

Irish Forest Biodiversity Research:

New Knowledge from the Canopy

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Forests are home to more plant and animal species than any other terrestrial ecosystem on earth. The biodiversity supported by our forests is important for many reasons, providing food, jobs, energy and medicine as well as recreational and cultural values. Worldwide pressures on forest biodiversity such as deforestation, commercial forestry and climate change have increased in recent times and global attention has now turned to the sustainable management of our forests. When managed effectively it is possible that forests can achieve multiple objectives including timber production and ecosystem services. Management measures taken in this regard must be evidence-based, and research examining the extent of plant and animal diversity in common forest types is essential to the scientific understanding of biodiversity conservation. These issues were addressed by research scientists in Ireland during the FORESTBIO project, which investigated species diversity with a view to informing effective forest biodiversity conservation. This four-year project concluded in December 2010, during the International Year of Biodiversity.

Introduction

Forests are home to a wealth of biodiversity and provide us with vital ecosystem services. Unfortunately, global pressures threatening these habitats are increasing, and these include deforestation, climate change, invasive species and the commercial use of forests. Ecosystem services provided by forests include carbon sequestration (which moderates climate change), biodiversity conservation, and opportunities for recreation and tourism. Effective management of forests is necessary to promote the conservation and enhancement of biodiversity, which in turn helps maintain a full set of ecosystem processes and increase ecosystem stability. Also referred to as Sustainable Forest Management, this is an essential part of implementation of the Convention on Biological Diversity, to which all European countries are signatories. Current strategies to enhance forest biodiversity include the designation of special areas within forests for biodiversity conservation, increased natural regeneration, deadwood accumulation and promotion of mixed tree species forests. Targeted research is required to provide the foundations on which future forest biodiversity conservation policies are built to allow us to meet our commitments under EU and UN environmental policies.

Extensive historical deforestation in Ireland has meant that much of our native forest estate has been depleted. Over the last century there has once again been an increase in our forest estate through public and private afforestation schemes which establish forest stands in areas that were previously not forested. Just over 10% of Ireland's land area is now forested, primarily with non-native commercial conifer plantations. Much

of this forest is now entering its second rotation (where the first forest crop has been harvested and new planting is now taking place, also known as restock or reforestation). Furthermore, the planting of mixed forest stands is increasing, in line with recognition of the environmental benefits of this forest type, particularly where broadleaved (deciduous) trees are included in the mix. Broadleaved forests support a greater diversity of plants and animals than coniferous forest. This is believed to be related to the greater structural complexity of broadleaved forests, which provides increased habitat for a range of species. These forest types will make up the forests of Europe over the next century, and thus present an ideal selection of sites on which to base a study of forest biodiversity.

Plantation forests compare favourably with many other intensive land uses in the biodiversity that they support. Effective management of our forests will allow us to promote forest biodiversity, and can even play a part in protecting threatened species. FORESTBIO (Management of biodiversity in a range of Irish forest types) was a collaboration between University College Cork, Trinity College Dublin and Coillte that ran from 2007 to 2010. The project was funded by the Irish Government through COFORD (The National Council for Forest Research and Development). The aim of the project was to assess the biodiversity of a comprehensive range of species in some common forest types and determine the causes of high and low biodiversity to inform management and policy decision-making. The diversity of familiar species, such as ground vegetation and birds, as well as less visible species, such as epiphytes and invertebrates, was surveyed in a targeted network of 60 sites throughout the island of Ireland. Survey sites included commercial coniferous plantations, mixed tree species plantations, and native woodlands.

Methods Employed

Biodiversity surveys were conducted at Sitka spruce reforestation plantations of four age classes from newly planted to commercial maturity, mixed species plantations of Norway spruce with oak and Norway spruce with Scots pine, as well as in both oak and ash native woodlands. Data on second rotations plantations were compared with data on first rotation (or afforestation) plantations collected during the earlier BIOFOREST project (<http://bioforest.ucc.ie/>), conducted by the same team of researchers.

Standard biodiversity assessment methods such as point counts for birds, and visual surveys of percent coverage for plants, were employed where possible, together with some novel techniques not previously used in Ireland. Among the novel techniques used were thermal canopy fogging for invertebrate sampling and terrestrial LiDAR (Light Detection and Ranging) for assessment of forest structure. The biodiversity of ground vegetation, epiphytes (ground and canopy), invertebrates (ground- and canopy-dwelling spiders and beetles, and moths) and birds was assessed at all sites. A complementary survey of deadwood in native woodlands and plantation forests was also conducted at a sub-set of project sites due to the recognised importance of both fallen and standing deadwood for biodiversity in forests.



Image 1. The fogging technique being used by Rebecca Martin at a Sitka spruce plantation in Ireland

Despite advances in our knowledge of forest biodiversity, still little is known about the canopy invertebrate fauna of our forests. Canopy fogging is a relatively new technique used for the collection of large volumes of insects from forest canopies. It was developed during the 1980s for use in tropical forests, where access to the forest canopy is particularly problematic, and there it revealed exceptionally high canopy insect species richness. We now know that forest canopies contain a major proportion of the diversity of the Earth's organisms and make up the bulk of the biomass in forest ecosystems. Sampling of invertebrates from the canopy using more traditional techniques (such as sweep netting and beating trays) is a very difficult and labour intensive undertaking. The canopy fogging technique allowed us to sample insects in the forest canopy without needing to access the canopy directly.

Canopy fogging disperses an aerosol knockdown insecticide into the tree canopy from a machine operated from the ground beneath the tree. The fog is clearly visible and rises through the canopy in still conditions, allowing researchers to observe its progress. It rapidly paralyses and knocks down the canopy insects, which are collected using an arrangement of plastic sheets suspended just above the ground beneath the trees. The fogging method is, however, highly susceptible to mechanical failure and heavily constrained by weather conditions, and can only be used on sunny days with very low winds. The canopy must also be dry, and so sampling cannot be carried out after recent rainfall as the insects may stick to the damp trees rather



Image 2. Point count surveying for bird biodiversity being conducted by Oisín Sweeney in a Sitka spruce plantation in Ireland

than fall to the ground. When successful it does, however, sample a large vertical portion of the forest canopy and produce very large sample numbers.

Forest Biodiversity in Ireland

This four-year project revealed a wealth of biodiversity in Ireland's forests, not only in our native woodlands, but also in our plantation forests. A total of 346 species of ground vegetation were recorded across the 60 study sites, 136 ground-dwelling spiders, 64 ground-dwelling beetles, 122 moths, 42 canopy-dwelling spiders, 87 canopy-dwelling beetles and 39 species of bird. The species richness of plants, spiders, insects, birds and other groups was typically highest at the beginning and end of the plantation forest cycle. For some groups, particularly those adapted to living or feeding on native broadleaved trees, the inclusion of broadleaved trees in plantations had a positive effect on biodiversity.

In addition to the many species recorded for each group studied, one new Irish plant record and one new county plant record of a near-threatened species were found in plantation forests during this research. Three rare woodland flowering plant species and two near threatened moss species were recorded in our plantation forests. Four moth species, the barred red, the cloaked pug, the satin beauty and the tawny-barred angle, were found exclusively in plantation forests, demonstrating the value of our commercial forests for biodiversity. The rare garden warbler, which favours broadleaved forests, was also recorded in Irish forests during the survey. Two new species records were recorded for Ireland during the canopy fogging of native oak woodlands. The spider *Entelecara acuminata* was sampled in County Kilkenny, and the beetle *Anobium inexpectatum* was sampled in Counties Galway and Kerry. *Entelecara acuminata* is patchily distributed in southern England, is rarer in northern England and has been recorded in Scotland. *Anobium inexpectatum* is also on the UK conservation Red List. This species is generally found in association with old broadleaved trees, and in particular with stems of ivy *Hedera helix* growing on these broadleaves. It feeds on deciduous wood only, and is rarely found in conifers. These species may have previously gone undetected in Ireland due to limitations of traditional sampling methods which did not allow for detailed exploration of forest canopy biodiversity.

Biodiversity of Native Woodlands

Oak and ash native woodlands in Ireland supported broadly similar numbers of bird and invertebrate species, though ash woodland supported more ground vegetation and epiphyte species. Although similar numbers of species were found, these species differed between the two woodland types, particularly for plants and insects. The conservation of both oak and ash woodlands in the landscape can therefore act to increase biodiversity.

Native woodlands were generally more species rich and supported different communities to plantations. Where similar or greater numbers of species were supported in plantations, the communities differed from those in native woodlands, and where communities were similar, more species were supported in native woodlands. Ground-dwelling beetles were an exception, possibly because this group is composed of generalists in Ireland, where few forest specialists are found. Since forest plantations are the predominant forest type in Ireland, attention should focus on the preservation or extension of native woodlands, and on the management of plantations to encourage native woodland characteristics. This will ultimately enhance the biodiversity within existing forests, and maximise biodiversity in the landscape throughout the island as a whole.



Image 3. *Anobium inexpectatum*: This small, wood boring beetle is typically found in the canopies of broadleaved trees. It was reported for the first time in Ireland in 2007 on oak trees.

Photo: Frank Köhler (koleopterologie.de)

Biodiversity of Pure and Mixed Commercial Stands

This study found that the different groups of plants and animals displayed similar patterns in species richness and community composition over the forest cycle in both first and second rotations of Sitka spruce. Biodiversity was typically high at the beginning and end of the cycle and low during the closed-canopy middle stages where little thinning has been carried out and light penetration is low. The different plant and animal groups also displayed similar patterns of community composition across



Image 4. *Entelecara acuminata*: This small spider spins small sheet webs in forest canopies. It has recently been found for the first time in Irish forest canopies where it may have previously gone undetected due to its arboreal lifestyle and small size.

Photo: Lynette Schimming



Image 5. Large Emerald *Geometra papilionaria*

Photo: Veronica French

stages in the forest cycle; composition was generally most distinctive in the early stages of both first and second rotation plantations.

The inclusion of a broadleaved species (oak) or a light-canopied conifer (Scots pine) in an intimate mixture with Norway spruce had little effect on the diversity or community composition of most of the groups studied. The exceptions were those groups specifically adapted to living or feeding on native broadleaved trees, and epiphytes also showed a positive response to the addition of a light-canopied conifer. The proportion of Scots pine and oak in the majority of the mixtures studied was less than 40%, and most of the planted oak trees had been outcompeted by surrounding Norway spruce, such that they formed an understorey layer rather than part of the main canopy. It is likely that mixed tree species planting would have a more positive effect on forest biodiversity through the planting of more compatible tree species mixtures, or targeted management strategies that allow the secondary species to reach the canopy. This is an important finding in terms of its potential impact on future forest plantings in Ireland and elsewhere.

Deadwood

Both fallen and standing deadwood in forests provides habitat for a wide range of organisms, particularly insects and birds, that would otherwise be absent from a forest. The history of extensive deforestation and exploitation of forests for wood resources in Ireland was evident in the paucity of large-diameter logs and snags (two common deadwood categories) found in both native woodlands and plantation forests in this study. Deadwood levels in Irish forests are low even compared to those in Great Britain which has also experienced extensive forest clearance. Deadwood is one of the most important components of forest ecosystems, is an indicator of the conservation value of a forest, and one of the factors that most clearly distinguish woodlands with natural characteristics from more intensively managed forests. Despite the low levels of deadwood recorded in Irish forests, deadwood was positively related to diversity of a range of species in the forests investigated.

Indicators of Forest Biodiversity

The development of indicators of biodiversity in forest habitats is a long-term goal of forest biodiversity research in Europe. The Convention on Biological Diversity requires all countries to identify and monitor components of biodiversity that are important for conservation and sustainability. It recognises that monitoring can exploit the use of indicators to avoid the need for extensive species surveys. In cases where not all groups of



Image 6. Great spotted woodpecker returning to the nest with food. Absent from Ireland for hundreds of years, the great spotted woodpecker has recently re-colonised County Wicklow. They are found predominantly in oak woodlands, where they feed on insects from deadwood. Photo: Dick Coombes

interest can be included in a survey, an evaluation of biodiversity can be conducted using measurable parameters that act as correlates or surrogates of true biodiversity. Information about unsurveyed groups can be inferred from known relationships with structural and environmental variables (indicators) or other taxonomic groups (surrogate taxa). Indicators are not substitutes for surveys of plants and animals in terms of providing detailed information about a site's biodiversity. However, they can serve as a means of assessing the effectiveness of management for biodiversity, or enable identification of sites with potential biodiversity interest without having to conduct labour- and time-intensive surveys.

The results of the FORESTBIO project suggest that certain environmental/structural variables can serve as indicators of biodiversity in the forest types studied. There is broad overlap between groups for several of these indicators, increasing our confidence that they might enable managers and operators to get an impression of a site's biodiversity value. This confidence is further increased by substantial overlaps between some of the indicators identified during the previous BIOFOREST project and those arising from the FORESTBIO project. A new project (BIOPLAN) is now underway in Ireland to test this theory, and is being conducted in collaboration with Forest Research UK in order to test indicators across both countries.

For further information see www.ucc.ie/en/planforbio

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Image 7. Grey oyster mushroom: A bracket fungus that favours broadleaved deadwood Photo: Rebecca Martin



Image 8. Primrose *Primula vulgaris*: Primroses are a common feature of Irish woodlands during spring and, like the bluebell, flower in high light conditions before the leaves come on the trees. They are found throughout Ireland, where there are a number of hybrids. Their flowers are heterostylous, i.e. individual plants bear either pin flowers (with a long style and short stamens) or thrum flowers (with a short style and long stamens). Fertilisation can only take place between pin and thrum flowers. Pin-to-pin and thrum-to-thrum pollination rarely takes place and is ineffective.