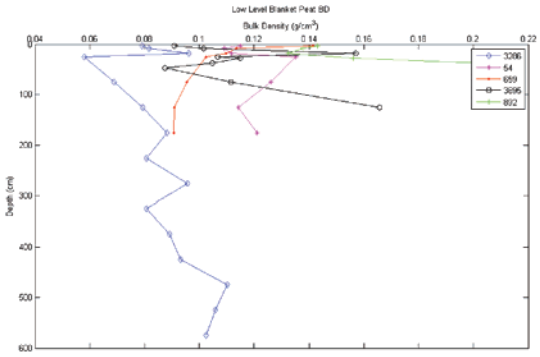

Figure 3: Average bulk density data for low level blanket peat sites including sites 3286, 54, 659, 3695, 892.

C dynamics in organic soils: Gas sampling for CO_2 and CH_4 began in July 2009. Litter collectors have been put out at all sites. Litter bags will be put out at sites and soil will be sampled for fine root turnover in January 2010.

C stocks and stock changes in mineral soils: Site selection is in progress.

CO_2 and N_20 fluxes in recently afforested grassland: The aim of this WP is to assess the impact of afforesting grassland on the fluxes of CO_2. N_2O and CH_4 from the soil. Tthe site selected is a recently (2005) afforested ~ 10 ha grassland site at Dripsey, Co Cork. The eddy covariance flux tower was installed in the summer of 2008. The instrumentation on the 2 m scaffold tower (Figure 4) includes: radiation and PAR sensors; air temperature and humidity sensors; a LICOR 7500 sensor for 10 Hz CO_2 and H_2O concentrations; a 3D sonic anemometer; soil temperature and soil moisture.

Data collection began in September 2008. The data collected includes meteorological and flux data. For the measurement of N_2O and CH_4 fluxes from the Dripsey afforested site, 16 permanent collars have been placed at the soil surface in two transects. Soil moisture and temperature probes have been installed under each collar to allow for continuous measurements. The N_2O fluxes will be measured monthly during the winter and weekly during the growing season, measurements began December 2009.

ACTIVITIES PLANNED

- National scale soil C stocks: Complete the estimate of soil carbons stocks and stock changes in Irish forest soils.
- C dynamics in organic soils: Continue gas sampling for CH_4 and CO_2 fluxes and to collect litter decomposition and quantity data as well as root turnover data.
- C stock changes in mineral soils: Select sites and to complete site sampling.
- CO_2 and N_2O fluxes in recently afforested grassland: Continue N_2O data collection.

OUTPUTS

A national workshop with COFORD and UCD is planned for February 2010.

Figure 4: The eddy covariance flux tower.

WOODCARB

Carbon stocks and stock changes in harvested wood products

PROJECT TEAM

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COMPLETION DATE: May 2010

BACKGROUND

Wood products are an important store of carbon. The Kyoto Protocol allows C sequestration in forests to be used to offset greenhouse gas (GHG) emissions. Currently, the C stored in wood is regarded as oxidised at the time of harvest. Carbon in Harvested Wood Products (HWP), however, will likely play a role in 'second commitment period' climate change rules (beyond 2012). The results of this project will contribute to the assessment of the role of forests and HWP to Ireland's GHG reporting commitments.

OBJECTIVES

- Conduct literature review.
- Collect data about timber production, wood processing and HWP import and export statistics.
- Develop a national C accounting model for HWP.
- Use the model developed to analyse the impacts of the production accounting approach and to carry out an uncertainty assessment using Monte Carlo Analysis.
- Develop national estimates for the service lives of the main HWPs used in Ireland.
- Incorporate lifecycle data in the HWP accounting model.
- Prepare final report.

PROGRESS

The literature and model reviews have been conducted. Sources for data have been identified. Data collection and construction of database has begun. Additional data needs will be identified as the model is developed.

Several stakeholder meetings were held. A scoping meeting was held at COFORD in July 2009. Eugene Hendrick, Kevin Black, Alistair Pfeiffer and the WoodCarb project team were present. Contacts with Kim Pingoud (VTT, Finland), Sebastian Rueter (vTI, Germany) and Henry Phillips have been established. Meetings with Eoin O'Driscoll (DRIMA Marketing) and Kenneth Skog (FPL, USA) (via telephone) have also been held. In addition to these meetings, the following events were attended:

- International Conference on Carbon Storage in Wood Products, Wood in Sustainable Development CEI-Bois Roadmap 2010, 1 September 2009, Brussels.
- L.U.C.A.S. Land Use and Carbon Analysis System of New Zealand, Seminar by Peter Stephens, 14 September 2009, Dublin.
- GIS tools for Private Sector Roundwood Forecasting, COFORD Workshop, 29 September 2009, Portlaoise, Co Laois.
- Microsoft Office Excel 2003 Expert Skills, Training, 23 September 2009, University of Limerick, Co Limerick.
- Networking and Presentation Skills, Training, 1 October 2009, University of Limerick, Co Limerick.

ACTIVITIES PLANNED

- Complete literature review.
- Develop and test the model.
- Present work at conferences.
- Submit manuscript to scientific journal.
- Develop national estimates for the service lives of HWP.
- Incorporate lifecycle data into model.
- Prepare final report.

FORESTBIO

Managing for biodiversity in a range of Irish forest types

PROJECT TEAM

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Dr Sandra Irwin, University College Cork*
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COMPLETION DATE: December 2011

BACKGROUND

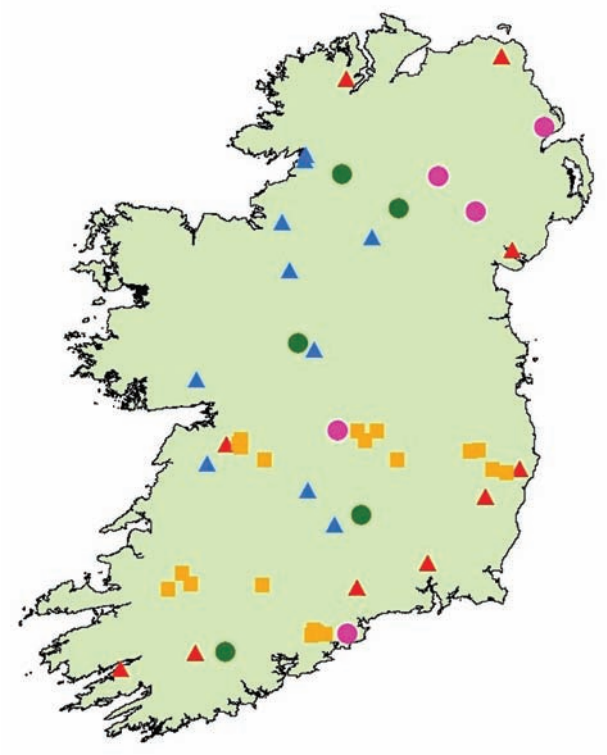
The COFORD/EPA funded BIOFOREST project (2001-2006) was an integral part of the emerging body of knowledge on forest biodiversity in Ireland following a period of intensive afforestation and associated landscape changes during the latter part of the twentieth century. Although expansion of the existing forest estate remains a priority, the character of Ireland's forests is undergoing considerable change. An increasing proportion of existing conifer forests is being harvested and restocked, and a high proportion of plantings now consists of a mix of conifer and broadleaved species. FORESTBIO seeks to address gaps in the knowledge of forest biodiversity in three forest types (second rotation conifer plantations, mixed tree species plantations and native woodlands) through surveys of plants, birds and invertebrates.

OBJECTIVES

- Determine the biodiversity of second rotation forests, mixed-species forests and native woodlands at different stages of the forest cycle.
- Make inter-forest type comparisons and comparisons with data from BIOFOREST.
- Identify indicators of biodiversity for different forest types and describe monitoring techniques.
- Identify measures that may be used to enhance the biodiversity of the different forest types.
- Compare Irish and UK forest biodiversity using existing data and study sites.

PROGRESS

The current reporting period was concerned primarily with data analysis by plant and bird specialists, and laboratory identifications by invertebrate biologists. Data entry has been completed for many of the taxa being studied and data analysis is well underway. The first results are beginning to emerge, particularly from the first and second rotation Sitka spruce plantation studies that compare the findings of the FORESTBIO research in second rotation plantations with the findings in first rotations of BIOFOREST project. For each taxon, analysis will also be undertaken on native woodland surveys, and on mixed plantation surveys, as well as an over-arching analysis across all three surveys at all 60 FORESTBIO sites.



FORESTBIO study sites: ▲ native oak woodlands, ▲ native ash woodlands, ● Norway spruce:Scots pine mixes and pure Norway spruce, ● Norway spruce:oak mixes and pure Norway spruce and ■ second rotation plantations.

This work is at varying stages of advancement for each of the target taxa. An analysis of deadwood in native and plantation forests has also been completed.

While a number of the taxa under investigation in this project can be identified in the field, invertebrate identification can only be undertaken in the laboratory with the aid of a microscope and specialised identification keys. The current reporting period has been mainly concerned with this aspect of the work for invertebrate biologists. Identification of all ground-dwelling specimens was completed in August and of canopy-dwelling specimens by the end of 2009. All data collected by researchers on this project are being compiled into a GIS database which will provide an updateable system that allows access, visualisation and further analysis of the spatial data component within the FORESTBIO project.

ACTIVITIES PLANNED

- Data analysis for each taxon under investigation (ground vegetation, epiphytes, invertebrates and birds) covering: afforestation versus reforestation at different stages of the forest cycle; canopy mixes; oak and ash native woodlands and inter-forest type comparisons.
- Analysis for each taxon will include species richness and abundance, species assemblages, identification of biodiversity indicators, management recommendations and specific methods used will be dependent on taxonomic group.
- Completion of cross-taxon analysis.
- Preparation of findings for dissemination at conferences and in peer-reviewed journals.
- Completion of the GIS database.
- Investigation of relationship between terrestrial laser scanning data and manually collected biodiversity data.

OUTPUTS

French, V., Oxbrough, A., Irwin, S., Kelly, T.C. and O'Halloran, J. 2009. *Moth diversity in native woodlands and plantation forests.* ENVIRON '09.

Irwin, S. 2009. A novel approach to forest biodiversity assessment. *Science Spin.*

Irwin, S., Kelly, D. L., Kelly, T., McCarthy, N., Mitchell, F., Coote, L., Oxbrough, A., Wilson, M., Martin, R., French, V., Fox, H., Sweeney, O., Moore, K. and O'Halloran, J. 2008. *Planning and management tools for biodiversity in a range of Irish forests.* (Poster presentation). Scientific Seminar in the connection to the European Forest Institute Annual Conference: Forest Ecosystem Management in the 21st Century, Dublin, Ireland.

Martin, R., Oxbrough, A., Irwin, S., Kelly, T.C. and O' Halloran, J. 2009. *Assessing the biodiversity of canopy arthropods in a range of forest types throughout Ireland.* 2nd European Congress of Conservation Biology: Conservation biology and beyond: from science to practice, Prague.

Terrestrial Laser Scanning image of native woodland structure.

Moore, K.A. 2009. *Bryophyte Identification.* Dublin Naturalists Field Club, March 2009.

O'Halloran, J. 2009. *PLANFORBIO*. Presentation to COFORD Council. Cork, March 2009.

Oxbrough, A. 2009. *Biodiversity indicators of ground-dwelling spiders in Irish plantation forsts and native woodlands.* ERI Research Open Day, UCC, May 2009.

Palmu, E. 2009. *Initial effects of afforestation on ground beetles* (Coleoptera: carbidae) *in Irish grasslands and peatlands.* MSc Thesis, Lunds University, Sweden (Practical work carried out at UCC.

Sweeney, O.F.McD. 2009. *Woodland and Forest Biodiversity. Trees - why we need them.* Dunmanway, October 2009.

Sweeney., O.F.McD., Wilson, M.W., Irwin, S. Kelly, T.C., and O'Halloran, J. Bird communities of second rotation plantations in Ireland at different stages of the forest cycle. Submitted to *Ibis*.

Sweeney, O. F.McD., Wilson, M., Kelly, T.C., Irwin, S. and O'Halloran, J. 2008. *Bird diversity and abundance in different stages of the forest cycle in first and second rotation plantation forests.* Current Ornithological Research in Ireland: 5th Ornithological Research Conference, University College Cork, November 2008.

Sweeney., O.F.McD., Wilson, M.W., Kelly, T.C., Irwin, S. and O'Halloran, J. 2009. *What differences exist between the bird communities of first and second rotation plantation forests?* In: Keller, V. and O'Halloran, J. (eds) 7th Conference of the European Ornithologists' Union Abstracts, Swiss Ornithological Institute, Sempach.

Sweeney., O.F.McD., Wilson, M.W., Kelly, T.C., Irwin, S. and O'Halloran, J. 2009. *Bird density and species richness in native and plantation woodlands in Ireland: what differences exist and why?* 2nd European Congress of Conservation Biology: Conservation biology and beyond: from science to practice, Prague.

Sweeney., O.F.McD., Martin, R., O'Halloran, J., Irwin, S., Kelly, T.C., Wilson, M.W., and McEvoy, P.M. A lack of large diameter logs and snags characterises dead wood patterns in Irish forests. Submitted to *Forest Ecology and Management.*

John O'Halloran is a partner in a consortium preparing a bid for funding under ENV.2010.2.1.4-1 Functional significance of forest biodiversity. This bid is based on a pan-European partnership with partners including CEH (UK), ALTER Europe, LTER Europe and ICO forests as well as a number of universities. The aim of the proposal is to integrate, enhance and facilitate the use of European research on the significance of forest biodiversity for ecosystem functioning and the provision of ecosystem goods and services.

A 'Mammals in forests' workshop was hosted by FORESTBIO research project at the all Ireland Mammal Symposium, Waterford Institute of Technology and the National Biodiversity Data Centre, 8 November 2009.

Oisín Sweeney presents the findings of his work on FORESTBIO at the 2nd European Congress of Conservation Biology at the Czech University of Life Sciences.

HENHARRIER

Optimum scenarios for Hen Harrier conservation in Ireland

PROJECT TEAM

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COMPLETION DATE: December 2012

BACKGROUND

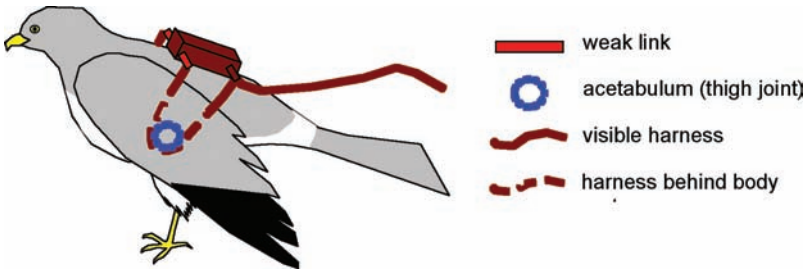
Hen Harriers can be adequately provided for within Irish Special Protection Areas (SPAs) only when detailed data on their habitat requirements are available. A greater understanding of foraging behaviour and success of Hen Harriers will enable the investigation of the importance of within-habitat variation in determining the value of land to foraging Hen Harriers. This project specifically addresses the issue of land use designation and habitat preferences of the Hen Harrier. Although a species of great conservation concern, previous research in Ireland has focussed almost exclusively on population size. This project is the first large scale study of Hen Harrier breeding ecology and habitat requirements.

OBJECTIVES

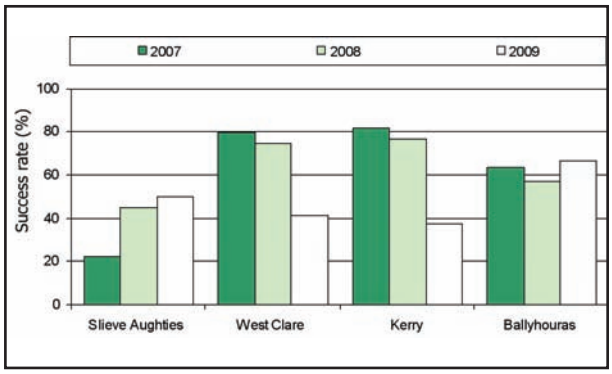
- Increase knowledge of Hen Harrier ecology and foraging behaviour.
- Determine the value to Hen Harriers of the main habitats in the SPAs.
- Improve understanding of Hen Harrier habitat requirements at the landscape level, and revise recommendations accordingly, incorporating these into an Indicative Strategy for Hen Harrier management in the SPAs.
- Compile a GIS database of land use and habitat types within the SPAs, to function both as a tool for decision-making by SPA managers and stake-holders, and as a source of data for researchers.

PROGRESS

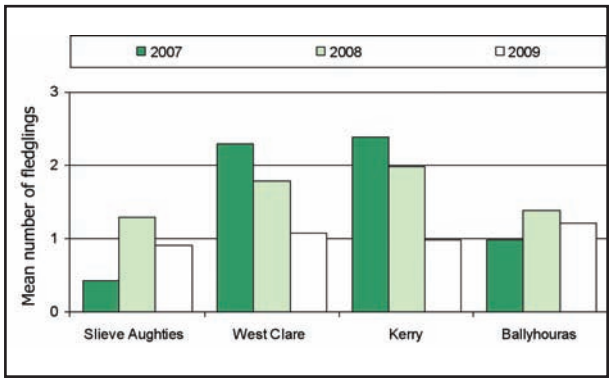
The current reporting period included the third field season on breeding biology of Irish Hen Harriers. The four study areas selected at the outset of the project were the focus of fieldwork by researchers who gathered detailed information on the 49 nests found within these areas this year. Nest cameras were deployed at a number of nests to gather detailed data on breeding biology and information on parental behaviour during the nesting stage. Control nests, which were unvisited for the duration of the field season, were used for the first time this year in all study areas. Significant efforts were made to track adult Hen Harriers using GPS tags this year, but ultimately were unsuccessful as we were unable to capture adult birds during the current field season. Significant advances were, however, made in modifying existing technology and developing new ideas to enable the use of modern GPS tags with adult Hen Harriers in the Irish landscape, which will be used in future breeding seasons. A harness attachment system, tailor designed for hen harriers has been developed. This system incorporates a weak link designed to break after the desired time has elapsed, allowing the harness to slide off the birds leg and drop to the ground with the tag attached, thus permitting efficient data retrieval from tags. Detailed analysis has been conducted on habitat preferences and breeding success of hen harriers collected to date. The most common nesting habitat was second rotation



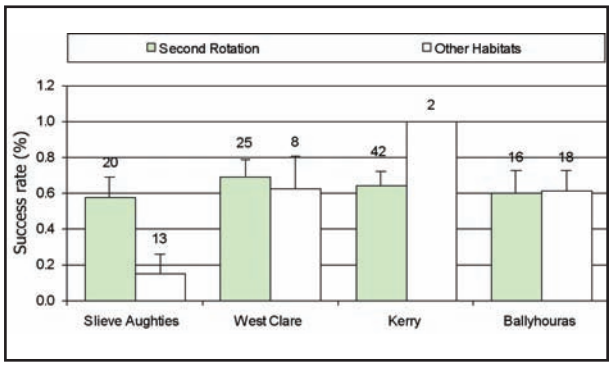
Leg-loop harness designed at UCC to attach GPS tag to Hen Harrier.



Percent of Hen Harrier nests that produced fully fledged in each of the study areas.



Mean number of fully fledged young from all nests in each of the study areas.



Success rates of nests (mean) located in second rotation pre-thicket forests and all other habitat types in each of the study areas. Values over each bar indicate the sample size.

pre-thicket forest, followed by heath and bog. The probability of nests fledging successfully was found to differ between nests located in second rotation forest, and those located in any other habitat. No effect of habitat composition in the landscape within 2 km of nests was seen on the numbers of chicks fledged from successful nests, but, interestingly, cover of second rotation forest was negatively related to nest success.

ACTIVITIES PLANNED

- Finalise trials of GPS tracking device and prepare for GPS tracking of adults during the 2010 breeding season.
- Data collected so far on harness attachment and subsequent recapture in the field using VHF technology will be prepared as a manuscript.
- Locate and track nests during the fourth breeding season of the project and continue juvenile wing-tagging programme.
- Trap and tag adult Hen Harriers using GPS tags.

OUTPUTS

Irwin, S. 2009. Technology supports ecological investigations of Hen Harrier habitat use. *Science Spin* 36: 17-18.

O'Donoghue, B.G., O'Donoghue, T.A., Kelly, T.C. and O'Halloran, J. 2008. *Non-breeding ecology of Hen Harriers* Circus cyaneus *in Ireland.* Current Ornithological Research in Ireland: 5th Ornithological Research Conference, University College Cork, November 2008.

O'Donoghue, B.G. 2009. *Hen Harriers in Ireland.* Irish Raptor Study Group Annual Conference 2009.

O'Donoghue, B.G., O'Donoghue, T.A., O'Halloran, J., Irwin, S., Kelly T.C., Oliver, G. and O'Mahony, B. 2009. *Hen Harrier Breeding Ecology in Ireland.* ENVIRON '09, Waterford Institute of Technology.

O'Donoghue, B.G., O'Donoghue, T.A., Kelly, T.C. and O'Halloran, J. 2009. *Over-wintering Hen Harriers* (Circus cyaneus) *in Ireland.* Poster Presentation. Raptor Research Foundation Annual Conference 2009, Pitlochry, Scotland.

Wilson, M.W., Irwin, S., Norriss, D., Newton, S.F., Collins, K., Kelly, T.C. and O'Halloran, J. 2008. *Habitat selection around nest sites by Hen Harriers* Circus cyaneus *in Ireland*. Current Ornithological Research in Ireland: 5th Ornithological Research Conference, University College Cork, November 2008.

Wilson, M. W., O'Mahony, B., Dell'Omo, G., Irwin, S., Kelly, T. C. and O'Halloran, J. 2009. *GPS tracking of Hen Harriers (Circus cyaneus) using a novel system combining VHF and GPS.* In: Keller, V. and O'Halloran, J. (eds) 7th Conference of the European Ornithologists' Union Abstracts, Swiss Ornithological Institute, Sempach, 152pp.

Wilson, M.W. and Dell'Omo, G. 2009. *Using GPS tracking in studies of birds: Recent developments and current challenges.* Symposium No.5. In: Keller, V. and O'Halloran, J. (eds) 7th Conference of the European Ornithologists' Union Abstracts, Swiss Ornithological Institute, Sempach, 152pp.

Wilson, M. W., Cullen, C., O'Donoghue, B.G., Oliver, G., O'Mahony, B., Ryan, B., Troake, P., Irwin, S., Kelly, T. C. and O'Halloran, J. 2009. *Habitat, nest site selection and breeding success of Hen Harriers in Ireland*. Raptor Research Foundation Annual Conference 2009, Pitlochry, Scotland.

In May 2009, *Living the Wildlife* ifeatured a piece on Hen Harrier Research in Ireland. Filming for RTE's EcoEye series was undertaken during the 2009 breeding season and will be aired in April 2010. The programme focuses on the breeding ecology of Hen Harrier in afforested landscapes in Ireland.

RHODO

Achieving effective Rhododendron control

PROJECT TEAM

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COMPLETION DATE: October 2011

BACKGROUND

Foremost among alien invasive species in Ireland in terms of the area covered and density is rhododendron. Successful control of rhododendron is required to maintain these habitats in favourable conservation status. The scale of rhododendron infestation is such that it needs to be tackled at the landscape scale.

This project aims to develop cost-effective methods which use little or no herbicide, for use in conservation areas and to bring costs down. These issues will be tackled in a practical manner that will lead to (a) protection of environmental quality and (b) help in the development of alternative methods and skills in controlling a non-native invasive species like rhododendron.

OBJECTIVES

- Increase knowledge of rhododendron invasion.
- Ascertain the effectiveness of reducing rhododendron natural regeneration post clearance.
- Survey and collect indigenous pathogens affecting rhododendron in Ireland.
- Isolate pathogens and test under laboratory conditions with a view to use as bioherbicides.
- Run workshops during and at the end of the project on rhododendron control.
- Produce national rhododendron control recommendations.

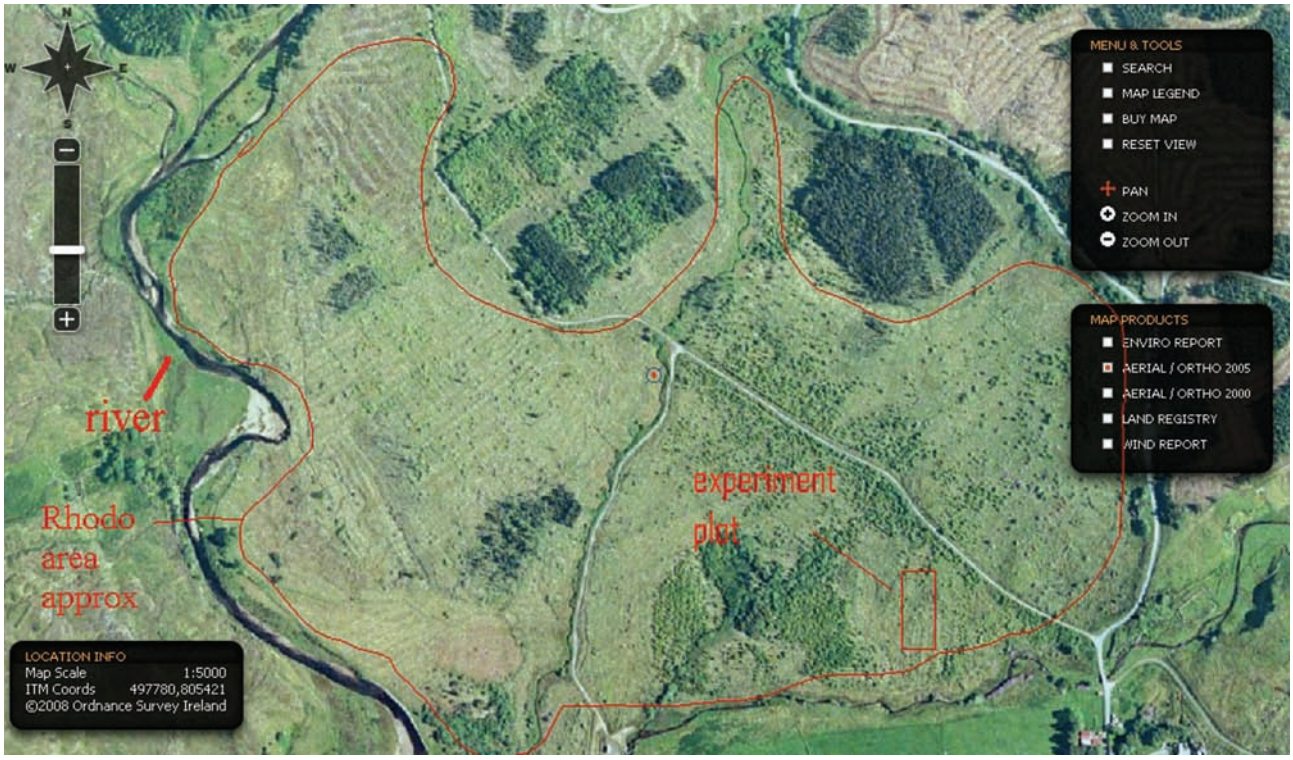
PROGRESS

Key research questions have been identified and experimental protocols are being devised to answer them. Following extensive literature searches four areas were selected for detailed investigation:

- Development of an aging key for rhododendron;
- Invasion dynamics of rhododendron;
- Calorific value of rhododendron;
- Seed longevity and viability.

The RHODO team will collaborate with CABI (Centre for Agricultural Bioscience International) UK to isolate fungi that may have possibilities for use as a mycoherbicide. The investigation of innovative fungal isolates on rhododendron for the development of bioherbicides will be carried out in two phases. First, survey and collection of pathogens affecting rhododendron and subsequent isolation. Second, inoculation of young rhododendron plants with fungal isolates under laboratory conditions to ascertain their potential as bioherbicides

Chondrostereum purpureum strain on a plum tree in Moorstown, Co Tipperary.



Rhododendron re-invasion study site ay Newport, Co Mayo.

ACTIVITIES PLANNED

- Collaboration with CABI on the identification of fungi that may have possibilities for use as a mycoherbicide will commence. A member of CABI UK will visit WIT to work with the team.
- Detailed protocols for all experiments will be finalised and, once complete, experimental work will begin with seed viability tests.
- Outreach will commence with presentations at national and international meetings.

OUTPUTS

Irwin, S., Kelly, D. L., Kelly, T., McCarthy, N., Mitchell, F., Coote, L., Oxbrough, A., Wilson, M., Martin, R., French, V., Fox, H., Sweeney, O., Moore, K. and O'Halloran, J. 2008. *Planning and management tools for biodiversity in a range of Irish forests.* (Poster presentation). ENVIRON 2008, DkIT.

FUNCTIONALBIO

Functional biodiversity in forests: diversity of soil decomposers and predatory and parasitic arthropods

PROJECT TEAM

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COMPLETION DATE: September 2010

BACKGROUND

In forests, growth and decomposition are the two most important ecosystem functions. Plants supply the majority of growth within the ecosystem, while fungi and soil fauna are the main drivers of decomposition. A large amount of research has been carried out on forest plants, therefore this project is designed to study the biodiversity associated with the other important functional aspects of forest ecosystems. The taxa selected were: fungi, soil microarthropods, parasitoid wasps, bugs and nematodes. Mycorrhizal fungi are important within forest ecosystems as they form associations with the roots of many tree species and assist in the assimilation of nutrients. Soil arthropods play a major role in decomposition and nutrient cycling and also help inoculate roots with mycorrhizae. Within the forest system, there is far greater biodiversity below-ground than above-ground, for example there are approximately 1,000 species of soil invertebrates in a single square metre of beech forest.

Apart from soil fauna, some groups of above-ground arthropods are being studied. Ecological theory suggests that arthropod communities with more complex food web structures and high numbers of predatory and parasitic species have greater inherent population stability and are less prone to pest outbreak. Parasitic hymenoptera were studied as a representative above-ground group.

OBJECTIVES

- Compile a literature review of previously conducted biodiversity studies that relate to this work.
- Select forest sites in Ireland where field sampling will be conducted in collaboration with groups from UCC and TCD.
- Compile a macrofungal basidiomycete and ascomycete inventory of selected woodland sites encompassing the functional groups: ectomycorrhizal fungi, saprotrophs, pathogenic wood-decay fungi.
- Obtain information on the abundance of fruiting bodies of edible forest fungi in the selected woodland sites.
- Relate fungal diversity to site and management factors such as native/non-native broadleaf versus plantation conifer canopy, conifer/broadleaf mixtures, second rotation versus first rotation plantation, stand age, soil type, herb layer vegetation.
- Relate the efficiency of fungal biodiversity indicators to other biodiversity indicators in Irish forests.
- Assess additional aspects of biodiversity (Hemiptera, parasitic Hymenoptera, nematodes and soil microarthropods) in forests that have not been covered by the BIOFOREST project (2001-2006).
- Assess the below-ground biodiversity of forests in detail.
- Provide inventories of the biodiversity in the habitats studied.
- Develop methodologies to assess biodiversity in forests.
- Draw up recommendations to enhance biodiversity in plantation forests.

PROGRESS

Lists of mite species recorded from forests have been compiled and reviews of the Collembola, Hemiptera, parasitic Hymenoptera and nematodes are ongoing and being placed in the context of the fauna recorded from other Irish habitats, in particular agricultural grassland, peatland and some coastal habitats. The analysis for the mites is virtually complete and shows that, in Ireland, many species have been exclusively recorded in forests, in particular in habitats such as fungal fruiting bodies. Thus we can conclude that forests add considerably to the biodiversity of mites in the Irish landscape. This work is ongoing and databases are updated as new data become available.

Macrofungal basidiomycete and ascomycete inventory. The third of the three planned annual samplings was completed in November 2009. During the 2009 autumn

period, 28 sites were sampled compared with 26 in 2008. The total number of site visits in 2009 was 83, compared with 55 in 2008. Over the course of three years the project has sampled 910 quadrats covering approximately 18,200 m^2 of forest.

Data acquired from field sampling include a quantitative assessment of each macro fungal found in a site including substrate data.

Site variables were also collected. These include:

- Soil nutrient data measured using the new PRS technology.
- Deadwood quality and volume has been assessed.
- Soil samples have been collected and are being analysed for N, P, K, Ca, Mg, pH, moisture content and carbon content.
- Data on the physical canopy structure of each site have been collected .
- Data on canopy cover has been collected using the canopy scope method.
- A full list of vegetation present at each site has been compiled.

Ectomycorrhizal (EM) fungi. Fifteen sites have so far been sampled (primarily Sitka spruce) by soil coring. A preliminary screening based on morphological criteria has separated EM samples into recognisable types. Samples of all types have been retained in glutaraldehyde for morphological assessment, and at -80ºC for identification by molecular methods. Abundance of different types on tree roots has been scored. Work has commenced on molecular identification.

Significant outcomes to date. In total, 478 fungal species have been identified from fruit bodies taken from the sites. There were 125 new species realised in 2009 compared with 108 new species in 2008 and 247 new species in 2007. Preliminary analysis of the fungal species found that 178 were listed as common on the British checklist of fungi www.basidiochecklist.info/index.htm .

Five forest types were sampled: first and second rotation Sitka spruce, Scots pine, ash and oak. A representative of each of these types was selected in each of five geographical areas of the country.

A very large diversity of mites and Collembola has been recovered in studies where sampling was carried out by climbing trees (Figure 2). The assemblages in the soil and in moss on the tree are different from the assemblages on the bare branches which are made up of a relatively small number of species; however, these species tend to be specific to such bare branch habitats while the many similar species occur in moss on trees and in soil. The species occurring on the broadleaved species (oak and ask) are different to those occurring on conifers (Figure 3). Virtually no differences were detected between first and second rotation Sitka spruce. The sites sampled were blocked into different regions which were seen to differ significantly from one another. In particular the assemblages found in the Clare/Galway/Tipperary, Cork/Kerry and Wicklow/Kildare area were fairly distinct, while those from Laois/Offaly and Sligo/Roscommon were intermediary in structure.

Approximately, 270 genera of parasitic wasps have been identified from the five forest types sampled. Each forest

Figure 1: *Phaeolus schweinitzii* - a common parasite on Sitka spruce.

Figure 2: Tree climbing has proved to be a valuable method of sampling invertebrates in canopy habitats.

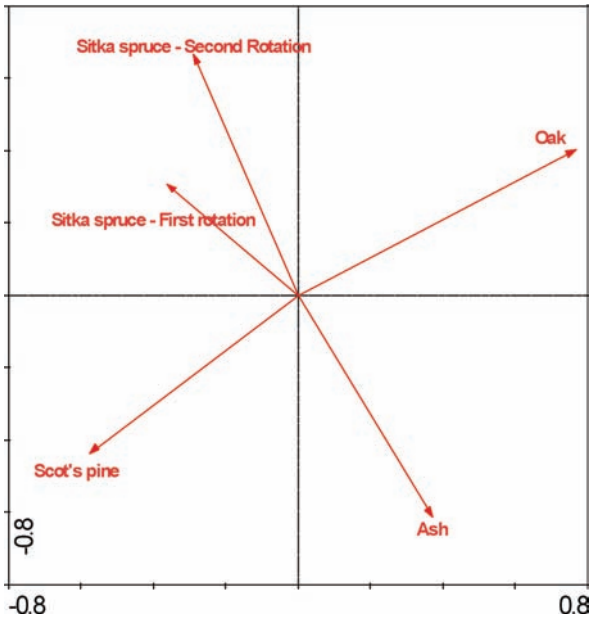

Figure 3: Canonical Correlation Analysis of mites occurring in different forest types. Forest types close together, particularly on the horizontal axis, on the graph are most similar.

type appears to have a unique fauna, with only 18 genera common to all forest types. The broadleaf forests, ash and oak, show the greatest diversity with approximately 180 and 170 genera respectively. Comparatively lower parasitoid diversity was found in the coniferous forests with Scots pine, first rotation and second rotation Sitka spruce forests with 85, 65 and 67 genera respectively. Much of the diversity of the ash forests can be attributed to one site: St John's Wood in Roscommon. To date, only half of the specimens from this site have been identified, but 126 genera have been determined. The ichneumonid, *Pantisarthrus luridus* (Foester), was recorded for the first time in Ireland from an ash site at Donadea Forest Park (Kildare). Many specimens have been sent to the Natural History Museum, London, for verification and it is likely that at least some of these will be new Irish records.

ACTIVITIES PLANNED

- Continue to add to species databases.
- Critical fungal identification will sent to experts for verification.
- The assessment of ectomycorrhizal diversity on roots of each site will be completed in early in 2010 using mophotyping and molecular methods
- Quantitative analysis of macrofungal diversity data will be completed.
- The relationship between fungal diversity and other biodiversity metrics on the forest sites will be evaluated.
- Completion of the identification of the specimens collected. This will now involve collaboration with international experts to ensure proper identification of 'difficult' species.
- Analysis and publication of data.

OUTPUTS

A visiting scholar exchange post was taken at Oregon State University from May 2009 to mid July 2009. A poster was presented on the project at the North American forest ecology workshop NAFEW2009 in Logan Utah in June 2009 www.nafew2009.org.

A presentation on the project entitled *Fungal Diversity in Irish Forest Ecosystems* was given by Richard O'Hanlon at the seminar Forest Fungi in Ireland at Avondale House, Co Wicklow on 28 August 2009.

FORFLUX

Biogeochemistry of Irish forests

PROJECT TEAM

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James Johnson, Trent University, Canada
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COMPLETION DATE: November 2010

BACKGROUND

The Irish landscape has undergone a unique transition from being virtually treeless to supporting a highly productive, intensively managed forestry sector over the last six decades. These plantations are distinctly different from the naturally regenerated and long-established managed forests of most of Europe and North America. Understanding ecosystem processes in plantation forests is a key to sustainable forest management. In recent decades, we have become more aware of the interaction of the forest with the atmosphere, the soil and surface waters. The need now is to understand the long-term implications of these interactions.

OBJECTIVES

- Quantify major nutrient pools and fluxes at Irish forest monitoring plots.
- Develop tools supporting sustainable forest management assessment.
- Quantify concentrations and long-term trends of atmospheric ammonia and solutes in deposition, throughfall and soil water.
- Model soil-water percolation, nutrient nitrogen and mineral weathering rates.

PROGRESS

Final field equipment was installed during January 2009, for monitoring of deposition chemistry, persistent organic pollutants and soil nutrient contents. Additional soil and vegetation samples were collected during June 2009. Ambient trace-gas monitoring stations has been ongoing for NH_3, SO_2 and NO_x at the three intensive forest

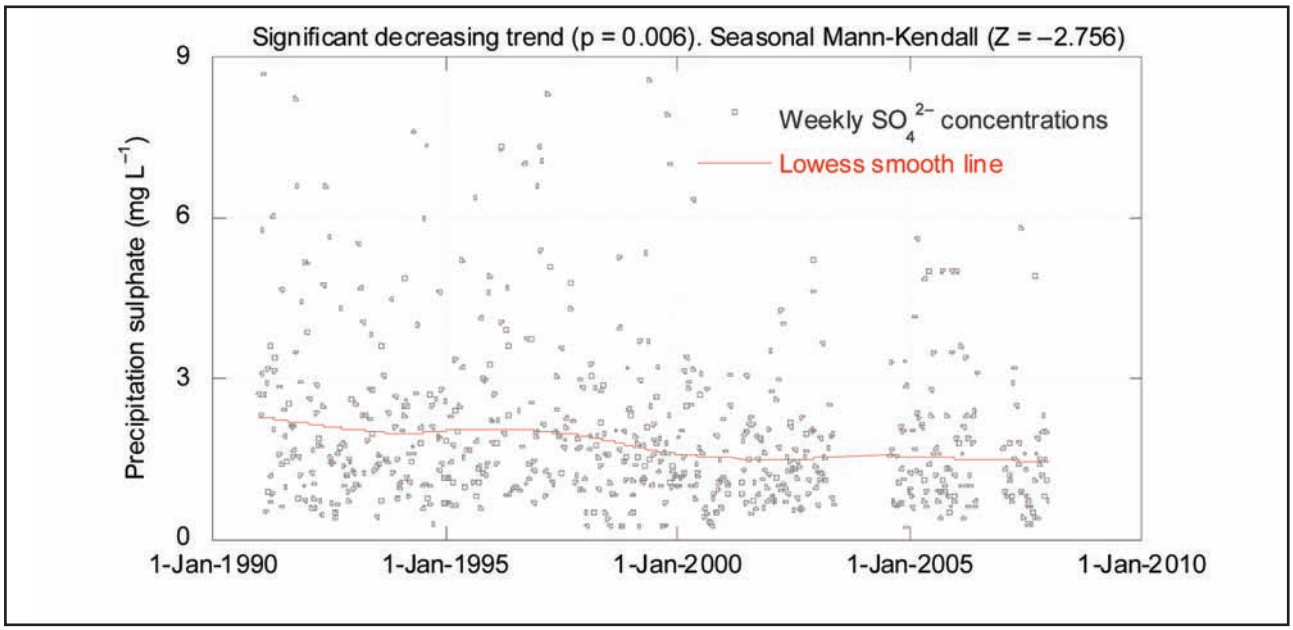


Figure 1: Weekly observations of sulphate (mg L^{-1}) in precipitation at Roundwood and Ballinastoe from 1991 to 2007 (Ballinastoe since 2004 after felling of Roundwood). A Lowess smooth line for the observations is also shown. The seasonal Mann-Kendall test indicates a significant decreasing trend of sulphate.

monitoring plots, and the sampler in use has been part of an international intercomparison. Innovative ion-exchange-resin samplers for throughfall and soil solution are being tested, and may lead to a low cost, long-term sampling approach that could facilitate deposition and soil-solution monitoring at remote sites to be visited only once per year, while greatly increasing the spatial resolution of deposition data. Database development is ongoing, and a data quality review has been initiated. Analysis of long-term trends in monitoring data is underway, using the non-parametric Mann-Kendall test. Indications are that significant long-term trends are present, notably in sulphur, which shows a decrease consistent with known reduced emissions from coal across Europe.

During July 2009, the second meeting of the project advisory group was held. The PhD work at Trent University is ongoing. Research presentations were given at the BIOGEOMON, LSW and EFI conferences.

ACTIVITIES PLANNED

- Final Advisory Group Meeting, July 2010.
- Write-up of PhD thesis.
- Forest Ecosystem Monitoring Network Workshop, 4–5 March 2010.

OUTPUTS

Input to curriculum development and teaching: case study on forest biogeochemistry for new UCD course Soil Science Applications, utilising Level 2 site Ballinastoe. Manuscripts submitted to *Soil Science and Biogeochemistry.*

HYDROFOR

Assessment of the impacts of forest operations on the ecological quality of water

PROJECT TEAM

Prof. Michael Bruen, University College Dublin
Dr Mary Kelly-Quinn, University College Dublin
Tom Drinan, University College Cork
Hugh Feeley, University College Dublin
Joanne Finnegan, National University of Ireland, Galway
Dr Conor Graham, University College Cork
Dr Simon Harrison, University College Cork
Dr Mark Healy, National University of Ireland, Galway
Gero Jahns, University College Dublin
Prof. John O'Halloran, University College Cork
John Regan, National University of Ireland, Galway
Dr Michael Rodgers, National University of Ireland, Galway
Martina Woods, University College Dublin
Sean Blacklocke, University College Dublin*

** Email: sean.blacklocke@ucd.ie*

COMPLETION DATE: August 2013

BACKGROUND

HYDROFOR is an EPA- and COFORD-supported multi-sector co-operative project to investigate the impacts of forestry operations on Ireland's aquatic ecology. In addition to further investigating the nature and effects of these impacts, the study partners are assessing the effectiveness of certain measures such as riparian buffer strips to mitigate these impacts. Impacts under study include acidification, eutrophication, sedimentation and hydromorphological change. The HYDROFOR researchers' professions span the natural, engineering and social sciences.

OBJECTIVES

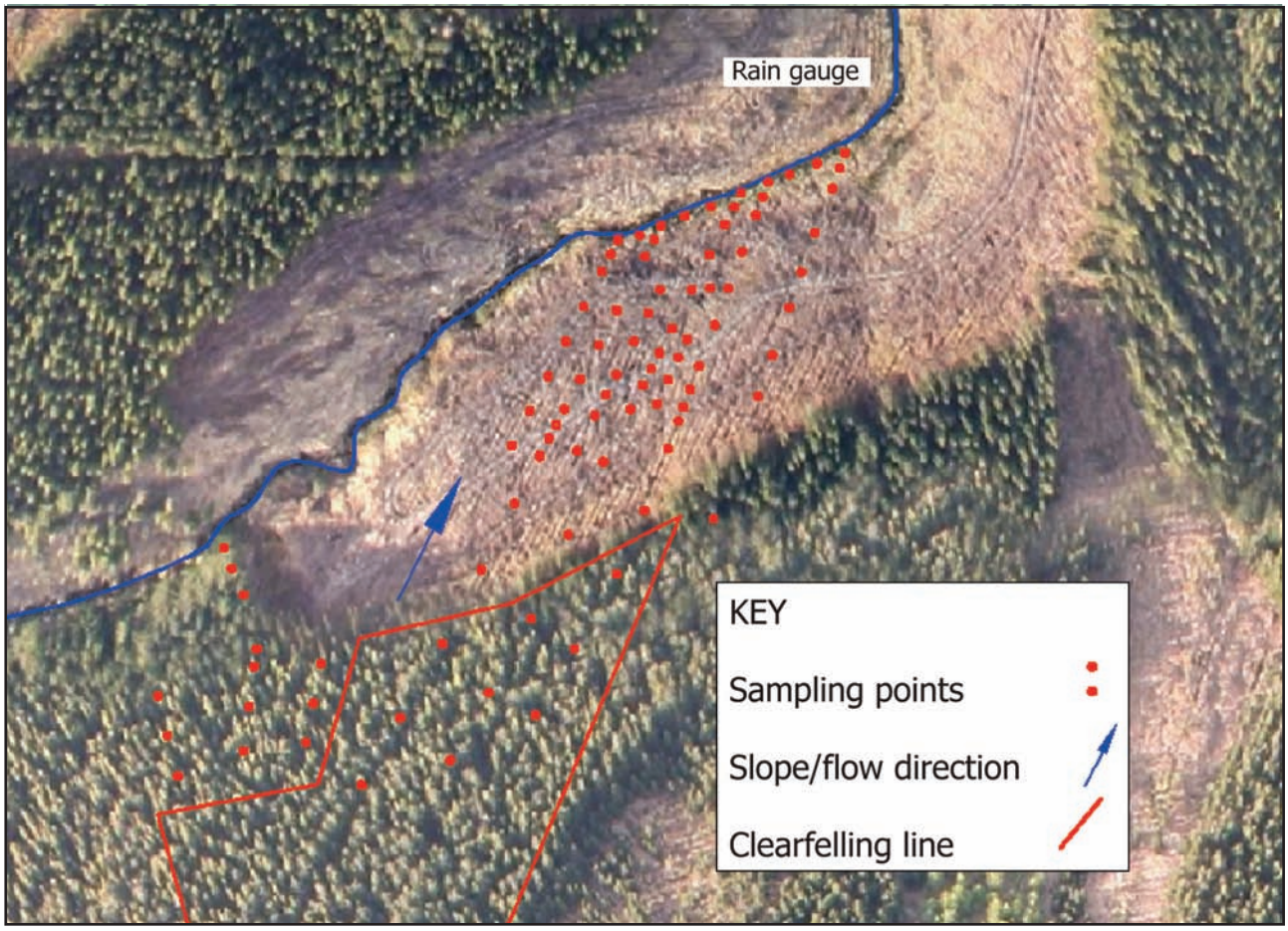
- Review relevant international and national literature.
- Compile a database of relevant data from previous similar projects and combine and analyse with HYDROFOR data.
- Undertake temporal and spatial assessment of the inputs from forest activities.
- Quantify nutrient and sediment losses to water in relation to the nature, scale and duration of forestry activities.
- Test the effectiveness of buffer strips as forestry mitigation measures.
- Evaluate the likely impact of expansion of forest cover in Ireland on hydro-ecology.

PROGRESS

- Negative correlations between percent forest cover in catchments and ecological quality of waterways (invertebrates) have generally been shown, but outliers persist.
- Felling in lake catchments has shown clear and consistent impact of lake chemistry as indicated by elevated levels of nitrogen, phosphorous, dissolved organic carbon, reduced metals and lowered levels of dissolved oxygen.
- Multiple study sites across several study plots are now fully equipped to measure the effects of felling and effectiveness of riparian buffers and baseline conditions have been established.
- The preponderance of the most recent and relevant GIS data needed to make the most informed judgments about the cause-and-effect relationships between forestry operations and ecological quality of water in Ireland have been acquired and are being analysed with the most advanced tools available.

ACTIVITIES PLANNED

- Set up instrumented catchment with FutMon Project.
- Select and finalise planting study sites.
- Continue monitoring of mature forestry sites.
- Select and commence sampling 2010 harvesting site.
- Complete plot instrumentation at Glennamong site.
- Complete plot instrumentation at Altaconey site.
- Collect pre-clearfelling data from Glennamong and Altaconey sites.
- Complete GIS characterisation of Glennamong and Altaconey sites.
- Complete water chemistry and invertebrate analysis for small lakes.



Subsurface and surface water sampling locations at Altaconey study site.

OUTPUTS

- Maintenance of project website: www.ucd.ie/hydrofor/home.htm.
- HYDROFOR GIS Database (Draft).

Feeley, H. and Kelly-Quinn, M. *HYDROFOR Literary Review.* December 2009 (Draft).

Blacklocke, S. 2009. *Development of Regression Models to Predict Forestry Impacts on Aquatic Ecology and Effectiveness of Mitigation Measures: The HYDROFOR Strategy*. Presentation for the Environmental Sciences Association of Ireland's ENVIRON '09 Annual Conference, Waterford, Ireland.

Blacklocke, S. et al. 2009. *Tapping old knowledge trees and growing new ones: the HYDROFOR Project strategy for developing predictive models of forest and water interactions in Ireland*. Presentation and proceedings for the International Water Association's 13th International Specialized Conference on Diffuse Pollution and Sustainable Basin Management, Seoul, South Korea.

SANIFAC

Assessment and mitigation of soil and nutrient losses from acid-sensitive forest catchments

PROJECT TEAM

Dr Michael Rodgers, National University of Ireland, Galway
Dr Liwen Xiao, National University of Ireland, Galway
Mark O'Connor, National University of Ireland, Galway
Connie O'Driscoll, National University of Ireland, Galway
Zaki-ul-zaman Asam, National University of Ireland, Galway

** Email: michael.rodgers@nuigalway.ie*

COMPLETION DATE: October 2010

BACKGROUND

From the 1960s to the 1980s a substantial amount of afforestation occurred in Ireland, on blanket peat. This first rotation crop is now being harvested, or is due for harvesting over the coming years. But it is well known that forest harvesting has the potential to cause releases of solids, nutrient and acidic substrates from soils, causing eutrophication and acidification in receiving waters. This project is particularly relevant to the Forest Water Relations Theme in: (a) examining the effectiveness of buffer zones and grass in the protection of the water quality of receiving waters from forest activities and (b) quantifying the particulate and soluble loads and fluxes in an acid-sensitive forest environment, pre- and post-clearfelling.

OBJECTIVES

- Develop guidelines for the selection of sustainable clearfell sizes in acid-sensitive catchments based on comprehensive quantitative and qualitative experimental data, including dilution and buffer zone capabilities in the catchment.
- Review design guidelines and develop soil and nutrient mitigation rates for riparian woodlands and buffer zones based on comprehensive field data.
- Investigate grass seeding as the method to mitigate the nutrients loss after harvesting.
- Investigate the mechanisms of soil nutrient release from peats and logging residues to surface runoff.
- Identify and quantify the sources of nutrient release after harvesting using litter bag experiments.

PROGRESS

A workshop was held on 7 May 2009 in Newport, Co Mayo. The attendees were from COFORD, Coillte, Forest Service, Marine Institute, Fisheries Boards, National Parks and Wildlife Service, EPA, Teagasc and Galway County Council. Two steering committee meetings were held on 6 April and 16 November 2009. A project meeting was held on 22 September 2009 at the Marine Institute, Newport.

All four 10 ha catchments were fully instrumented. Nine monitoring stations - six in Srahrevagh River study catchment and three in Glennamong catchment - were set up. Nine experimental plots which could be used for buffer zone study in Shrahrevagh were instrumented. In Glennamong, a 0.1 ha buffer area was established. Weather stations have been instrumented at both study sites. Rainfall, wind, air temperature, radiation, air humility, flow, physical, chemical and biological data are being collected. Figure 1 shows some of the biological survey data. Grass surveying was carried out in the Srahrevagh catchment four years after harvesting (Figure 2). A grass seed germination trial was carried out (Figure 3). The buffer zone in Glennamong has been seeded with grass. About 2,000 litter bags have been placed on site to identify and quantify the sources of nutrient release after harvesting.

The suspended sediment (SS) concentrations at upstream and downstream stations at Srahrevagh, the control site and buffer area in Glennamong are similar and low. The SS concentrations were about 3-5 mg l^{-1} at base flow. They could increase to about 30 mg l^{-1} in storm events. The total

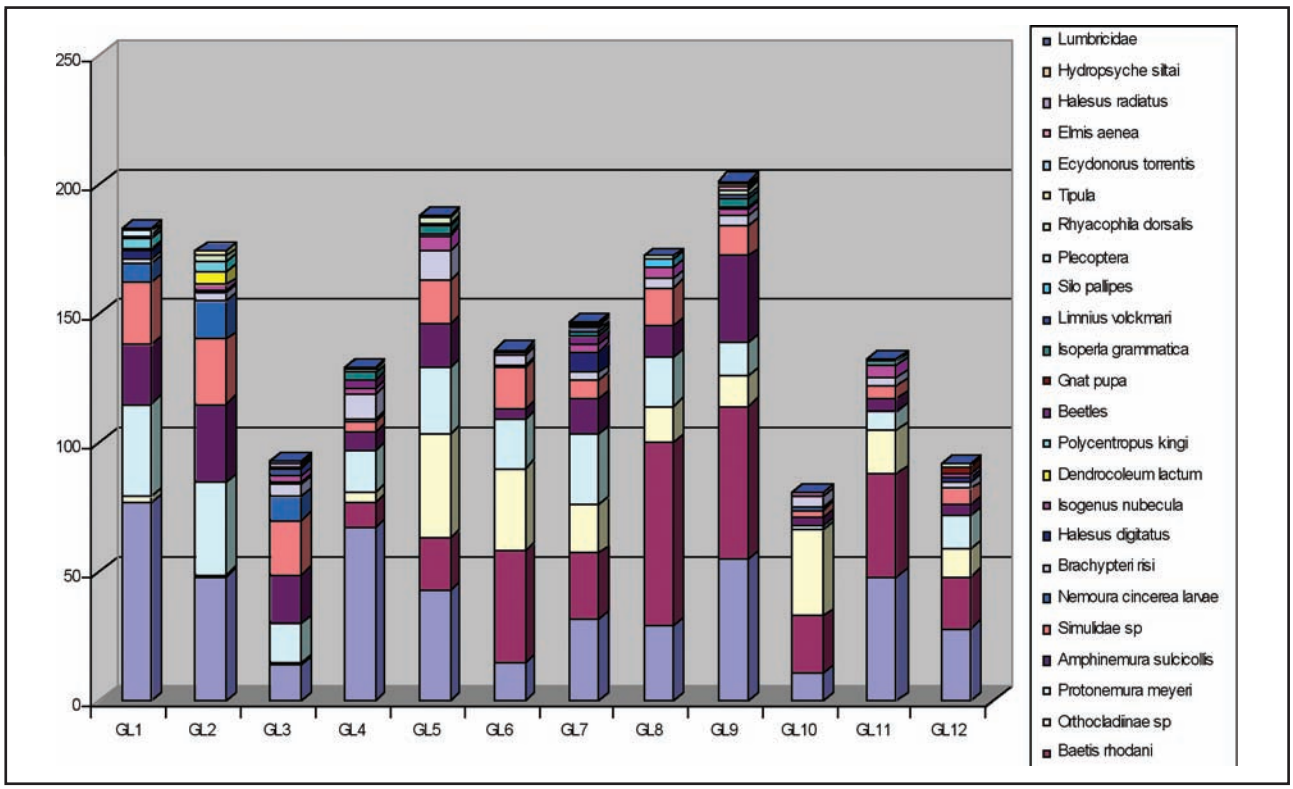


Figure 1: Macroinvertebrates survey in Glennamong river.

reactive phosphorus (TRP) concentrations at the upstream area of Srahrevagh, control site and buffer area in Glennamong were continuously low. The mean concentrations are less than 10 μg/l. The phosphorus concentrations at thedownstream station in Srahrevagh were similar to the value at upstream station in storm events (Figure 4) and base flow condition, indicating that the phosphorus concentrations are back to pre-clearfelling values four years after clearfelling. The phosphorus concentrations in the main Srahrevagh and Glennamong rivers are similar and low, less than 10 μg TRP l^{-1}.

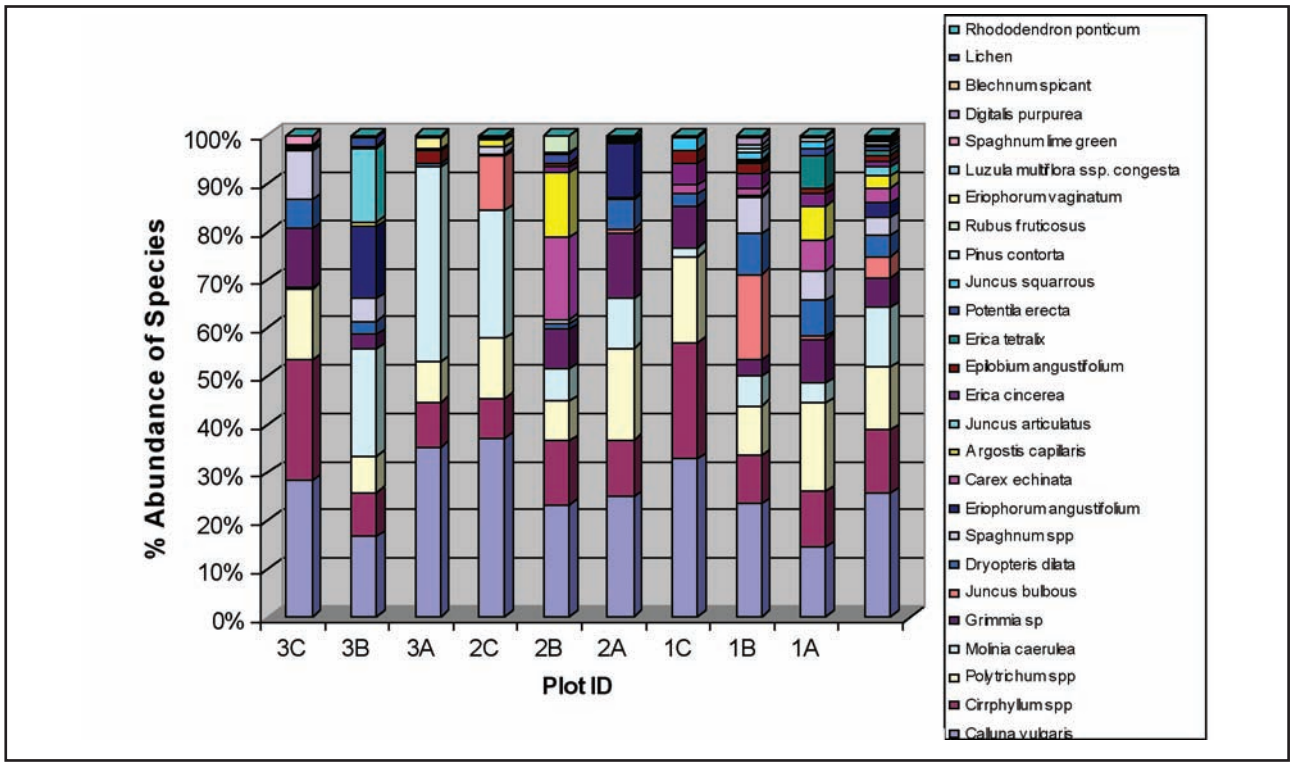


Figure 2: Grass surveying in summer 2009 in Srahrevagh catchment clearfelled four years ago.

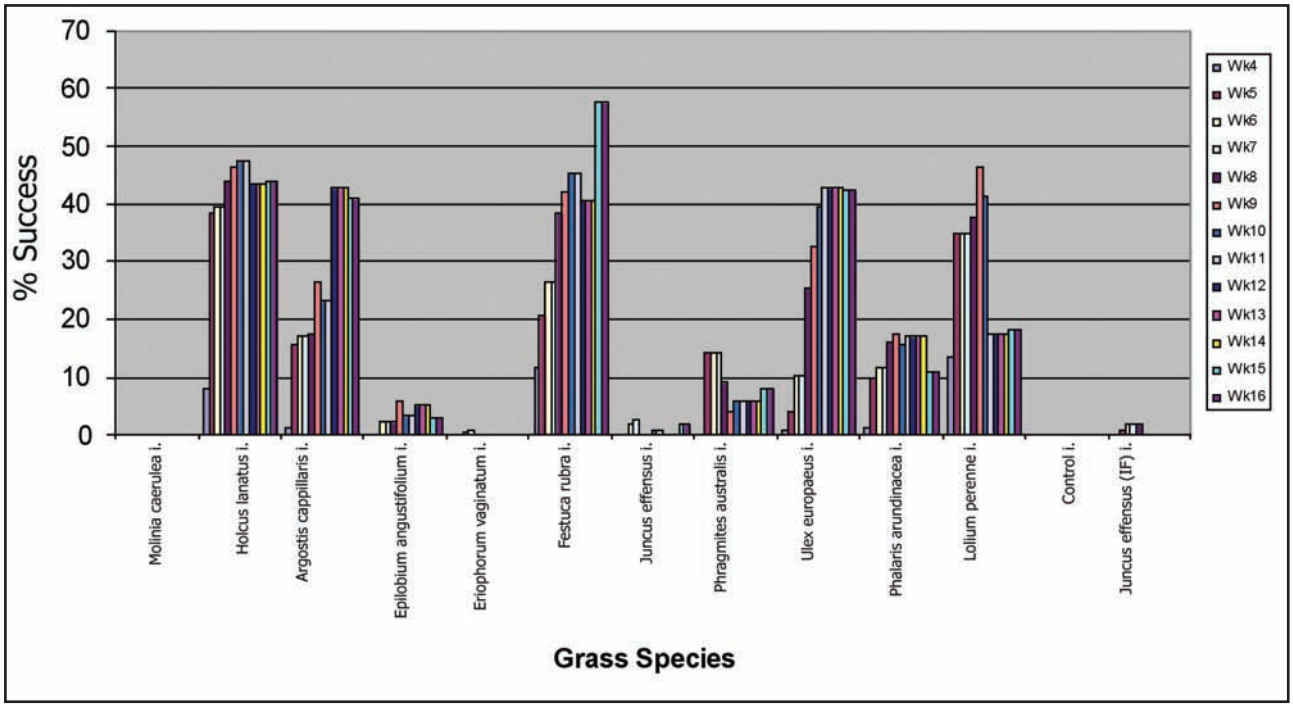


Figure 3: Grass germination study.

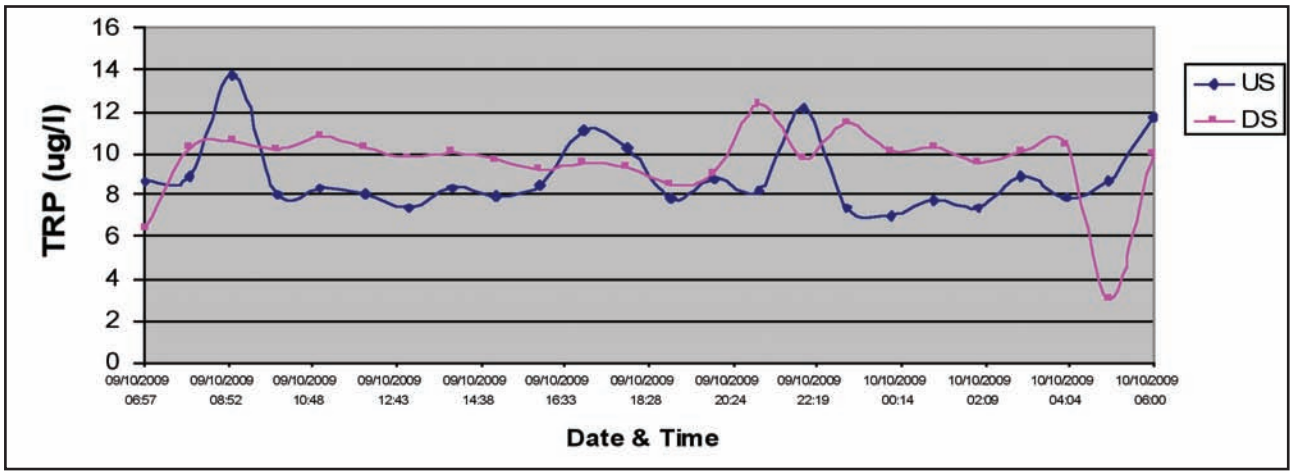


Figure 4: Phosphorus concentrations at US and DS stations at Srahrevagh.

ACTIVITIES PLANNED

- Project and steering group meetings will be held.
- Continue reviewing literature relevant to the project during the study period.
- Data collection for at Srahrevagh and Glennamong catchments will be continued.
- Biological surveys will be conducted four times per annum.
- The buffer zone will be seeded again in spring 2010.
- Litter bags will be collected once every six months for nutrient analysis.
- Grass study will be continued.
- Flume and agitator study will be continued.

OUTPUTS

Michael Rodgers, Liwen Xiao, Mark O'Connor, Connie O'Driscoll and Zaki-ul-Zaman Asam. *Assessment and mitigation of soil and nutrient losses from acid-sensitive forest catchments.* In: HYDROFOR inter-project workshop, UCD Dublin. 16 January, 2009

Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *The impacts of forestry activities on the water ecology and flow regime in acid sensitive salmonid receiving waters in the Burrishoole Catchment, Newport, Co Mayo* (poster). In: Postgraduate ecology forum in ECI, NUI Galway. 14–17 April, 2009.

Michael Rodgers, Liwen Xiao, Mark O'Connor, Connie O'Driscoll and Zaki-ul-Zaman Asam. *Assessment and*

Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: A review of the findings in the previous study. In: SANIFAC steering meeting in Tullamore Court Hotel, Tullamore, Co Offaly. 6 April 2009.

Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the field study and the future field study plan.* In: SANIFAC steering meeting in Tullamore Court Hotel, Tullamore, Co Offaly. 6 April 2009.

Zaki-ul-Zaman Asam, Michael Rodgers, Liwen Xiao, Mark O'Connor and Connie O'Driscoll. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the laboratory study and the future laboratory study plan*. In: SANIFAC steering meeting in Tullamore Court Hotel, Tullamore, Co Offaly. 6 April 2009.

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Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the field study and the future field study plan.* In: Technical workshop: Sediment and nutrients release from forest harvesting operations in the Burrishoole catchment in Newport, Co Mayo. 7 May 2009.

Zaki-ul-Zaman Asam, Michael Rodgers, Liwen Xiao, Mark O'Connor and Connie O'Driscoll. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the laboratory study and the future laboratory study plan.* In: Technical workshop: Sediment and nutrients release from forest harvesting operations in the Burrishoole catchment in Newport, Co Mayo. 7 May 2009

Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *Forestry impacts on diatom assemblages in two acid sensitive streams, Co Mayo, Ireland.* In: British Diatom Meeting 2009 Freshwater Biological Association, Ambleside, UK. 26 October 2009. (Won the best poster award).

Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the field study and the future field study plan*. In: Meeting with COFORD, Marine Institute, Newport, Co Mayo. 22 September 2009.

Zaki-ul-Zaman Asam, Michael Rodgers, Liwen Xiao, Mark O'Connor and Connie O'Driscoll. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the laboratory study and the future laboratory study plan*. In: Meeting with COFORD, Marine Institute, Newport, Co Mayo. 22 September 2009.

Liwen Xiao, Michael Rodgers, Mark O'Connor, Connie O'Driscoll and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: A review of the findings in the previous study.* In: Meeting with COFORD, Marine Institute, Newport, Co Mayo. 22 September 2009.

Michael Rodgers, Liwen Xiao, Mark O'Connor, Connie O'Driscoll and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: A review of the findings in the previous study and the proposal tasks in the future study.* In: SANIFAC steering meeting in Marine Institute, Newport, Co Mayo. 16 November 2009.

Connie O'Driscoll, Michael Rodgers, Liwen Xiao, Mark O'Connor and Zaki-ul-Zaman Asam. *Assessment and Mitigation of Soil and Nutrient Losses from Acid-Sensitive Catchments: the preliminary findings of the field study and the future field study plan.* In: SANIFAC steering meeting in Marine Institute, Newport, Co Mayo. 16 November 2009.

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Services and Technology Transfer

COFORD staff-delivered services

Advice and input on economic and environmental matters

COFORD staff provided advice to the Forest Service and the Department of Agriculture, Fisheries and Food on:

- broadleaf silviculture;
- climate change and forests;
- forest statistics;
- forest reproductive material;
- wood energy;
- water quality and forestry;
- forest biodiversity.

Broadleaf silviculture

The increasing importance of managing broadleaved forests for roundwood production and wood energy is reflected in an ongoing programme of thinning demonstrations organised by COFORD with the support of Teagasc (BROADFORM project). During 2009 field days were held in Co Kilkenny and Co Roscommon. Further field days on tending and thinning of young ash will take place in 2010 and will be announced in the COFORD newsletter.

In 2008 COFORD commissioned a review of the performance of broadleaf/conifer mixtures. As a result of this work, a COFORD Connects note on mixtures of oak and nurse conifer species is in preparation. COFORD provided advice to the Forest Service on the design of tending and thinning systems for broadleaves. Outcomes from this work include:

- development of tending and thinning systems for broadleaf crops;
- development of systems for managing broadleaf/conifer mixtures;
- support in the development of a draft grant scheme for thinning broadleaves.

Climate change and forests

COFORD's work in climate change includes the CLI-MIT research programme, reporting on carbon stock changes in Irish forests to national and international processes, provision of forecasts of Kyoto-eligible carbon sequestration, input to the implementation of forestry aspects of the National Climate Change Strategy, input to climate change aspects of national forest policy, COFORD staff involvement in international negotiations under the United Nations Framework Convention on Climate Change, and provision of information on climate change aspects of forests to the agriculture and forestry sectors, government departments and agencies and to the public. Outputs in 2009 included:

- compilation of the 2008 levels of carbon sequestration in forests established since 1990 (work carried out by Dr Kevin Black and colleagues in the CLI-MIT programme using the CARBWARE model);
- forestry aspects of the Fifth National Communication to the United Nations Framework Convention on Climate Change;
- elaboration of afforestation costs and sequestration rates used in the SEI/McKinsey and Co. study: Ireland's Low-Carbon Opportunity - An analysis of the costs and benefits of reducing greenhouse gas emissions (http://www.sei.ie/Publications/Low_Carbon_Opportunity_Study/Irelands_Low-Carbon_Opportunity.pdf);
- forest sequestration material (in collaboration with Ciaran Black, Coillte) for the IIEA report Farm to Fork (http://www.iiea.com/events/iiea-report-launch-from-farm-to-fork).

Forest statistics

Forest statistics, compiled on a consistent basis and over a number of years, are vital to benchmarking the performance of the forest sector, and in guiding state and private sector investment. COFORD is responsible for the compilation of national wood harvest and forest product trade statistics. Furthermore, through the forest economics and policy research programme, FORPOLEC, COFORD is estimating the macro economic contribution of the forest sector, in both tradable goods and services, and in public goods. The main outputs in 2009 were:

- compilation of national roundwood harvest, wood product production and trade statistics for 2008 as part of the Joint Forest Sector Questionnaire compiled by EUROSTAT/Food and Agriculture Organisation/United Nations Economic Commission for Europe (UNECE)/International Tropical Timber Organisation and quantification of wood product flows within Ireland;
- compilation of 2008 wood energy harvest and use statistics for the Joint Wood Energy Enquiry (http://www.unece.org/timber/mis/energy/JWEE.htm), compiled on behalf of the UNECE/International Energy Agency, in collaboration with SEI;
- COFORD Connects note on *Woodflow and forest energy usage*.

Forest reproductive material

Work continued on the implementation of the recommendations of the report of the Forest Genetic Resources Working Group: *Sustaining and developing Ireland's forest genetic resources – An outline strategy* (http://www.coford.ie/iopen24/sustaining-developing-irelands-forest-genetic-resources-p-966607.html).

Under the auspices of the forest nursery group, a process to register chemicals for use in the nursery sector was initiated, in co-operation with the Pesticides Control Service, Department of Agriculture, Fisheries and Food. This resulted in a list of registered chemicals, which is available at (www.pcs.agriculture.gov.ie).

Work on reproductive material mainly deals with monitoring, compilation and updating of the national catalogue of seed stands on an annual basis (required under EC regulation), including advice on felling licence applications in respect of each seed stand. COFORD staff also provided Irish input to international gene conservation and tree improvement processes (particularly EUFORGEN), and co-ordinated the Irish element of the British and Irish Hardwoods Improvement Programme (BIHIP). Work also included input to the Department of Agriculture, Fisheries and Food Advisory Committee on Genetic Resources for Food and Agriculture. Outputs from the work include:

- review and updating of the annual national catalogue of seed stands;
- development of co-operative clone banks, seedling seed orchards and seed source field trials with UK partners in BIHIP.

Wood energy

The wood energy portfolio includes advice on wood energy supply chain development and related matters through woodenergy.ie, joint hosting (with SEI) of the register of wood fuel quality testing laboratories, wood energy workshops (organised jointly by Waterford Institute of Technology (Forestry) and Danish Forestry Extension) and input to national renewable energy policies and measures through SEI and the Department of Communications, Energy and Natural Resources. Outcomes attributable to the work of COFORD, in conjunction with industry, Forest Service and other agencies included:

- continued expansion of the wood energy heating market and the growth of supply of woodchip, graded firewood, pellets and briquettes;
- increased levels of early harvest in privately owned plantations (adding value to existing crops);
- increased use of wood energy in the power generation sector;
- increased levels of expertise and knowledge in the management of energy wood supply chains;
- development of an industry-led wood fuel quality assurance scheme.

Forests and water

Forestry was identified in Ireland's National Summary Characterisation Report of the Water Framework Directive as a pressure which should be addressed in the River Basin Managelent Plans and Programme of Measures. COFORD staff participated in the steering group that was formed to guide the associated field research projects on acidification, eutrophication and sedimentation undertaken by University College Dublin and University College Cork. These projects were established to assist in the evaluation and applicability of the research in identifying potential impact from forests and forestry practices, and to advise on the programme of measures to mitigate potential impacts on receiving waters.

Web-delivered advisory services

There were 53,293 unique visitors to the COFORD website in 2009 - a 13% decrease in traffic compared to 2009. The total number of hits on the site was 1,173,947.

Web-facilitated and delivered advisory services available at the COFORD web site currently comprise:

- CLIMIT - forests and climate change;
- GROWFOR – forest growth and yield modelling for the main conifer species in Ireland, and financial appraisal of crop management;
- WINDTHROW – estimating windthrow probability in forest plantations in Ireland;
- woodenergy.ie – advice on all aspects on the wood energy supply chain
- woodspec.ie – advice on specifying wood products based on the Woodspec manual.

GROWFOR queries (17) generated in 2009 are shown according to category in Figure 1. Registered GROWFOR users have access to the latest versions of the software as well as up-to-date standing roundwood prices.

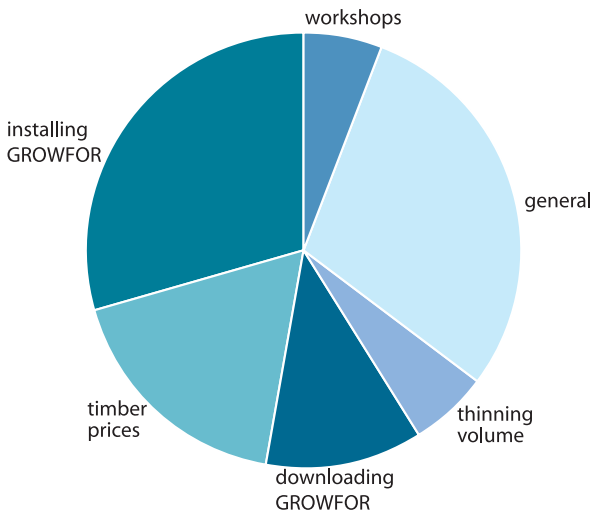


Figure 1: Query categories at GROWFOR during 2009.

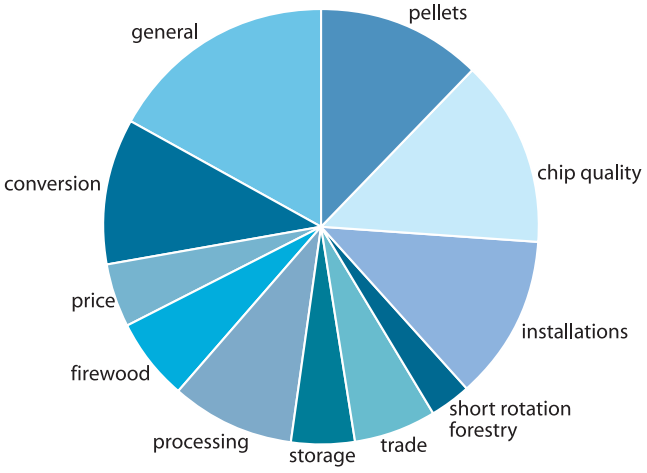


Figure 2: Query categories at www.woodenergy.ie during 2009.

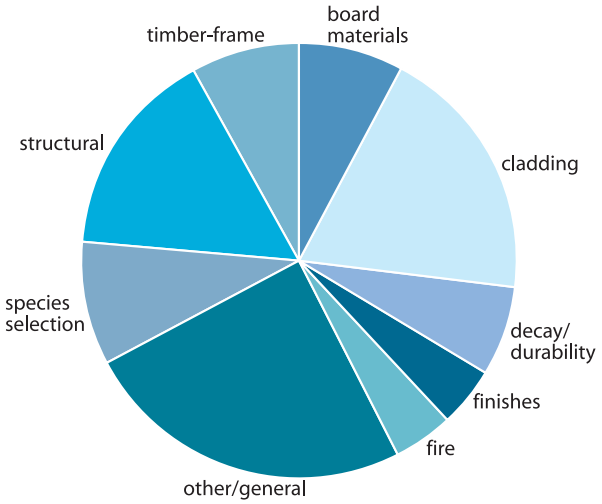


Figure 3: Query categories at www.woodspec.ie during 2009.

During 2009 woodenergy.ie had 16,955 unique visitors, and the site generated 73 queries, shown by category in Figure 2. Woodspec.ie attracted 43,391 visitors, and generated 89 queries, shown by category in Figure 3.

Networking and knowledge transfer

Support was given during 2009 to facilitate travel and mobility, seminars and workshops and working visits through the Networking and Knowledge Transfer Support Initiative.

Six travel and mobility grants, two working visit grants and two seminar grants were awarded. Reports on the visits and events are available on the COFORD website.

Events

COFORD was involved in the organisation and hosting of conferences and workshops in 2009 as listed below. Presentations made at these events are available on www.coford.ie.

- International land-use, land use change and forestry workshop 11-13 March
- National forestry conference - 27 March – (in conjunction with the Irish Timber Growers Association and the Society of Irish Foresters)
- Technical Workshop on Sediment and Nutrient Release from Forest Harvesting Operations in the Burrishoole Catchment - 7 May
- Bioenergy 2009 - 17 June (in conjunction with SEI and Teagasc)
- Forest biomass supply chain workshops - 18/19 June
- WoodWisdom (European Research Area Network on Networking and Integration of National Programmes in the Area of Wood Material Science and Engineering in the Forest-Based Value Chains) meeting - 19/20 August
- Forest fungi seminar - 28 August
- FORECAST workshops on the new roundwood production forecast and associated tools - 22, 29 September
- Book launch (If trees could talk) - 24 November
- Broadleaf field days - 20 May, 22 October - with Teagasc
- GROWFOR workshops - 18 November, 9 December - with PTR Ltd

Publications

- Annual report 2008
- Roundwood production from private sector forests 2009-2028. A geospatial forecast by Henry Phillips, John Redmond, Máirtín Mac Siúrtáin and Anita Nemesova
- If trees could talk – Wicklow's trees and woodlands over four centuries by Michael Carey
- Forestry 2030 papers

COFORD Connects

- An outline of the ForestEnergy series of COFORD Connects notes.
- Standard shortwood harvesting of conifer first thinnings for 3 m pulpwood and industrial roundwood.
- Integrated harvesting of conifer first thinnings for 4.3 m energy wood and industrial roundwood.
- Whole-tree harvesting of conifer first thinnings for energy wood chip production.
- Producing firewood from conifer first thinnings.
- Whole-tree harvesting of broadleaf first thinning for energy wood chip production.
- Production of wood chip from premature clearfelling of lodgepole pine on cutaway peat.

- Storage and seasoning of conifer roundwood in the forest.
- Forest storage and seasoning of conifer and broadleaf whole trees.
- Storage and seasoning of conifer and broadleaf firewood.
- Long term storage and seasoning of conifer energy wood.
- An overview of the 2008 UNECE Timber Committee meeting.
- An overview of the Irish wood-based biomass sector 2007.
- Woodflow for the Republic of Ireland for 2008.
- Climate change and Irish forestry.

E-Newsletter

The monthly email newsletter Forestry and Wood Update continued to be compiled and circulated. The COFORD website facilitates online subscription, with the number of subscribers now standing at over 2,500.

COFORD involvement in national and international organisations and processes

WoodWisdom-Net: Networking and Integration of National Programmes in the Area of Wood Material Science and Engineering in the Forest-Based Value Chains

Ireland, along with 11 other countries is participating in the WoodWisdom 2 ERA-NET which is a network of 19 national funding organisations that have joined forces to encourage researchers in transnational cooperation for innovative projects in forest-based value chains. COFORD is one of the funding agencies participating in the ERA-NET and as a member of the Management Team is responsible for the dissemination aspects of the project. During the year COFORD staff were involved the development of the project website, the compilation of newsletters and the preparation of promotional material (banners and brochures). They also participated in the preparations for a joint call seeking proposals for collaborative transnational projects on applied research that was launched in November 2009.

COFORD staff activities

Dr Eugene Hendrick is the Irish representative on the EU forest sink experts group in the international climate change process, and a member of the Heads of National Forest Research Institutes. He is the national correspondent for the UNECE/FAO/EUROSTAT/ITTO Joint Forest Sector Questionnaire, and the Irish representative on the International Council of the International Union of Forest Research Organisations (IUFRO). He gave the following presentations in 2009:

- Using forests to sequester carbon: projections to 2020. Presentation at the Institute of Irish and European Affairs Conference - The Greening of Irish Agriculture - Responding to the Challenge of Climate Change, January 2009 (www.iiea.com/documents/iiea-agri-conference-brochure).
- Forests, climate change and energy. Presentation at the annual conference of the Irish Bioenergy Association (IrBEA) – Fueling Ireland's Future, January 2009 (http://www.irbea.org/index.php).
- Forests and climate change. Public lecture during Tree Week, March 2009 (http://www.treecouncil.ie).
- Role of Irish forests in climate change mitigation. Presentation (with Dr Kevin Black) to the Oireachtas Joint Committee on Climate Change and Energy Security, March, 2009 ((http://www.oireachtas.ie/viewdoc.asp?fn=/documents/PRESS_2009/20090512.htm).
- Wood fuel A key renewable energy feedstock. Presentation at the Renewable Energy Summit, April 2009.
- Forest research for 21st century Ireland - Meeting society's needs. Presentation at the Scientific seminar held during the annual conference of the European Forest Institute: Forest Ecosystem Management in the 21st Century (http://www.ucd.ie/bioenvsci/efi/efisciprog.html), September 2009.
- Making the most of the private forest resource. Presentation at the Teagasc National Forestry Producers Group Conference – Organising to Grow Together, September 2009.

Alistair Pfeifer is the national representative on the COST Domain Committee for Forests, their Products and Services. He also is a member of the Forests and Water Steering Group that is developing a Programme of Measures for Forestry under the Water Framework Directive, and serves on the management committee of WoodWisdom-Net.

John Fennessy represents COFORD on the British and Irish Hardwood Improvement Programme. He is also Chairman of the BIHIP Oak Group. He is national co-ordinator on European Forest Genetic Resources Network (EUFORGEN) and is the Irish representative on its Stand-forming Broadleaves Network. He is a member of the Advisory Committee on Genetic Resources for Food, Agriculture and Forestry of the Department of Agriculture, Fisheries and Food and is Strategic and Integrative Decision Board (SIDB) member of the European forest tree breeding infrastructure network - TREEBREEDEX (http://treebreedex.eu). He co-authored a chapter on *Sustainable Forestry in Northern Ireland and the Republic of Ireland,* with Roy W. Tomlinson in *A Living Countryside? The politics of sustainable development in rural Ireland*, edited by John McDonagh, Tony Varley and Sally Shortall and published by Ashgate Publishing Ltd in July 2009.

Financial Statement

COFORD EXPENDITURE ON R&D AND RUNNING COSTS IN 2008 AND 2009[1]

	2009	2008
	€000	€000
1. Sectoral research and development		
Reproductive material and forest nurseries[2]	265	338
Silviculture and forest management[3]	745	625
Harvesting and transport[4]	0	36
Wood processing and product development[5]	331	784
Socio-economic aspects of forestry[6]	105	74
Environmental aspects of forestry[7]	1,713	1,163
	3,159	3,020
2. Linkages and technology transfer		
Linkages[8]	15	35
Technology transfer	210	529
	225	564
3. Salaries and running costs		
Salaries	255	246
Running costs	661	465
	916	711
TOTAL	**4,300**	**4,295**

1 COFORD operates a cash-based accounting system, in keeping with Department of Agriculture, Fisheries and Food procedures.

2 Forest genetics and seed, nursery practice, micropropagation of planting stock, storage, handling and transport of planting stock, and seedling physiology.

3 Forest establishment and regeneration, spacing and thinning, decision support models, pruning and shaping of forest crops, short rotation wood fibre and energy crops.

4 Harvest scheduling and planning, harvesting methods, forest roads, wood transport systems and logistics, environmental aspects of forest harvesting and wood transport.

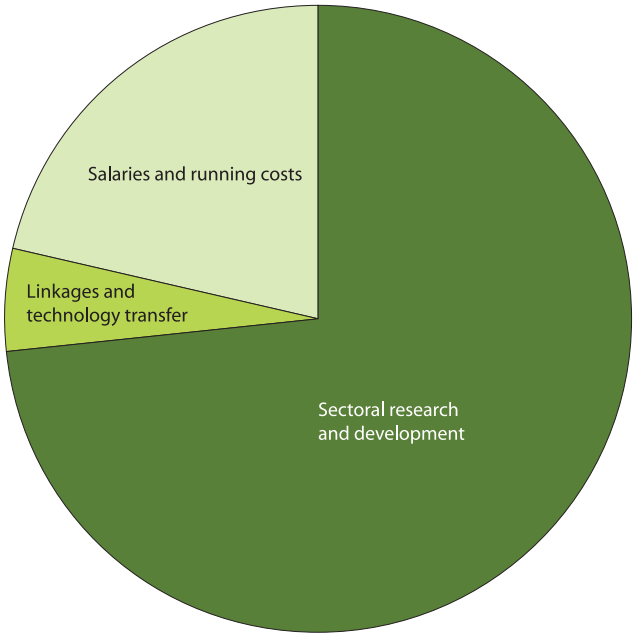
5 Wood properties, timber drying, finishing and preservation, strength properties of timber, timber grading, storage of timber, timber engineering and product development, wood fuel harvesting, processing and storage, non-timber forest products.

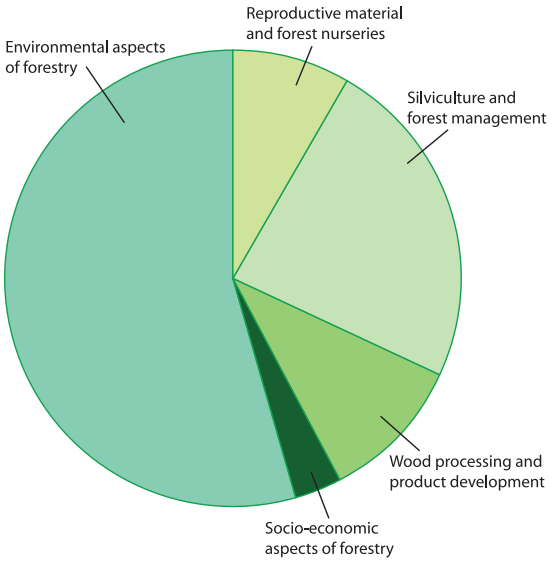
6 Macro economics of Irish forestry, sociological aspects of forestry.

7 Environmental aspects of forestry, biodiversity, water quality and carbon sequestration.

8 Attendance at conferences by COFORD, networking and knowledge transfer support initiative, COST meetings.

COFORD EXPENDITURE 2009





INTERNAL FINANCIAL MANAGEMENT AND CONTROL

The COFORD Council approves in advance the yearly budget of expenditure under the research and development, technology transfer, researcher training and running costs sub-measures. All new research and development projects are approved by the Council. The executive reports to the Council on expenditure against budget.

The executive has delegated authority to approve projects up to a limit of €30,000 per project (COFORD contribution) and up to €150,000 in any one financial year. Approval of expenditure is by the Director.

Financial risks related to projects are appraised by the executive during project budget negotiations. Expenditure claims are assessed by the Financial Administrator and by the Accounts Division of the Department of Agriculture, Fisheries and Food. Performance against budget is assessed by COFORD staff prior to project expenditure approval. An in-house management information system tracks project expenditure. Expenditure against financial commitment items is also tracked on the SAP system of the Department of Agriculture, Fisheries and Food.

COFORD's accounts and financial procedures are subject to periodic audit by the Internal Audit Unit of the Department of Agriculture, Fisheries and Food. COFORD reports expenditure against budget on a monthly and quarterly basis to the Forest Service. Public procurement rules are followed for all COFORD expenditure.