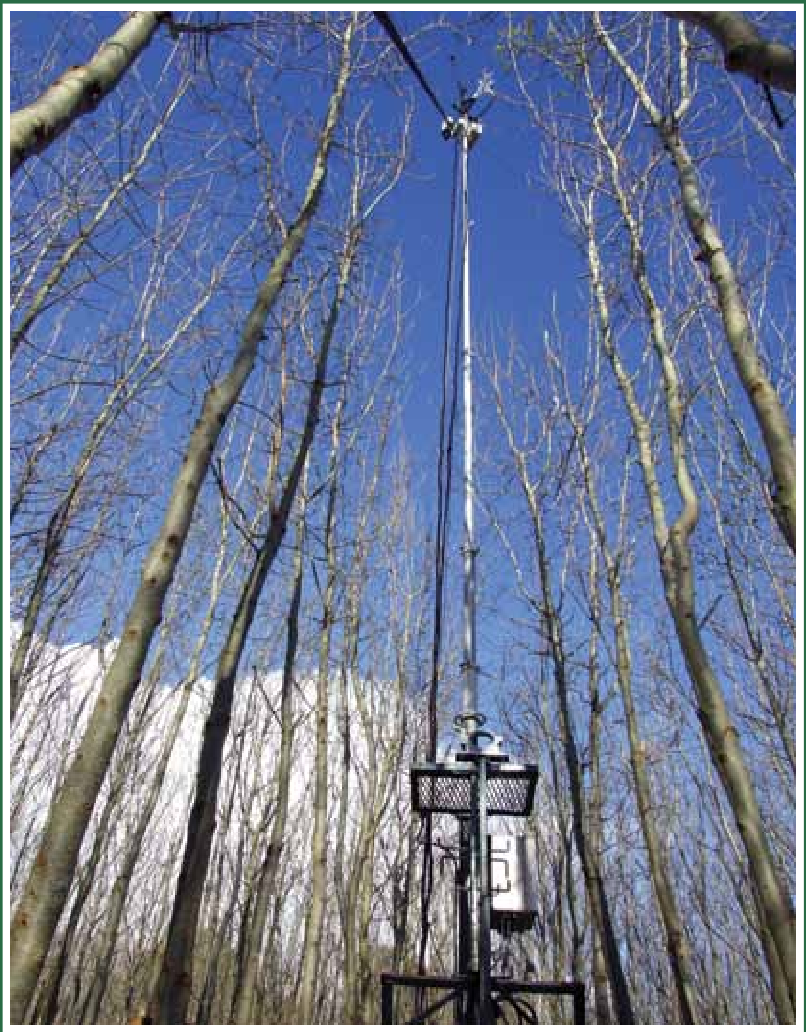
IRISH FORESTRY



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Contents

The Society of Irish Foresters

Comann Foraoiseorí na nEireann

Mission Statement
To lead and represent the forestry profession, which meets, in a sustainable manner, society's needs from Irish forests, through excellence in forestry practice.

Objectives
- To promote a greater knowledge and understanding of forestry in all its aspects, and to advance the economic, social and public benefit values arising from forests.
- To support professionalism in forestry practice and help members achieve their career goals.
- To establish, secure and monitor standards in forestry education and professional practice.
- To foster a greater unity and sense of cohesion among members and provide an appropriate range of services to members.

Submissions of articles to *Irish Forestry*

Submissions

1. Original material only, unpublished elsewhere, will be considered for publication in *Irish Forestry*. Where material has been submitted for publication elsewhere, authors must indicate the journal and the date of submission.

2. All submissions must be in MS Word, submitted electronially to the Editor, *Irish Forestry* at sif@eircom.net (see Guidelines). Authors are requested to keep papers as concise as possible and no more than 12 pages in length (including tables and figures).

3. Submissions will be acknowledged by the Editor. Authors will be informed if the paper is to be sent for peer review. If peer review is not envisaged an explanation will be provided to authors.

4. On submission, authors should indicate up to three potential referees for their paper (providing full contact details for each referee). Choice of peer reviewer rests in all cases with the Editor.

5. Peer reviews will be communicated to authors by the Editor. Changes suggested by the reviewer must be considered and responded to. The decision to publish will be taken by the Editor, whose decision is final.

6. Guidelines for authors on *Irish Forestry* house style and layout can be downloaded as an MS Word template from http://societyofirishforesters.ie/Irish Forestry.

Front cover: Reaching for heaven. *An extendable mast reaches above the canopy of a young ash forest carrying meteorological and air sampling instrumentation. The UCD CARBiFOR project measures the changes in atmospheric* CO_2 *concentrations above a number of forest types to calculate the carbon uptake by the trees. The mast is mobile and is moved periodically to monitor a number of differently aged forests. This photograph, taken by Brian Tobin, won second place in the 2010 UCD Images of Research Competition.*

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EDITORIAL

Forest Diversity and Irish Forestry

As many members of the Society may have noticed, *Irish Forestry* has embraced the modern era with the recent revamping of the website. All issues of the journal are now freely available online to members and non-members alike, except for the most recent ones. It will be an important archive of information, especially for our younger members who may have received only a few issues of the journal. In addition to the many obvious benefits of this move, primarily for Irish readers, it will improve the international profile of the journal. *Irish Forestry* is an important medium of communication for the forestry sector in Ireland. In particular, researchers will benefit from this, with published articles now being readily accessible internationally. The Society should be commended for taking this important step. Furthermore, the editorial board plans to get the journal listed on one or more international citation databases.

Advances in science and technology impact on our lives almost daily. A few years ago the idea of using satellite data in our daily lives might have seemed unlikely, but now GPS systems are common place and indeed most mobile phones now have this capability. Therefore, it is not surprising that remotely sensed imagery will play a greater role in forestry in Ireland, so the McInerney et al review paper in this issue is timely in that regard. The authors explore the use of satellite data in forestry, but they also present information on data derived from other sources, including terrestrial, and active remote sensing methods.

Sitka spruce is deservedly the most important tree species in forestry in Ireland and this is unlikely to change in the foreseeable future, despite the moves to diversify species composition. This species is often the subject of unfair and biased commentary. This negative commentary is often based on subjective views rather than on scientific evidence. In this issue, O'Hanlon and Harrington present the results of their study of fungal biodiversity in Irish Sitka spruce forests. The results of their study show that stands of Sitka spruce in Ireland have higher macrofungal species richness than native Sitka spruce forests in Canada and is as high as that found in native Irish oak forests. On foot of these results, "put that in your pipe and smoke it" might be said to some of the critics of Sitka spruce! Perhaps Sitka spruce forests are not the damp deserts they are sometimes made out or perceived to be.

Sitka spruce is also the subject of another paper, by Farrelly et al. The results reported in this issue and in a series of other papers published by the senior author as part of his Ph.D. studies at UCD, focus on the development of models to predict the productivity of Sitka spruce. The authors point out that Sitka spruce is being planted increasingly on better quality land than was the case in the past, so new models need to be developed to quantify the potential productivity of the species on these newer site types. The research will contribute towards the development of a decision-support system for use in *Irish forestry*. The results of their analysis also suggest that the planting of an additional 457,000 ha of forests in Ireland could likely be achieved using predominately marginal agricultural land, without compromising agricultural productivity.

In the Forest Perspectives section, Niall OCarroll summarises some extracts from Lady Gregory's Journals on the Cultivation of Trees at Coole Park, with some explanatory notes. Niall provides a brief background as to how he developed an interest in this topic, going back to the time that he worked during his 'practical year' in Gort State Forest as a UCD undergraduate student of forestry. Lady Gregory's frequent references to the woods stimulated Niall's interest in the exercise. The article is a fascinating account of the activities in Lady Gregory's estate, especially the background from Lady Gregory's perspective, preceding the handing over of the estate to the then Forestry Division of the Department of Lands.

John Joe Costin presents a very interesting account of his travels in China and Japan where he viewed many fine and unusual conifer species, many of which are important amenity species in Ireland. He describes some of the historical background to the origins of several species and provides interesting anecdotes about trees and burial traditions.

The sheer diversity of topics covered in this issue is impressive, from mycorrhizas below the ground to satellites high in the air. There should be something of interest in this issue for virtually all readers, which is good for the sustainability of the journal. However, the relatively low number of articles published in this issue is cause for some concern. It may reflect an underlying decline in research activity, or more likely it may also reflect the fact that Irish researchers are increasingly publishing in other journals. This apparent dearth of submissions provides an opportunity for increasing the content in the non-reviewed article sections, and there is a wealth of material in this issue combining culture with science and technology, the combination of which our new President regards as the contemporary genius of our people. These developments, in addition to the steps outlined above regarding the website, should improve the profile of the journal and secure its status as a medium for communicating issues of importance to forestry in Ireland and beyond.

Extending Forest Inventories and Monitoring Programmes Using Remote Sensing: A Review

Daniel McInerney[a], Juan Suarez[b], Maarten Nieuwenhuis[c]

Abstract
This paper presents a review of remote sensing technologies that are applied in forestry. It presents an overview of the data sources and applications that are used to map, monitor and estimate forest parameters. In particular, it deals with methods that use data from space borne sensors as well as methods that utilise terrestrial, active remote-sensing methods. The paper also comments on techniques that have already been used in Ireland, but also discusses other methodologies that are relevant to the Irish forest sector, including supporting field based inventories, updating digital map datasets and providing high-resolution forest stand estimates at a range of scales. In addition, the paper presents techniques to monitor land-use, land-use change and forestry (LULUCF) and to upscale field plot measurements with remotely sensed data.

Keywords: *remote sensing, forest monitoring, forest inventory, optical imagery, LiDAR*

Introduction

Field inventory techniques have been employed in forestry to assess and monitor forests at a range of scales, from stand management through to regional and national inventories. These inventories are based on sampling methods - either random, systematic, stratified or cluster sampling. Using the data collected during these inventories, they provide a direct means of inferring forest parameter estimates of forest areas.

Due to the extent of forest resources, forest practitioners have long considered remotely-sensed imagery as a useful source of data to incorporate into their inventory and monitoring practises. Aerial photography has been used since the early 1940s to map the extent of forest resources as well as to derive other stand information, such as species composition and the extraction of tree height using stereo-photos (Lund et al. 1997). Its use, now in digital format, continues to be widespread within national and stand forest inventories; however, in recent years, in some cases their use has been replaced by spaceborne satellite imagery due to its comparatively lower cost per unit area (Tomppo et al. 2008a; McRoberts et al. 2002).

Since the launch of the first Landsat sensor in 1972, the multi-spectral nature of the resulting images has been integrated into regional and large-scale forest monitoring programs (McRoberts and Tomppo 2007). Although the spatial resolution (the individual size of each picture element) is coarser than in aerial photography, the synoptic view, image information from a wider light spectrum and large extent of

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multi-spectral satellite images offers substantial advantages for forest inventories. Over the past four decades the number of Earth observation satellite sensors has increased exponentially, ranging from low resolution to very high spatial resolution imaging sensors. More recently, active sensors, such as RADAR and LiDAR instruments have gained considerable popularity due to their ability to record data independently of light and prevailing weather conditions, whilst producing high resolution information pertaining to the structure of the Earth's surface and, in particular, living vegetation.

The aim of this paper is to provide a comprehensive review of remote sensing research and operational use cases relevant to forest monitoring and forest inventory programmes. It focuses on the use of optical satellite imagery and active remote-sensing data for forest mapping and outlines the principle advantages and limitations of these technologies within forestry applications in Ireland. It concludes with an outlook on future developments in earth observation science and an overview of opportunities that exist for forest monitoring at a range of spatial scales.

Remote Sensing

Remote Sensing can be very loosely defined as a process of collecting information without coming in contact with the object (Lillesand et al. 2008). With respect to Earth observation, it can be considered to relate to the acquisition of imagery of the Earth's surface.

Efforts to acquire aerial imagery began at the start of the 20th Century using cameras mounted on aeroplanes, balloons and kites. These technologies were adapted and refined largely for military reconnaissance purposes during the First and Second World Wars (Campbell 2002). The benefit of this technology was subsequently identified and used by geographers, geologists and land resource managers (Campbell, 2002). It has long been acknowledged that much information relevant to forestry is discernible on a variety of image datasets and, as a result, a myriad of techniques has been developed to classify forest land in terms of forest related variables that can be seen on the imagery (Horler and Ahern, 1986; Varjo 1996; Wynne et al., 2000; McRoberts et al. 2002; Pekkarinen et al. 2009).

The first step to acquire space borne remotely-sensed data was taken by the United States National Aeronautics and Space Administration (NASA) on the 23rd of July 1972 with the successful launch of the Earth Resources Technology Satellite (ERTS-1), which was later renamed Landsat 1. The Landsat program continued and the technology improved as new sensors were launched. This has led to one of the largest and most comprehensive archives of remotely sensed imagery of the Earth, spanning four decades. This archive was recently made publically available free of charge by the United States Geological Survey at http://glovis.usgs.gov. After Landsat, numerous countries began to develop and launch their own sensors (e.g. France with the Systēme Pour l'Observation de la Terre (SPOT) in 1986, India Remote Sensing in 1989/1991, European Space Agency ERS sensor in 1991, the Disaster Monitoring Constellation [DMC] based in England in 2002, and a range of privately owned sensors, for example Ikonos in 1999). As a result, in the 21st century numerous sensors are acquiring imagery of the Earth at a range of spatial and spectral resolutions with varying swath widths. In addition, the development of sensor technology is advancing and improving at a very fast rate with an associated decrease in the image cost per unit area.

Techniques of forest monitoring

Over the last decade there has been an increased need to monitor forests to assess national-level compliance with international conventions and to quantify global public goods, such as protected forest areas and the contribution of forests to carbon sequestration (World Bank 2008). Data emanating from national forest inventory and remote sensing are both objective means of addressing these needs. Both can be precisely overlaid between different time periods within specific geographic areas and can be used for retrospective spatial analysis. However, the spatial scales relating to the estimation of parameters differ substantially when national forest inventories (NFI) data are used in isolation or in conjunction with satellite imagery. In addition, data acquired from satellite sensors tends to be updated at much more regular and consistent intervals.

Numerous studies have demonstrated that remote sensing can substantially improve forest resource assessments with respect to the added value that the data offer to estimate and map forest variables at a range of scales. In addition, they provide an objective source of data, which can be used for repeated and retrospective analysis (Reese et al. 2002; McRoberts 2008; Tomppo et al. 2008a).

Forest inventories, notably NFIs, extend over large areas and the synoptic view of the landscape provided by remote sensing systems is clearly advantageous. In addition, the repeated acquisition and the objective nature in which the images are acquired are considerable benefits, thus complementing sample-based forest inventories. These benefits were identified during the early 1980s and research was initiated to assess the potential of integrating remotely sensed data into forest monitoring programmes (Häme et al. 1987; Tomppo 1991). Remotely sensed data have since been used for:

- classification (identification of forest, land-use and/or land-cover classes);
- estimation or prediction of continuous parameters, for example timber volume or basal area per hectare.

Classification Studies

Satellite image classification uses spectral information represented by the satellite image spectral bands to classify each individual pixel based on the spectral information stored in the image pixel. This type of classification is termed spectral pattern recognition. In general, the classification process assigns each image pixel to a one landcover (e.g. water, coniferous forest, deciduous forest, corn, wheat, etc.) or landuse (forest agriculture, urban fabric etc.) class. The resulting classified image consists of a mosaic of pixels, each of which belong to a particular theme, and is considered a thematic "map" of the original image. Satellite image classification can be carried out in two ways: unsupervised, where no training or reference information is provided to aid the classification and generally used for exploratory image analysis or, supervised where an expert provides 'ancillary data' to guide the classification algorithm.

The use of imagery acquired by different sensors has led to a range of applications to map forests at different scales. Forest classification over large areas has long been researched to provide broad classifications of forest types. European efforts have included the use of data from the Advanced Very High Resolution Radiometer (AVHRR) sensor system (Häme et al. 2001; Schuck et al. 2003), while more recently this work was extended by Pekkarinen et al. (2009) to improve the classification of European forest cover using Landsat ETM+ data and the Corine Land Cover 2000 (CLC2000) database and a k-means clustering and *k*NN technique. Similar approaches were employed by Hagner and Reese (2007) in Sweden to provide an automatic classification of forest types for use in the CLC database derived from Landsat TM/ ETM+ data, field inventory data and a neural network.

Horler and Ahern (1986) utilised spectral radiation data from Landsat TM image scenes as a means of identifying the separability of forest classes in a study area in western Ontario, Canada. Two main techniques were used, namely feature selection and principal components. Feature selection, is a statistical technique that selects a subset of explanatory variables based on their importance to build robust statistical models thereby improving classification performance. Principal component analysis (PCA) is another statistical technique that transforms a number of potentially correlated explanatory variables into a number of uncorrelated bands. This technique is frequently used to reduce or compress the number of explanatory variables into a number of principal components, in which the first two components hold the majority of the information of the entire set of variables. In the above mentioned study, it was found that the best three TM bands (3, 4 & 5) were almost as good as the first three principal components.

Decision tree methods (i.e. techniques that recursively partition a dataset based on binary rules) have been used by researchers to analyse and classify remotely sensed data as an alternative approach to traditional image classification approaches for landcover mapping (Hansen et al. 1996). A non-parametric supervised classification based on a decision tree model was used by Joy et al. (2003) to classify vegetation types in Arizona using field inventory data, Landsat TM imagery and additional spatial data. The overall accuracy achieved was 74.5%, with errors caused by the lack of clear differentiation between mixed conifer and spruce dominated stands. Brown de Coulston et al. (2003) used a decision tree method with field observations and Landsat ETM+ data to map vegetation types in Pennsylvania, USA, and achieved an accuracy of 99.5% when only forest and non-forest classes were considered. Landuse data at different scales were used in conjunction with Landsat data and a regression tree method in the Amazon by Cardille and Clayton (2007) to reinterpret existing land-cover classifications by determining what categories are most highly related to the polygon land-use data across the study area. It is important to point out that the above-mentioned errors are based on the estimation errors that are calculated at a pixel level, i.e. the level of agreement and disagreement between validation pixels with those in the classification. These pixel-based errors do not, however, provide a means of calculating the errors associated with the area estimates of the different vegetation cover types within the study area, which are frequently sought.

Forest Parameter Estimation Studies

With respect to forest parameter estimation, Franklin (1990) concisely summarised the methodology involved in these approaches as follows:

1. Establish a number of field inventory sampling points;
2. Collect forest structure information at these points;
3. Use remotely-sensed satellite imagery, locate the points on the image;
4. Extract the image features relating to each sampling point;
5. Develop the model relating the field data to the image features;
6. Use the model to predict the forest parameters based on the spectral data;
7. Develop and select error estimation methods;
8. Validate the predictions and estimates at pixel level and for different areal units.

Once a suitable model is produced using the image features as explanatory variables, the model is inverted to predict the forest stand characteristics for unsampled forest areas. The range of datasets that have been integrated into these types of inventories is diverse, but in general the modelling techniques have relied on regression models, such as stepwise regression, regression trees, most similar neighbour and k-Nearest neighbour (*k*NN) estimation. However, other techniques such as neural networks (Atkinson and Tatnall 1997) and boosting and bagging (Briem et al. 2002) also exist, whose properties and configurations vary based on the inventory, image and ancillary datasets used.

The integration of remotely sensed satellite imagery with field inventory data for the estimation of forest stand parameters dates back to the 1980s. Forest classification maps were already used effectively for stratification purposes and to plan field surveys, and it soon became clear that spatially explicit estimates of forest parameters would be highly useful to support strategic forest management and planning.

As in all remote sensing applications, the measurement and estimation of forest resources relies on the interactions of electro-magnetic radiation with the target object and subsequent analysis of the returned signal recorded by the sensor. Statistical relationships between the EMR signal and the forest parameters are then analysed. One of the earliest applications in this area was developed by Jaakkola (1983), who used Landsat TM imagery within a multi-stage timber inventory in a study area in Finland. His research consisted of estimating timber volume using regression equations that used the image data as independent variables. Timber volumes of Scots pine and Norway spruce were quantified by Ardo (1992) using the spectral values from Landsat 5 TM imagery for a study area in southern Sweden. Data from 99 randomly selected forest compartments were used to develop a regression model between spectral radiation data and the measured timber volume. The predictions were then compared against 99 forest compartments located within the study area of 1,335 ha for which field data were available and it was found that there was a close correlation between the measurements and predictions.

Häme et al. (1987) used spectral data from three SPOT 1 XS images to estimate stand characteristics ranging in size from 0.5 - 5 ha in Finland. The parameters estimated using regression models included tree stem volume, mean age and mean diameter. It was concluded that better estimates could be achieved using Landsat TM imagery as opposed to SPOT-1 due to the higher spectral resolution of the Landsat data, despite the higher spatial resolution of the latter sensor.

Research in this area continued to be pioneered by Scandinavian researchers, who were first to successfully integrate such a method into a NFI (Tomppo et al. 2008b). The Reference Point Sample (RSP) technique was proposed by Kilkki and Paivinen (2006) as a pixel based approach that assigns known 'reference' pixel data to unknown pixels through a weighting system. This was subsequently refined to integrate additional sources of data and was implemented by Tomppo (1991) on an operational basis within the Finnish National Forest inventory. This technique was and remains fully operational within the Finnish NFI and it has become known as 'Multi-Source National Forest Inventory' (MSFI) (Tomppo 1996), as it not only combines field inventory data with optical satellite imagery, but also uses digital terrain and ancillary spatial data. MSFI is underpinned by k-Nearest Neighbour (*k*NN), a non-parametric statistical estimation technique. The process links field inventory plot data with spectral responses of a satellite image and imputes the known variables of field plots to unsampled forest areas. This basic principle was adapted by other researchers, who proposed methods related to *k*NN, but which differed based on the underlying statistical relationships, e.g. most similar neighbour (Moeur and Stage 1995) and Gradient Nearest Neighbour (GNN) (Ohmann and Gregoire 2002).

The following describes the technique in very broad terms, but for further details on this technique, the reader should consult the following references (Fix and Hodges, 1951). However, in very broad terms the technique utilises two sets of observations, the first, the reference dataset contains the spatial location of the NFI plot, forest parameter plot estimate and associated spectral information retrieved from the satellite image based on its pixel or neighbourhood of pixels. The set of target pixels consists of all unsampled forest pixels for which a forest parameter estimate is sought. Each target pixel is assigned a weighted average of the plot level forest variables calculated from a subset of the reference data set that consists of the nearest pixels, based on the similarity of pixels in their spectral information. This basic principle was adapted by other researchers, who proposed methods related to *k*NN, but which differed based on the underlying statistical relationships, e.g. most similar neighbour (Moeur and Stage 1995) and Gradient Nearest Neighbour (GNN; Ohmann and Gregoire 2002).

Due to its transparency and success, the MSFI approach was adopted and adapted to a variety of forest conditions. The Swedish Forest Authorities applied the technique within their NFI (Holmgren et al. 2000; Nilsson 2002) using a range of image datasets, but primarily using Landsat TM/ETM+, and more recently SPOT 4/5 XS imagery. The outputs from the Swedish MSFI have been applied to habitat modelling for moose and birds by Reese et al. (2002). The MSFI technique has been widely tested throughout the world: in New Zealand to assist in their preharvest inventory, where it was applied to a 1,000 ha block of Radiata pine (Tomppo et al. 1999), in Norway (Gjertsen et al. 1999; Gjertsen 2007), in Mediterranean forest conditions in Italy to estimate basal area using Landsat 7 ETM+ data (Maselli et al. 2005; Baffetta et al. 2009), in central Europe where Koukal et al. (2005) tested the influence of radiometric calibration on forest estimates in the Austrian NFI, and for mapping temperate forest types in Scotland (McInerney and Suarez 2005).

A recent research area has focused specifically on the error estimation techniques employed in remote sensing. Rather than only considering the calculation of errors (RMSE and associated standard errors) at pixel level, the use of measures to determine the uncertainty of predictions and/or classifications over larger geographic areas, extending outside of the study region, has been investigated. This is considered a necessary extension to the validation of remote sensing analysis as pixel based estimation techniques provide only necessary measures for individual study areas, and cannot often be used to make direct inferences over larger areas. Some examples of these types of calculations can be found in McRoberts et al. (2002), Tomppo and Halme (2004) and Kim and Tomppo (2006).

It is evident from the above review that optical satellite imagery is being widely used to assist in the monitoring of forests and in the measurement of forest parameters. Similarly, a wide range of traditional as well as new statistical techniques have been employed in the analysis of satellite imagery, in conjunction with field inventory data, while a variety of ancillary datasets have also been integrated in the analysis procedures to improve the estimation of forest parameters and prediction of forest variables through pre- and post-stratification approaches.

Remote Sensing studies in Ireland

Over the past two decades a number of forestry remote sensing projects have been carried out in Ireland, primarily to assess the spatial distribution and composition of forest stands. The Department of Agriculture, Fisheries and Food continues to make operational use of Ordnance Survey Ireland (OSi) digital aerial photographs for the monitoring of the national forest estate, in particular to update forest vector maps and for pre-stratification of national forest inventory plots (Forest Service 2007).

The largest national remote sensing project that was carried out in Ireland resulted in the creation of the Forest Inventory and Planning Systems (FIPS) datasets in 1998. This project was lead by the Irish Forest Service with support from Coillte Teoranta, the European Commission's Joint Research Centre in Italy and the National Remote Sensing Centre in the United Kingdom. Twenty forest development classes were mapped across Ireland using medium resolution optical satellite imagery from the Landsat TM sensors and digital aerial photographs. The satellite images were classified using a two-phase process consisting of a neural network and a maximum likelihood classification, which was carried out using SILVICS (McCormick and Folving 1998; Gallagher et al. 1999). The FIPS project superseded two pilot projects that had established the usefulness of remote sensing and digital spatial data for the identification of the spatial distribution of forest stands in Ireland (MacSiúrtaín et al. 1994).

Following on from the development of FIPS, the Irish Forest Soils project was carried out by researchers at Teagasc to create a series of national, digital thematic maps that included a soil classification map, a map of parent materials and a landcover map (Bulfin et al. 2002; Loftus et al. 2002). These maps were produced through the use of satellite image classification and photogrammetric techniques, based on OSi aerial photography, digital terrain data and Landsat 5 TM imagery.

Coillte Teoranta conducted a research study that focussed on the estimation of forest health in coniferous plantations using colour infra-red photography (Stanley et al. 1996). In particular, the research exploited the use of the infra-red band of the aerial photos to assess the extent of discolouration within the foliage of coniferous tree species.

More recently, a number of research studies have been carried out to evaluate the use of remote sensing for forest mapping and monitoring. McInerney and Nieuwenhuis (2009) estimated standing volume and basal area per hectare using field inventory data from the Irish NFI, medium resolution optical satellite imagery from the SPOT 4/5 sensors and ancillary spatial data. Pixel based estimates of the two above mentioned parameters were calculated for unsampled forest pixels (i.e. pixels with no NFI information) using two supervised non-parametric techniques, namely *k*NN estimation and the Random Forest algorithm in regression mode (Breiman 2001). These techniques can be considered to be "supervised" in so far as a reference set of variables is used to impute values across the forest areas of the satellite image, based on a weighted average of the reference data. The weighted average is calculated based on the spectral similarity of the unsampled forest pixel to observations in the reference set. Within the study, it was found that at a pixel level, the relative Root Mean Square Errors (RMSEs) were approximately 50 – 59% for volume and basal area per hectare in a study area in the mid-west of Ireland. This research demonstrated that it is possible to regionalise NFI stand parameters using medium resolution satellite imagery. In particular, it demonstrates that it can produce more detailed, spatially referenced forest resource information at a regional scale than could be achieved from the sole use of NFI data. With some refinements, the methodology could be used on an operational basis to support field-based forest inventories in Ireland. In order to achieve this, it will be necessary to produce areal based estimation errors over large areas, e.g. at provincial and national levels, in addition to the pixel based estimation errors presented above.

As part of the Global Monitoring and Environmental Security (GMES) Service Element, a consortium lead by Metria, a Swedish Geomatics company, and supported by University College Dublin and the Irish Forest Service, carried out an image classification of Landsat TM/ETM+, SPOT 4/5 and IRS images for two study areas in Ireland, namely county Wicklow and parts of Mayo/Roscommon. The focus of the study was to produce a high resolution forest mask using a minimum map unit of 1 ha for three time dates: 1990, 2000 and 2006 (McInerney et al. 2010b). In particular, the project sought to map and quantify forest change, focusing in particular on afforestation on peatland areas and changes in forest cover during the 16-year period. Such research demonstrates the way in which LULUCF can be measured using archived satellite imagery and provide much needed information on the state of Irish forests.

LiDAR

In recent years, light detection and ranging (LiDAR) data has gained considerable interest. This is due to the high quality and resolution of the returned datasets, which consist of three-dimensional point data from the top of the vegetative surface (Digital Surface Model) and non-vegetated surface (Digital Terrain Model). The datasets consist of points that are precisely located using a differential GPS and highly precise timing clock. Figure 1 provides a simplified overview of the processing of airborne

LiDAR data to derive forest based metrics. Raw LiDAR data are acquired over an area, with the raw data analysed within a processing system. The dataset consists of a first return, representing the top of the vegetation canopy, and a last return, representing the ground surface. In general, these returns are filtered to remove any anomalies and are interpolated to produce a continuous surface of values. These interpolated dataset produce the digital terrain model (DTM) and the digital surface model (DSM). The subtraction of the DTM from the DSM results in the canopy height model (CHM), which can be considered a digital representation of the top of the vegetation canopy or of the dominant trees. By using region growing and pattern recognition techniques, it is possible to identify individual trees and to delineate tree canopies within the canopy height model (Figure 2).

Numerous studies have demonstrated the use of airborne LiDAR to estimate forest stand metrics, such as stand canopy height (Gobakken and Naesset 2004; Naesset 1997), individual tree heights (Suarez et al. 2005), above-ground biomass (Patenaude et al. 2004) and species classification (Moffiet et al. 2005). Clifford et al. (2010) demonstrated the use of LiDAR for a study area in Ireland and determined that the LiDAR-derived estimates of tree height compare very favourably with conventional field based measurements. A recent review article by van Leeuwen and Nieuwenhuis (2009) summarises studies on space-borne, airborne and terrestrial LiDAR applications in forestry worldwide and the potential of these different LiDAR sensors, on their own or in combination with each other, to derive detailed measurements of trees and forest stands.

It is clear that LiDAR can provide detailed information on the structure of forest resources. In particular, tree height, crown dimensions and species can be separated using information on branch and leaf structure. However, one of the principal limitations to the operational use of LiDAR in forestry is the cost per unit area in acquiring data, with the general rule: the more detailed the data (i.e. more points per unit area), the more costly it is. However, it has been demonstrated that sub-sampling the dataset can reduce the acquisition cost and that it is possible to combine the sample of high resolution LiDAR data with optical satellite imagery to regionalise the information over larger areas using statistical estimation techniques, thus reducing the extent of and cost associated with the initial data requirement (Hudak et al. 2002; McInerney et al. 2010a).

Terrestrial LiDAR

In recent years, research has been carried out to produce three dimensional scans of forest resources using terrestrial scanners (Nieuwenhuis 2008). Terrestrial scanners are mounted on tripods and utilise the same technology as airborne LiDAR scanners. They produce a fully three-dimensional dataset and to eliminate the problem of occlusion (where one tree blocks the view from the scanner to another tree), multiple scans are acquired from different locations within the forest plot, which are subsequently ‘stitched’ together. Using semi-automatic methods, it is possible to derive detailed individual tree based measurements relating to diameter at breast height, stem straightness, taper and branchiness, as well as non-timber information such as understory structure, deadwood and terrain classification (Bienert et al. 2006,

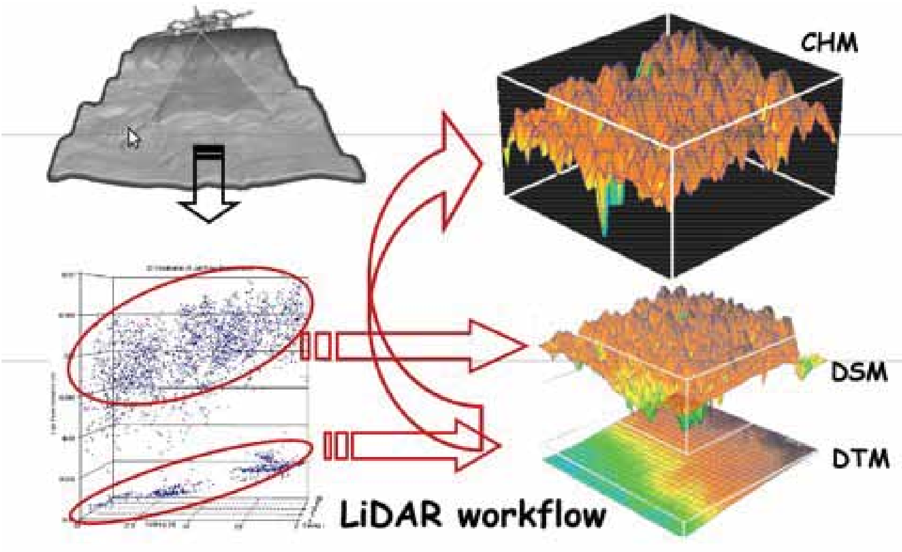

Figure 1: *Airborne LiDAR processing workflow.*

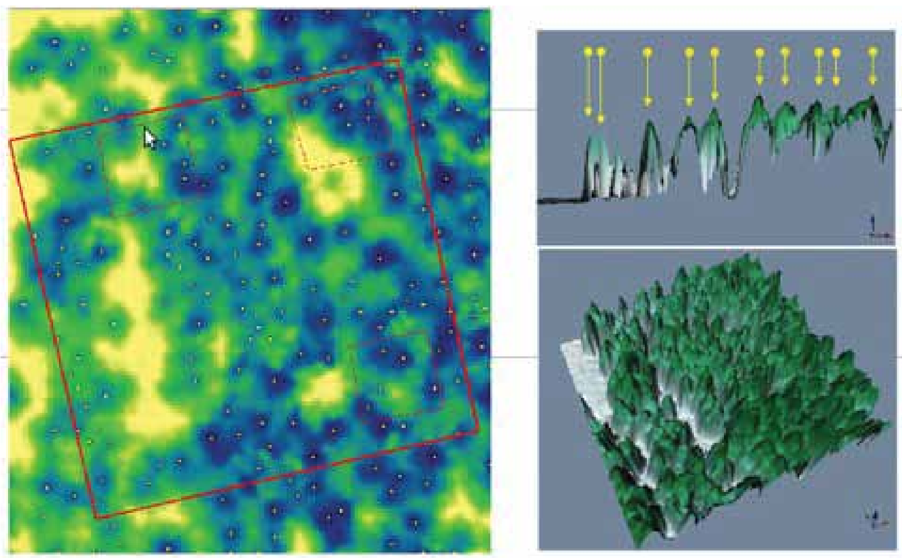

Figure 2: *Individual tree identification from LiDAR derived CHM.*

van Leeuwen and Nieuwenhuis 2010). This clearly offers many new opportunities in the acquisition of forest field information. The datasets are fully objective and provide extremely detailed information, which can be used to support forest inventories, as well as timber allocation and processing procedures (Keane 2007, Murphy et al. 2010). However, there are some specific disadvantages in the use of these sensors that relate to acquisition time, limitations in the use of these sensors in some specific site and forest conditions and the need to further develop and refine detailed processing algorithms that can be used to pre-process and retrieve tree measurements (Nugent et al. 2009).

Conclusions and implications for operational use in Ireland

There is an implicit need for all forests at global, national and regional levels to be managed in a sustainable manner. Forest resources are changing at an increasing rate, due to more intensive management practices, storm and fire damage, effects from insects and diseases, and the consequences of climate change. In order to successfully monitor these changes over time in an objective, transparent and effective way, foresters require access to timely and objective information, which can only be obtained through the use of remote sensing. However, it would be incorrect to consider optical satellite imagery as a perfect imaging solution for the purposes of forest or indeed environmental monitoring. It is a science and technology that is continually evolving, but it also still has some inherent limitations that vary based on its field of use and geographic application area.

One of the main limitations in the use of remote sensing data in operational contexts is the difficulty of acquiring cloud-free satellite imagery over Ireland and other northern countries with temperate climates. With the current configuration of imaging satellites, this can mean that only three or four useable scenes are acquired during any one year.

The stability and continuity of satellite sensor missions has to be borne in mind when data are used within operational contexts. For instance, the failure of the Scan Line Corrector on-board the Landsat 7 ETM+ sensor (one of the most widely used satellite sensors for environmental and land monitoring) meant that the data acquired from this sensor were virtually unusable from 2004 onwards. A related issue was the fact that Landsat satellites were no longer being developed by the Government of the United States of America and this raised many questions regarding data availability and continuity of missions by the remote sensing community that was heavily dependent on this satellite.

In Ireland, the current generation of optical imaging satellites has limitations in clearly distinguishing young forest plantations from other land-cover types (such as scrub or rough agricultural land). This difficulty is caused by the mixed spectral resolution returned from the underlying ground vegetation and it is only possible to accurately classify the forest stand once it has matured to the point of canopy closure.

Despite the description of numerous examples of the use of remote sensing in forest applications, there still remains a reluctance to use remote sensing in many operational environments, despite the widespread use of aerial photographs by foresters. To an extent, it is true that remote sensing has remained a research discipline that is focussed on scientific methods to analyse and interpret images. Nevertheless, examples cited in this article illustrate the fact that remote sensing is an active component within operational forest monitoring and inventory programmes. In addition, over the last five years, Earth observation data have become almost ubiquitous within every day life through technologies such as Google Earth, Google Maps, Bing Maps and related web data services.

It continues to be necessary to bridge the gap in knowledge between foresters and remote sensing analysts to more successfully integrate remote sensing and forest management in Ireland. The recent generation of high spatial resolution satellite sensors, such as the Quickbird, Ikonos and GeoEye, offer equivalent, if not better image information for the same or lower costs when compared to aerial photographs. Moreover, the synoptic view offered by satellite images and the higher frequency of image acquisition make spaceborne satellite imagery more useful in operational settings. Within the context of forest monitoring and national forest inventory programmes, it is widely considered by the Scandinavian countries that remote sensing can substantially increase the cost-efficiency of an inventory. With these factors in mind, it is useful to outline some of the noteworthy new remote sensing technological developments of relevance to forestry:

1. Global daily coverage from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, which acquires data across 36 spectral bands at a resolution of 250, 500 and 1,000 m. As a result, it can provide dynamic larges-scale information on the state of forests;
2. Hyperspectral imaging sensors, which provides extremely high spectral resolution satellite imagery. For instance, a hyperspectral sensor could acquire 217 spectral bands within the spectral range of one image band from a medium resolution sensor, such as Landsat or SPOT. This increased spectral information can enable the extraction of very subtle differences between species, forest condition and health;
3. Synthetic Aperture Radar sensors, which are weather and light independent and are being increasingly used within forest resource assessments, particularly for the retrieval of tree height and stand structure. These sensors have being launched on-board ESA's Envisat sensor, as well as Japan's ALOS and Radarsat-2;
4. Combined use of terrestrial and airborne LiDAR, coupled with high spatial resolution satellite imagery, in order to improve the quality of the tree and stand derived information from above and below the canopy, thereby providing the most comprehensive tree-related information;
5. New commercial imaging sensors, such as GeoEye-1, WorldView-1 and Quickbird are offering very high resolution satellite imagery (50 – 61 cm spatial resolution), with the ability for the sensors to return to the same location at shorter temporal intervals;
6. European Space Agency's (ESA) Sentinel missions.

With respect to the last point, the European Space Agency has a short-to-medium term plan to launch five satellite sensors, which will be known as Sentinels, for the specific operational needs of the European Commission and European Space Agency Global Monitoring for Environmental Security (GMES) programme. Sentinel 2 will provide high-resolution multispectral imagery that will be used to monitor vegetation, soil and water bodies. The other Sentinel sensors will focus on atmospheric monitoring, and land and sea/ocean surface temperature monitoring using RADAR instruments.

Image quality and processing requirements are linked. As the spatial and spectral resolutions increase, the size of the datasets increases at an exponential rate. The requirements for more sophisticated computer processing and storage facilities will increase likewise. The image processing and analysis techniques are also developing in line with the developments of imaging sensors. In particular, the use of techniques such as *k*NN for parameter estimation will provide novel approaches to utilize disparate data sources in an efficient way to improve the spatial estimation of parameters. With the correct data sources, these techniques could be further developed to upscale high-resolution forest monitoring data, acquired from the ICP Level II plots in Ireland, over small homogeneous forest areas.

Despite the advances in the technology of space and airborne sensors, it is necessary to bear in mind that there always remains a need for field inventories, to train sophisticated statistical modeling tools and validate results derived from remote sensing analyses. However, the use of new satellite sensors and image analysis techniques, coupled with the needs and expertise of forest managers, can lead to the development of new applications to provide more comprehensive information for the sustainable management of the Irish forest estate.

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Modelling and mapping the potential productivity of Sitka spruce from site factors in Ireland.

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Abstract

The main objective of this study was to quantify the potential productivity of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in Ireland. Productivity data from 201 Sitka spruce stands were used to relate general yield class (GYC) to low resolution digitised data (climate maps, soil and subsoil maps), and easily assessable site quality variables (site and vegetation classifications). Three models were derived that explained 45-52% of the variation in GYC. A spatial model was used to derive spatial predictions of productivity and map the potential productivity of Sitka spruce throughout Ireland in a Geographical Information System (GIS). This model predicted that 73% or 5.103 million ha of the total land area in Ireland was capable of producing Sitka spruce growth of yield class 14 or greater. Furthermore, 62% of the total land area could potentially result in GYC 20 or higher yields. The results of the analysis indicated that significant potential exists for forestry development on marginal agricultural land where forestry expansion may not necessarily be in conflict with the achievement of growth targets from other agricultural subsectors (e.g. dairy and beef). A practical model was also developed, which may serve as a guide to evaluating the potential productivity of suitable sites for afforestation. Typically the confidence limits for fields with wet or dry grassland were ± 2.0 to 2.8 $m^3ha^{-1}yr^1$ and blanket bog was ± 2.4 to 2.9 $m^3ha^{-1}yr^{-1}$. A forecasting model, developed to derive predictions of productivity on forested land, might also be used to forecast timber yields.

Keywords: *Sitka spruce, Productivity models, Land-use, Spatial modelling, Site classification*

Introduction

At the beginning of the twentieth century only 1% of the land area of the Ireland was under forest (OCarroll 1984). A programme of state afforestation was introduced in 1922, but expansion was limited to sub-marginal and marginal agricultural land to avoid competition with agricultural production (Gray 1963). Sitka spruce (*Picea sitchensis* (Bong.) Carr.) was one of the exotic conifers used in the afforestation programme, and it quickly established itself as the workhorse of Irish forestry, being a highly adaptable species suited to the wide range of climatic conditions on the sites being afforested. The species grew well on difficult site conditions such as wet ground, exposed grassy areas, as well as on mountain and hills ranging from 150 to 550 m in elevation and on wet drumlin soils (O' Flanagan and Bulfin 1970; Bulfin et al. 1973; Joyce and OCarroll 2002).

Since the 1980s, the range of site types being afforested has expanded to include better quality enclosed land which had previously been in agricultural usage, as the

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most recent afforestation schemes are targeted to encourage private landowners to convert less productive agricultural land to forestry (Farrelly 2007). The strategic plan for forestry in Ireland, published in 1996, aimed to increase forest cover in Ireland to 17%, with a total productive forest area of 1.2 million ha by 2030 (Anon. 1996)[1]. The Irish Government, with co-financing for a period from the European Union, has since 1980, provided grants and premiums to incentivise the establishment of new forests. The prerequisite for receipt of grant aid is that the land must be capable of achieving a minimum growth rate of 14 $m^3ha^{-1}yr^{-1}$ for Sitka spruce.

Currently Sitka spruce is the most important species in Irish forestry occupying 52.3% of the total forest estate, or 327,000 ha, and accounting for 53% of all afforestation in 2010 (Forest Service 2010). Despite this widespread use of Sitka spruce in Irish forestry, relatively few studies have examined the growth potential of the species, the nature of relationships between its productivity and site quality variables, and the factors that limit the growth of the species in Ireland. Much of the previous research conducted in Ireland focused on measures to ensure successful plantation establishment or remedial measures to assist growth (i.e. cultivation, drainage and fertilization research experiments and trials) or the identification of the most appropriate provenances to plant. Other soil-site-yield studies focussed on quantifying the productivity of the species in relation to marginal agricultural land (Bulfin et al. 1973) or using process-based models to predict the relative sensitivity of forest production in Ireland to site quality and climate change (Goodale et al. 1998).

The prediction of productivity has become increasingly important in Ireland for: a) determining the suitability of land for afforestation to enable future forestry expansion under Government policy objectives; b) providing an objective means of assessing and comparing the potential productivity of land for forestry development; and c) aiding silvicultural decision making, forest management planning and production forecasting on forested sites. Several new studies have addressed Sitka spruce productivity, including Broad and Lynch's (2006) work on modelling of height growth, Farrelly's (2011) study on the relationship between site quality and productivity, and Farrelly et al.'s (2011a; 2011b) development of models to predict site index from site quality measures. However, while these latter models may have good statistical attributes, they rely on less readily available data (i.e. available magnesium, as well as soil moisture and nutrient regime). The development of practical models, only using variables that are easily available would make models more accessible to forestry practioners, to assist in site selection for afforestation or for production forecasting. Furthermore it is not possible to use such models to generate spatial predictions of productivity as many of variables are not yet digitized in a GIS. The development of practical models, using variables that are more readily available to forestry practitioners, would assist in site selection for afforestation or for production forecasting. Previous attempts to develop productivity maps used mean productivity values for soil series (Bulfin et al. 1973) or for soil classifications, which were then applied to mapped soil groups (Farrelly et al. 2002; Farrelly 2003).

[1] Forest cover in the Republic of Ireland in 2010 was 10.8% of the land area or 745,000 ha (Forest Service 2010).

The aims therefore of this study were (i) to derive productivity models for Sitka spruce to provide information for future afforestation projects; and (ii) assess the potential productivity of the species in Ireland, the area of land that is eligible for receipt of afforestation grant-aid, and the potential of the species in relation to different agricultural land-use types being afforested.

Materials and Methods

Sampling strategy

In total, 201 stands (greater than 1 ha in size) were visited between October 2006 and April 2009, covering the entire range of pure Sitka spruce stands, both publicly- and privately-owned, that were even-aged, uniformly stocked, and at post establishment stage in the Republic of Ireland, as described in Farrelly et al. (2009). The soil of each site was classified into one of the 41 soil associations from the General Soil Map of Ireland (Gardiner and Radford 1980). A soil association consists of one or more Great Soil Groups, usually formed from the same type of parent material, which are associated in the landscape in a particular pattern. In each association there are principal and associated soils. The principal soil usually comprises about 75% of the association, but this may be as low as 50% or as high as 100% (Gardiner and Radford 1980). Soil associations were then grouped into 13 soils groups, based on the principal soil types in each association (Table 1). Soil parent material was also taken from the General Soil Map of Ireland (Table 3). The sites were then stratified into five climate zones, based on annual accumulated temperature sum >5°C and growing season potential water balance (see Farrelly et al. 2009 for further details). Sites were then randomly selected from each soil group and climate zone combination (stratified random sampling) to cover as many soil types across five climate zones as time and resources allowed. These sites were sampled in more detail, as described in the next section.

Data collection

The sites selected for field visits contained even-aged stands, uniformly stocked and were aged from 16 to 83 years (mean 31.4 years). Within each stand, sample plots were randomly located. Sample plots were 0.04 ha (20 x 20 m) in size; smaller plots of 0.02 ha (20 x 10 m) and 0.01 ha (10 x 10 m) were used in younger unthinned crops. The latitude and longitude coordinates for the centre of each site were determined using a Global Positioning System (GPS). Site elevation was determined from a GIS-based Digital Elevation Model (DEM), which had horizontal and vertical resolutions of 25 and 1 m, respectively.

Site classification information was derived using Ordnance Survey of Ireland (OSI) 6 inch to 1 mile (1:10,560) maps. These maps are furnished with historical information pertaining to vegetation and field boundaries. Using these maps, each site was classified into four land-use types according to OCarroll’s (1975) site fertility classification, as follows: (A) fields and ornamental ground; (B) presence of furze (*Ulex* spp.); (C) rough pasture with or without outcropping rock; and (X) old woodland.

Table 1: *Soil groups used in the study with soil associations, associated soils, the number of samples and actual soils sampled in forest plots (number in parenthesis).*

Soil Group	Soil Assoc(s)	Soils[1]	No. Samples	Actual sampled forest soils (number)
1	12, 13, 14, 16, 17, 19, 29	Acid Brown Earth, Gley, Podzol, Grey Brown Podzolic, Peaty Gley, Brown Podzolic, Interdrumlin Peat, Regosol	21	Brown Earth (6), Gley (6), Podzol (5), Brown Podzolic (3), Lithosol (1)
2	44	Basin Peat	10	Basin Peat (10)
3	5	Blanket Peat (High Level)	23	Blanket Peat (13), Gley (6), Brown Earth (2), Brown Podzolic (1), Lithosol (1)
4	24	Blanket Peat (Low Level)	9	Blanket peat (8), Gley (1)
5	6, 8, 9, 15, 20	Brown Podzolic, Gleys, Podzol, Blanket Peat, Acid Brown Earth, Podzol	21	Brown Podzolic (4), Blanket Peat (6), Podzol (4), Gley (4), Brown Earth (3)
6	10, 28, 30, 31, 32, 34, 35, 36, 37, 38	Grey Brown Podzolic, Gley, Interdrumlin Peat, Peaty Gley, Brown Earth, Basin Peat, Podzol	24	Grey Brown Podzolic (8), Basin Peat (5), Brown Earth (4), Gley (4), Brown podzolic (1), Podzol (1), Rendzina (1)
7	11, 21, 22, 25, 26, 27, 39, 40, 41, 42, 43	Gleys, Acid Brown Earth, Interdrumlin Peat and Peaty Gley, Brown Earth, Peat, Brown Earth, Grey Brown Podzolic	20	Gley (9), Blanket Peat (9), Basin Peat (1), Grey Brown Podzolic (1)
8	4, 23	Lithosol, Rock Outcrop and Peat, Blanket Peat, Peaty Podzol	16	Blanket Peat (7), Podzol (3),Gley (2), Lithosol (2), Brown Earth (1), Brown Podzolic (1)
9	2	Peaty Gley, Blanket Peat, Peaty Podzol	8	Peaty Gley (3), Blanket Peat (2), Peaty Podzol (2), Brown Earth (1)
10	1	Peaty Podzol, Lithosol, Blanket Peat	21	Podzol (7), Blanket Peat (7), Brown Podzolic (3), Gley (2), Brown Earth (1), Lithosol (1)
11	18	Podzol, Gley and Peat	5	Blanket Peat (2), Brown Podzolic (1), Gley (2)
12	7	Rendzina & outcropping Rock, Lithosol, Shallow Brown Earth	7	Gley (4), Lithosol (1), Brown Earth (1), Blanket Peat (1)
13	33	Shallow Brown Earth and Rendzina, Grey Brown Podzolic, Gley and Peat	16	Brown Earth (11), Gley (3), Rendzina (1), Brown Earth (1)
		Total	201	

[1] The first soil listed is the principal soil type, which occupies 50 – 100% of association; other soils listed are associated soils.

These maps also provided information on previous land-use[2], based upon the presence (or absence) of enclosures (field boundaries) for each site. Sample plots were then classified into their original habitat type prior to afforestation (Irish vegetation classification - Fossit 2000), using a combination of ground vegetation taken within the plot, from sub-compartment boundaries or from the edge of plantations.

In each plot, the height and age of four, two or the single largest dbh tree(s) per 0.04 ha, 0.02 ha and 0.01 ha plot, respectively, were measured. Productivity was estimated by General Yield Class (GYC; max. m.a.i. $m^3ha^{-1}yr^{-1}$) using top height age curves for Sitka spruce (Edwards and Christie 1981).

Digitised site data

A number of low to medium resolution GIS digitised datasets were available to derive site quality variables for use in the study. These included all the climatic surfaces (1 km^2) raster grids for Ireland (Sweeney and Fealy 2003), which were used to derive mean annual growing season (April-September) summer and winter precipitation and temperature, as well as mean annual and growing season global solar radiation for all plots. Mean annual growing season degree-day sums >5°C were derived from the primary monthly temperature maps (Farrelly et al. 2009). Mean annual windspeed data were available from the National Wind Atlas of Ireland (Anon. 2003). Soil associations, soil groups and parent material was available from the General Soil Map of Ireland (1:575,000 scale; Gardiner and Radford 1980).

A GIS National Habitat Map of Ireland was available as a 25 x 25 m^2 raster (pixel based) map (Fealy et al. 2009). This map of habitat classes includes details about cutover bogs, upland and lowland blanket bogs, wet and dry grassland, wet and dry heaths, fens, forests, urban areas and water bodies, and was generated using thematic landcover mapping techniques (Loftus et al. 2002) augmented by using parent material, soil and climate boundaries at a nominal scale of approx. 1:100,000 (Fealy, R.M. 2011 pers. comm.).

A potential agricultural land-use map was also derived from the General Soil Map of Ireland, based on Gardiner and Radford's (1980) grouping of the 44 soil associations into six land-use classes. The classification grouped soils based on their suitability for Irish agriculture into six land-use categories as follows: Extremely Limited, Very Limited, Limited, Somewhat Limited, Moderately Wide and Wide land-use.

The modelling approach

Regression models to predict GYC were developed using the data from all sites (n = 201) to produce a spatial model [1], which included all digitised data (all climate, elevation, parent material, soil groups and habitat type); and a practical model [2] which included all available site data. Multiple regression analysis, using stepwise, forward and backward elimination was employed. Main effects and two-way interaction effects were included in the analysis, but higher-order interactions were

[2] This classification is used by the Forest Service as an indicator of previous agricultural use and has been linked to fertility status. Afforestation on enclosed land attracts a higher level of grant-aid than on unenclosed land.

excluded. Variables that had the least significant (P<0.05) effect in the type III sums of squares analysis were removed sequentially from the model. The goodness of fit statistics were further checked by comparing the log-likelihood difference (under maximum likelihood for fixed effects) with the variable included and removed (difference distributed as chi-square with degrees of freedom equal to the difference in the number of parameters fitted). The most appropriate model(s) and the model with the best explanatory power with the minimum number of variables was selected. The statistical validity of the modelling procedures was examined by checking the distribution of residual error variation, and that there was no evidence that any of the underlying assumptions had been violated.

Generating spatial predictions of GYC

To generate spatial predictions of general yield class, the spatial model [1] was used. The digitised information was analysed and processed using ArcGIS 9.3 (ESRI 2008). Firstly, digitised data were converted to raster grids (pixel maps) made up of 111,750,262 pixels at 625 m^2 spatial resolution. Then the value for the intercept of the model (i.e. the constant) was applied to all grid cells. The regression equation was then applied using ArcGIS, by multiplying the values of the predictor variables by their relevant coefficients to derive a new raster layer. The ArcGIS overlay function was used to construct a new data layer (i.e. the GYC layer) based on the regression model and the digitised data (Figure 1).

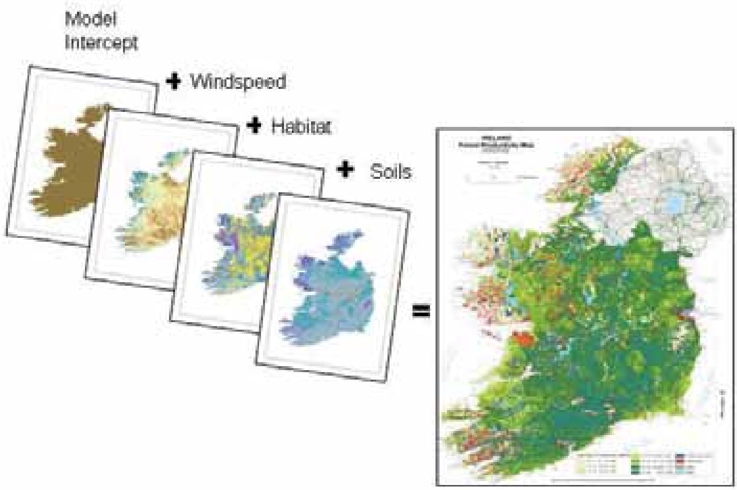

Figure 1: *Schematic representation of the generation of spatial prediction of GYC and the development of a national potential forest productivity map involves merging of spatial datasets of model intercept, windspeed, habitat and soils.*

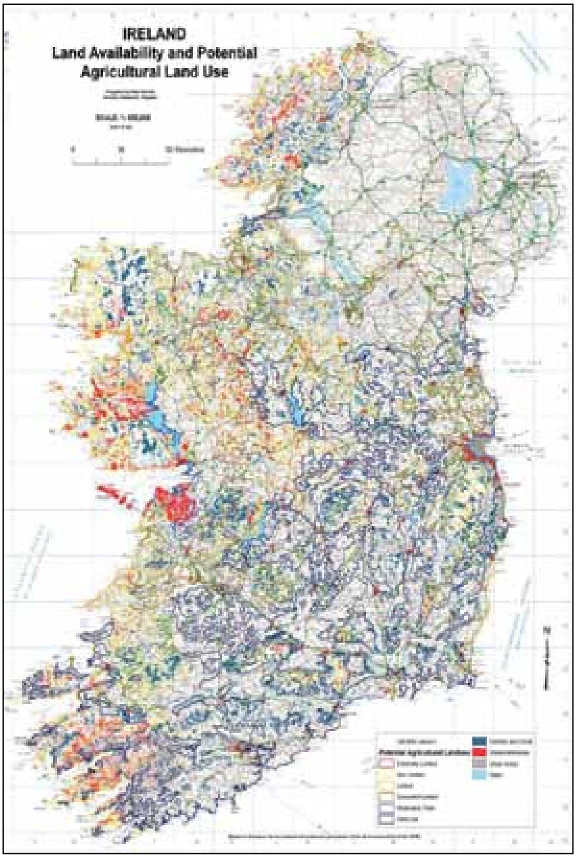

Figure 2: *Land availability for afforestation and potential agricultural land-use, courtesy of Gardiner and Radford (1980).*

Assessment of land eligible for grant aid and potential productivity

The GYC layer was overlain with the National Habitat Map of Ireland to produce a potential forest productivity map. The mean GYC for all plantable areas (all areas except urban, water, islands, bare rock, rocky complex, intact raised bogs, wetlands, coastal habitats, unreclaimed fens, salt marsh, sand, and existing forests) and the level of land availability for forestry were then calculated. In addition, the GYC layer was overlain with the potential agricultural land-use map to derive estimates of the mean GYC of Sitka spruce in the six potential agricultural land-use categories (Figure 2), as described earlier.

Results

GYC ranged from 4 $m^3ha^{-1}yr^{-1}$, on a wet, nutrient very poor site on unenclosed low level blanket peat (histosol) in the north west to a maximum of 34 $m^3ha^{-1}yr^{-1}$ on a very

Table 2: *Climate and site based variables assessed in the study, with proportion of variability in GYC explained by each variable (R^2_{adj}) and the significance of its relationships with GYC (P value).*

Variable	Units	Mean	Range	R^2_{adj}	P value
GYC	$m^3ha^{-1}yr^{-1}$	19.7	4.0 – 34.0		
Elevation (m)	m	195.3	9.0 - 583.0	0.11	<0.0001
Latitude	°N	53.2	52.0 – 55.2	0.02	0.025
Longitude	°W	7.8	6.1 – 9.8	0.00	0.0935
Annual mean windspeed	ms^{-1}	7.3	5.6 - 9.9	0.22	<0.0001
Annual mean temperature	°C	8.3	5.2 - 10.1	0.06	<0.0005
Growing season temperature	°C	11.4	8.5 – 12.9	0.07	<0.0001
Winter temperature	°C	3.9	0.4 – 5.9	0.04	0.0031
Spring temperature	°C	7.2	4.1 - 8.8	0.05	0.0009
Summer temperature	°C	13.4	10.6 – 14.8	0.08	<0.0001
Autumn temperature	°C	8.9	5.7 – 10.8	0.05	0.0007
Mean annual sum degree days >5°C	Day degrees	1348.9	706.9 - 1872.5	0.06	0.0002
Growing season sum degree days >5°C	Day degrees	1172.1	668.8 – 1453.0	0.07	0.0001
Annual global solar radiation	MJ/m^2	1.114×10^{-8}	9.412×10^{-7} - 1.286×10^{-8}	0.02	0.0194
Growing season global solar radiation	MJ/m^2	0.848×10^{-8}	7.122×10^{-7} -0.989×10^{-8}	0.02	0.0260
Annual mean precipitation	mm	1291.6	802.6 - 2044.2	0.14	<0.0001
Growing season precipitation	mm	544.9	366.0 – 834.7	0.13	<0.0001
Winter precipitation	mm	381.7	216.5 – 598.9	0.13	<0.0001
Spring precipitation	mm	273.3	178.4 – 414.1	0.12	<0.0001
Summer precipitation	mm	261.1	168.2 – 409.5	0.13	<0.0001
Autumn precipitation	mm	375.5	228.8 – 626.6	0.15	<0.0001

R^2_{adj}, Adjusted R^2.

moist, nutrient rich site on an old woodland site in the south east (Table 2). All the climatic variables tested showed significant relationships with GYC, with windspeed showing the strongest relationship. Of all the site factors examined, the strength of the relationship increased with the quality of the data used, with high resolution data providing best results. The field assessed habitat type category showed the strongest relationship with GYC, accounting for 38% of the variation (Table 3).

GYC Models

A spatial model [1] was developed following the stepwise regression procedure; this model explained 49% of the variation in GYC (Table 4). When all the site variables were tested, following the stepwise regression procedure, it was shown that wind speed, fertility class and habitat type were the key variables in this model. A practical model [2] which included these variables accounted for 52% of the variation in GYC (Table 4). The effect of fertility class varied significantly with wind speed, with GYC decreasing more rapidly on sites classed as rough pasture with or without outcropping rock (class C sites) for a given increase in windspeed (P<0.05) than on other site types. Since this habitat type model may be difficult to use in practice, a third model, the forecasting model [3], was developed. This model included windspeed, soil parent material and fertility class, and explained 47% of the variation in GYC.

Table 3: *Qualitative site quality variables recorded with proportion of variability in GYC explained by each variable (R^2_{adj}) and the significance of its relationships with GYC.*

Variable	Categories	Source of data (scale)	R^2_{adj}	P value
Soil Group[1]	Acid Brown Earth, Basin Peat, Blanket Peat High Level; Blanket Peat Low Level, Brown Podzolic, Gley, Grey Brown Podzolic, Lithosols and Rock, Peaty Gley, Peaty Podzol, Podzol, Rendzina, Shallow Brown Earth	General Soil Map (1:575,000)	0.19	<0.001
Parent Material	Sandstone and Shale, Basin Peat, Blanket Peat High Level, Blanket Peat Low Level, Granite, Mixed Granite-Rhyolite-Sandstone, Limestone, Mixed Limestone-Shale-Sandstone, Mica-Gneiss-Quartz-Sandstone, Shale, Shale-Schist-Sandstone, Sandstone, Sandstone-Granite-Mica Schist, Sandstone-Shale	General Soil Map (1:575,000)	0.20	<0.001
Closure type	Enclosed, Unenclosed	OSI Maps (1:10560)	0.27	<.0001
Site Fertility class	(A) Fields and ornamental ground, (B) Furze (Ulex spp.), (C) Rough Pasture with or without outcropping rock, and (X) Woodland	OSI Maps (1:10560)	0.32	<.0001
Habitat type	Cut bog, Fen, Dry grassland, Wet grassland, Dry heath, Wet heath, Lowland blanket bog, Upland blanket bog, Rocky complex, Old woodland, Scrub	Field survey (Plot)	0.38	<.0001

[1] Only principal soil types have been listed; associated soils are listed in Table 1. R^2_{adj}, Adjusted R^2.

Table 4: *Prediction models for Sitka spruce general yield class (GYC) using windspeed, habitat type and soil group (spatial model [1]), windspeed, site fertility class and habitat type (practical model [2]) and windspeed, site fertility class and parent material (forecast model [3]) (N = 201).*

No.	Model Name	Model	R^2_{adj}	SEE
1	Spatial	GYC = 41.85- 3.41(Wspd) + 0.62(CB) + 4.66(DG) + 5.0(DH) + 9.42(FEN) – 4.98(LBB) + 7.09(OW) + 0.46(RC) + 1.44(SC) + 0.76(UBB) + 5.40(WG) + 0.36 (ABE) – 2.93 (BP) – 2.57 (BPHL) -0.05 (BPLL) – 1.48 (BPOD) –1.64 (GLEY) + 1.32 (GBP) –2.39 (LITH) – 3.49 (PGLEY) + 0.09 (PPOD) +4.52 (POD) –2.18 (REND)	0.49	4.80
2	Practical	GYC = 37.72 -3.16(wspd) – 38.22(A) – 4.05(B) + 1.96(C) + 0.74(CB) + 5.34(DG) + 5.33(DH) + 8.15(FEN) – 4.53(LBB) + 8.32(OW) + 1.21(RC) + 5.63(SC) + 0.29(UBB) + 5.01(WG) + 6.09(wspd ×A) +0.79(wspd ×B) – 0.18(wspd × C)	0.52	4.65
3	Forecasting	GYC = 55.53 – 3.37(wspd) +0.76(A) – 3.62(B) – 5.04(C) + 0(Sandstone and Shale) – 3.37(Basin Peat) –10.54(Blanket peat High Level) – 12.76(Blanket peat Low Level) – 3.5 (Granite)-5.79(Mixed Granite-Rhyolite-Sandstone)- 7.34(Limestone) – 4.6(Mixed Limestone-Shale-Sandstone) – 10.06(Mica-Gneiss-Quartz-Sandstone) – 8.95(Shale) – 6.67(Shale-Schist-Sandstone) – 12.97(Sandstone) – 4.5(Sandstone-Granite-Mica Schist) – 5.70(Sandstone-Shale)	0.47	4.91

Note that all independent variables are significant at $P < 0.05$; R^2_{adj}, Adjusted R^2; SEE, Standard error of the estimate (in $m^3ha^{-1}yr^{-1}$).

Abbreviations are as follows:

Spatial model: *Wspd*: annual mean windspeed, *Habitat Type*: CB: Cutover bog, DG: Dry grassland; DH: Dry heath, FEN: Fen, LBB: Low blanket bog, OW: Old woodland, RC: Rocky outcrops, SC: Scrub, UBB: Upland blanket bog, WG: Wet grassland, WH: Wet heath. *Soil Group*: ABE: Acid Brown Earth, BP: Basin Peat, BPHL: Blanket Peat High Level, BPLL: Blanket Peat Low Level, BPOD: Brown Podzolic, GLEY: Gley, GBP: Grey Brown Podzolic, LITH: Lithosols and Rock, PGLEY: Peaty Gley, PPOD: Peaty Podzol, POD: Podzol, REND: Rendzina.

Practical and forecast model, *Site Fertility Class*: A: Fields and ornamental ground; B: Furze (*Ulex* spp.); C: Rough pasture with/without outcropping rock.

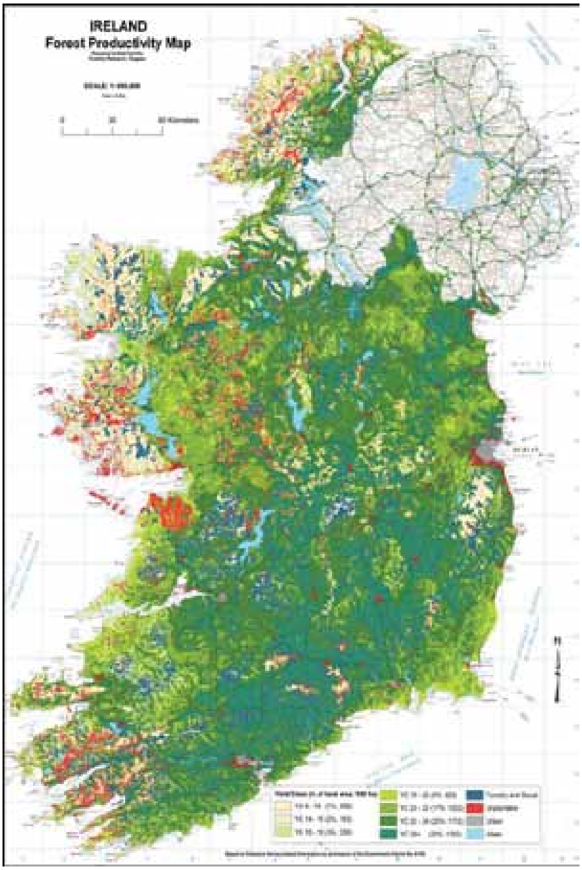

Figure 3: *Map of the potential productivity of Sitka spruce in Ireland.*

The spatial model [1] was used to derive a national forest productivity map for Sitka spruce in Ireland (Figure 3). The map indicates lower levels of productivity in the north-west, west, south-west and upland areas of the country.

Land availability and potential productivity

When the area already planted and the unplantable areas were excluded from the total land area of Ireland, 5.59 million ha (80% of the Republic of Ireland) was shown to be potentially suitable for forestry (Table 5). It is estimated that a potential 5.10 million ha of this land area could be used to grow Sitka spruce with a yield class of 14 or higher (threshold for receipt of grant-aid). Furthermore, a GYC of 20 or greater could be achieved on 4.29 million ha (62% of the total land area). On the 1.381 million ha of better quality land, this species has the potential to reach yield class 24 or greater (Table 6).

Table 5: *The maximum potential land availability for afforestation in Ireland*.

		Habitat Type	Area (ha)
		Cutover Bog	74,856
		Cutover Fen	283
		Dry Heath	181,652
		Lowland Blanket Bog	273,754
		Upland Blanket Bog	214,481
		Wet Heath	78,685
	Limited potential[1]		823,711
		Dry Grassland	3,266,859
		Wet Grassland	1,503,499
	Large potential		4,470,358
Total plantable area			*5,594,068*
	Forest and Scrub[2]		33,988
	Forestry		729,366
Total Forest and Scrub			763,354
		Bare Rock and Rock outcrop	235,907
		Intact Raised Bog	109,431
		Wetlands	34,275
		Coastal Complex	7,053
		Unreclaimed Fen	1,597
		Salt Marsh	275
		Sand	626
		Island not surveyed	7,784
		Urban/Built Land	89,015
		Water	141,005
Total unplantable area			*626,968*
		Total land area	**6,984,391**

[1] Although these areas are classed as productive, nutritional problems or environmental considerations may prohibit some of these areas from being planted. As the study considered potential rather than actual land availability, no environmental constraints were considered in the analysis.
[2] This classification covers unenclosed forest outside of managed plantations.

Table 6: *The potential productivity of Sitka spruce in Ireland classified according to grant threshold and general yield class categories.*

Productivity class	**Potential GYC ($m^3ha^{-1}yr^{-1}$)**	**Area (ha)**	**Land area (%)**
Below grant threshold (<14 $m^3ha^{-1}yr^{-1}$)	<14	457,774	7%
	14 – 16	142,683	2%
	16 – 18	235,991	3%
	18 – 20	428,721	6%
	20 – 22	1,202,136	17%
	22 – 24	1,711,730	25%
	24+	1,381,762	20%
Above grant threshold (≥14 $m^3ha^{-1}yr^{-1}$)	14+	5,103,023	73%
Productive and unproductive area	4+	5,560,798	80%
Total plantable area		5,594,068	80%

Of the 5.10 million ha that could produce a yield class of 14 or greater, a significant proportion (i.e. 38%), was classed as marginal agricultural land (Extremely Limited, Very Limited and Limited for agriculture) (Table 7). The trends in the predicted yield class reflected the quality of the land, with higher yield class values of 24 or greater predicted for the “moderately wide” and “wide” agricultural land-use types (Table 7).

Discussion

The criterion for judging the success of a productivity model is that it must be capable of explaining at least 50% of the variation in GYC from a few easily measurable variables (Blyth and MacLeod 1981b; OCarroll and Farrell 1993; Klinka and Chen 2003). The results from this study indicate that models derived from available GIS digitised data and readily assessable site factors were moderately successful in explaining the variation in the productivity of Sitka spruce. The best model (i.e. the practical model [2]) explained 52% of the variation in GYC, considerably lower than the percentage variation explained by other models for Sitka spruce developed by Pearson (1992) and Farrelly et al. (2011), but higher than models developed in Great Britain by MacMillian (1991) and Hassall et al. (1994). Increases in predictive power were evident from the inclusion of higher resolution data (i.e. fertility class, habitat type) compared to lower resolution data (i.e. principal soil type). Thus, models using local site conditions as predictors were often better at a large geographic scale than models using low resolution generalised site information (Farrelly 2011). Nevertheless two of the developed models, the spatial model [1] and the practical model [2], were adequate predictors of GYC, in that they explained c. 50% of the variation in the productivity of Sitka spruce. The forecast model [3] was less successful, explaining less than 47% of the variation in GYC, owing to the nature of the low resolution map data used.

Table 7: *The potential productivity of Sitka spruce in Ireland classified according to grant threshold and general yield class categories.*

					≥ YC 4		≥ YC 14	
Potential Agricultural Land use	**Total Area (ha)**	**Forest & Scrub (ha)**	**Not Plantable (ha)**	**Plantable (ha)**	**Area (ha)**	**Mean GYC1**	**Area (ha)**	**Mean GYC5**
Extremely Limited	217,579	13,960	79,922	123,697	114,719	15.5 (16)	71,676	19.2 (20)
Very Limited	1,760,416	341,300	240,975	1,178,141	1,158,877	16.0 (16)	762,186	19.3 (20)
Limited	1,322,639	165,859	49,334	1,107,446	1,106,351	21.4 (22)	1,094,061	21.5 (22)
Somewhat Limited	1,153,834	107,830	46,237	999,768	998,267	22.6 (22)	995,498	22.6 (22)
Moderately Wide	802,072	41,039	43,056	717,977	717,482	23.2 (24)	715,297	23.2 (24)
Wide	1,606,694	91,070	48,585	1,467,039	1,465,101	23.9 (24)	1,464,305	23.9 (24)
Not surveyed	7,900	116	7,784					
Urban	18,706	398	18,308					
Water	94,552	1,783	92,769					
Total Area	**6,984,391**	**763,354**	**626,969**	**5,594,068**	**5,560,798**		**5,103,023**	

The values reported refer to arithmetic averages of GYC values ($m^3ha^{-1}yr^{-1}$), values in parenthesis report nearest GYC values.

However, the requirement that the model explain at least 50% of the variation in productivity is only one criterion influencing the choice of model. If a model is to be applied in practice, ideally it should use data that are easily obtainable and rely on a small number of variables. The function of the model also will influence the choice of model, i.e. is it to guide an individual land owner as to the potential productivity of a specific site, or is it to be applied on a national or regional basis?

Application of models

The models developed in this study are generally easy to use in practice, with each having a different objective. The spatial model [1] can be used primarily to derive spatial predictions of productivity and to generate a potential forest productivity map. National statistics and shifts in regional trends can be detected using this model, which might also be useful for policy and planning purposes. It is not suitable for on-site assessment because of the lowest scale of mapping used (1:575,000; General Soil Map).

For on-site assessment, the practical model [2] is more appropriate and uses variables that are readily available to foresters (i.e. wind speed, site fertility class and habitat type). The 95% confidence limits for yield class, calculated from the standard errors associated with the practical model [2], ranged from ±1.6 to 5.8 $m^3ha^{-1}yr^{-1}$. Typically the confidence limits for (A) fields with wet grassland or dry grassland were small ± 2.0 to 2.8 and for (B) unenclosed land with blanket bog were ± 2.4 to 2.9 $m^3ha^{-1}yr^1$, as they were most frequently represented in the data. The confidence limits for more common site types being afforested were generally low (± 2.0 – 3.5 $m^3ha^{-1}yr^1$), but for less-well represented combinations the confidence limits were wider (i.e. rocky outcrops). The practical model [2] is not, however, suited to assessing productivity on already afforested sites as it requires knowledge of habitat type prior to afforestation. The forecast model [3] was developed to address this shortcoming.

The level of precision of all the models presented here is adequate for use in operational forestry, but in some cases the predictions may not be any better than the subjective assessment of a site by an experienced forester who is familiar with the locality. However, the use of the model may be preferable. Subjective assessments are not always consistent or reliable and there are fewer foresters who have sufficient knowledge of enough local site factors to permit an accurate subjective site quality assessment. However, the models developed in this study may not adequately cope with the changing environmental conditions, i.e. climate change; thus a more specific process-based modelling approach may be required in future (e.g. Goodale et al. 1998).

Policy implications

The recent "Food Harvest 2020" report published by the Department of Agriculture, Fisheries and Food (DAFF 2010) has set dramatic growth targets for the agriculture, fishery and forestry sectors. The growth target for output from these three primary sectors is €1.5 billion by 2020. Within agriculture, the most ambitious growth target set is for milk output, where volume is set to increase by 50% by 2020. Importantly the growth targets set for all other sectors of agriculture are value rather than volume targets, which will mean that the achievement of these targets need not necessarily require the use of more or even the same amount of agricultural land. The question arises as to whether the achievement of these targets will negatively influence the attainment of forestry expansion targets, requiring an area of 22,850 ha to be planted per annum from 2010-2030. Given that forestry competes primarily with non-dairy farming enterprises, and given the high potential productivity of non-dairy land for forestry identified in this study, the achievement of the Food Harvest 2012 output growth targets are unlikely to conflict with the achievement of sectoral growth targets set for the Irish forestry sector.

Results of this study indicate that it is reasonable to assume that further forestry expansion can be achieved and that sectoral targets can be met by all sectors with adequate land-use planning. The results of our analysis suggests that the planting of an additional 457,000 ha of forests could likely be achieved using predominately marginal agricultural land, without greatly compromising agricultural productivity.

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The macrofungal component of biodiversity in Irish Sitka spruce forests

Richard O'Hanlon[a] and Thomas J. Harrington[a]

Abstract

Sitka spruce (*Picea sitchensis* (Bong.) Carr.) is the most commonly planted tree species in Ireland, with future increases in the area of Sitka spruce forests planned. In recent years the biodiversity of Sitka spruce plantations in Ireland has become a topic of much research interest. However, fungal biodiversity has yet to be systematically surveyed in Irish Sitka spruce forests. This study reports on the diversity of macrofungi from nine Sitka spruce plots in five counties surveyed over three years. One hundred and forty four species were discovered in the plots, including three species new (previously unrecorded) to the Republic of Ireland. Over half the species discovered were ectomycorrhizal species, highlighting the generalist nature of Sitka spruce as an ectomycorrhizal host in Western Europe. The 10 most common species are listed; members of the genus *Mycena* were the most commonly found macrofungi. On a relative sampling basis (species per m^2), the biodiversity of macrofungi in Irish Sitka spruce forests is comparable to that found in native Sitka spruce forests in Canada. The ability of Sitka spruce forests in Ireland to support native biodiversity is discussed with reference to studies of other taxonomic groups and recommendations for the promotion of fungal diversity in Irish Sitka spruce forests are made.

Keywords: *Diversity, ectomycorrhiza, decay, mushrooms, fungi*

Introduction

The word "biodiversity" has been defined in a variety of ways (more than 80 definitions in De Long 1996). In this article the definition used is that of the Convention on Biological Diversity (CBD): "Biological diversity means the variability among living organisms from all sources including, *inter-alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Convention on Biological Diversity 1992). Biodiversity in this form is extremely difficult to measure and therefore only the organism diversity at the level of species is examined because it encompasses different hierarchies of biological and ecological diversity. Biodiversity is known to have large effects on ecosystem productivity and stability (Bolger 2001; Gaston and Spicer 2004; Hector 2011) and therefore its conservation is extremely important. Bullock et al. (2008) calculated that biodiversity is worth more than €700 million per annum to the Irish forest sector. The protection of biodiversity is also one of the key principles examined by the Forest Stewardship Council (FSC) in Ireland to ensure that forest produce complies with Sustainable Forest Management (SFM) practices.

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Fungal biodiversity worldwide has been estimated at over 1.5 million species (Hawksworth 1991) with forests being seen as having the highest fungal biodiversity of all ecosystems. Fungi hold key roles in the maintenance of forest ecosystems including: (i) nutrient cycling, retention and formation of soil structure, (ii) provision of food in detritivore food webs in forests and forest streams, (iii) micro-habitat creation in forests by fungal pathogens and (iv) mycorrhizal mutualisms (Moore et al. 2001). Historic under-recording of many groups of fungi in Ireland, especially forest fungi, has led to a situation where the Republic of Ireland is considered to have much fewer macrofungal records than similar countries (100 fewer than in Northern Ireland and 2200 fewer than in England; O'Hanlon and Harrington 2011). In 2007 the FUNCTIONALBIO project (Bolger et al. 2009) was established to investigate functional biodiversity in forests, including the diversity of soil decomposers and predatory and parasitic arthropods. The project investigated fungal biodiversity in Irish forests that contained native (ash, *Fraxinus excelsior* L.; and oak, *Quercus robur* L., Q. *petraea* L.) and non-native (Scots pine[1], *Pinus sylvestris* L.; and Sitka spruce, *Picea sitchensis* (Bong.) Carr.) tree species. The results for the fungal section of the project (O'Hanlon 2011) for Sitka spruce forests are summarised in this article.

Sitka spruce is native to the west coast of North America, its range stretching along the coast from Prince William Sound in Alaska, south to Casper, California (Peterson et al. 1997). It is a light demanding tree, which grows well in moist fertile soils. In general, Sitka spruce forests are not intensively managed in North America. These Sitka spruce forests are characterised by having high tree species diversity, lush understory and shrub layers, and large amounts of coarse woody debris (CWD), especially fallen trees. In contrast, Sitka spruce forests in Ireland and the remainder of Europe are usually intensively managed. Low tree species and understory species diversity (French et al. 2008), short rotation lengths (Joyce and O'Carroll 2002), and low levels of CWD (Sweeney et al. 2010a) characterise Sitka spruce plantations in Ireland. Sitka spruce is the most commonly planted tree species in Ireland (National Forest Inventory 2007) and the United Kingdom (National Forest Inventory 2003). Sitka spruce now accounts for over 50% of the forested land in Ireland (National Forest Inventory 2007), with plans to increase this to over 60% by 2030 (Department of Agriculture, Food and Forestry 1996); therefore information regarding the effect of Sitka spruce plantations on native fungal biodiversity is important to inform future management of Sitka spruce plantations.

The objective of this study was to investigate macrofungal species richness (number of species) and functional group richness (number of species within specified functional groups) in Irish Sitka spruce forests. Comparisons of the results from this study with those from other non-native and native Sitka spruce forests were expected to reveal lower species richness in non-native forests, related to other major differences between non-native and native Sitka spruce forests (e.g. lower tree species diversity, lower vascular plant diversity, shorter rotation times, less CWD).

[1] There is some debate among experts as to whether or not Scots pine is native to Ireland, with the majority being of the view that it is a naturalized species.

Table 1: *Descriptions of the nine Sitka spruce forests surveyed in this study. The tree species present inside the plot, apart from Sitka spruce, are listed. Soil description was taken from the geological maps of Ireland (Gardener and Radford 1980). Characterization of the vegetation in the plots based on the Fossitt (2000) habitat scheme reflected the conifer plantation habitat type (WD4, forest with a broadleaf component of less than 25% and where the overriding purpose of the forest is commercial timber production).*

Plot name	County	Tree species present	Stand age	Soil type	Parent material
Ballygawley	Sligo	Qp	40	Lithosol	Granite and sandstone
Bohatch	Clare	Pa	30	Blanket peat	Basin peat
Chevy chase mature	Clare	-	40	Gley	Sandstone
Chevy chase young	Clare	Bp	20	Gley	Sandstone
Cloonagh	Sligo	-	18	Grey brown podzol	Limestone
Dooary	Laois	-	24	Gley	Carboniferous shale
Moneyteige	Wicklow	-	35	Peaty podzol	Granite and sandstone
Quitrent	Cork	Pc	28	Gley	Sandstone
Stanahely	Wicklow	-	25	Peaty podzol	Granite and sandstone

Tree species abbreviations: Qp, Quercus pertaea L.; Pa, Picea abies (L.) Karst.; Bp, Betula pubescens Ehrh.; Pc, Pinus contorta Dougl. ex. Loud.; -, few or no other tree species present.

Methods

Plot selection

Nine Sitka spruce sites were chosen (Table 1) from a list previously used by the BIOFOREST study (Smith et al. 2005; Iremonger et al. 2006; Smith et al. 2006). As much as was possible we tried to select pure (100%) Sitka spruce stands, although budget and time restrictions meant that some of the sites selected were mixed tree species stands. The stands ranged in age from 18 to 40-years-old. In each site a 100 m^2 permanent plot was established in an area that was considered typical of the site (similar aged trees, similar vegetation type, level ground and large distance to forest edge).

Macrofungal sampling

The plots were visited at least twice in the autumn (August-November) of 2007, 2008 and 2009. All macrofungi inside the plots were identified *in situ* where possible, and sporocarps (mushrooms) of unidentified species were retained for later identification according to a standard approach (Courtecuisse and Duhem 1995). We defined macrofungi as fungi which are visible to the naked eye and generally produce sporocarps greater than 5 mm in diameter. The macrofungal species recorded were split into functional groups based on their primary mode of nutrition; litter decay (LD), ectomycorrhizal (ECM), parasitic (P) and wood decay (WD) groups (Ferris et al. 2000). The microfungi, such as slime molds, rusts and smuts could not be examined using this approach. Similarly, some mycorrhizal groups (including arbuscular, ericoid and ectendomycorrhizal types) could not be sampled using this method. The functional groups used here are slightly arbitrary in that it is known that many fungi can switch between these functional groups depending on environmental conditions. Many species can be facultatively ectomycorrhizal, switching to decomposer lifestyles under certain conditions (Talbot et al. 2008; but see Baldrian 2009); while other decomposer species also function as weak parasites (e.g. honey fungus *Armillaria mellea*). However, the examination of functional group diversity is still of interest as it can highlight differences in the macrofungal communities of different forest types.

We examined the species richness and functional group richness of fungi in the Sitka spruce forests. Species richness is the total number of species found. Functional group richness is the number of species found which fit into one of the predefined functional groups i.e. LD, ECM, P and WD. The number of plots in which a species was recorded over the three years was used to give an indication of the distribution level of that species in Sitka spruce forests in the Republic of Ireland.

Results

Species richness patterns

A total of 144 macrofungal species were recorded in the Sitka spruce plots. Three species, previously unrecorded in the Republic of Ireland species list were found within the plots during this project, namely *Ophiocordyceps forquignonii*, *Cortinarius evernius* and *Elaphocordyceps longisegmentis*. The number of species recorded increased over the three years of the study (Figure 1). There was no macrofungal species ubiquitous to all plots (Table 2). *Mycena* was the most species rich genus, followed by *Cortinarius*, *Russula* and *Lactarius* with 19, 13, 11 and 9 species, respectively. Despite the high species richness of some genera, more than half (57%) of the species were found only once over the three years.

Functional group richness patterns

From a functional group point of view, 44%, 29%, 24% and 3% species could be classed as ECM, WD, LD and P species respectively (Figure 2). Of the 10 most widely distributed litter decay fungi, seven were of the genus *Mycena* (*M. vitilis, M. metata, M. leptocephala, M. rorida, M. filopes, M. stylobates* and *M. epipterygia*). The remaining three litter decay species were the wrinkled club (*Clavulina rugosa*), the earthy powdercap (*Cystoderma amianthinum*) and the puffball (*Lycoperdon nigrescens*). The most widely distributed ectomycorrhizal species included five

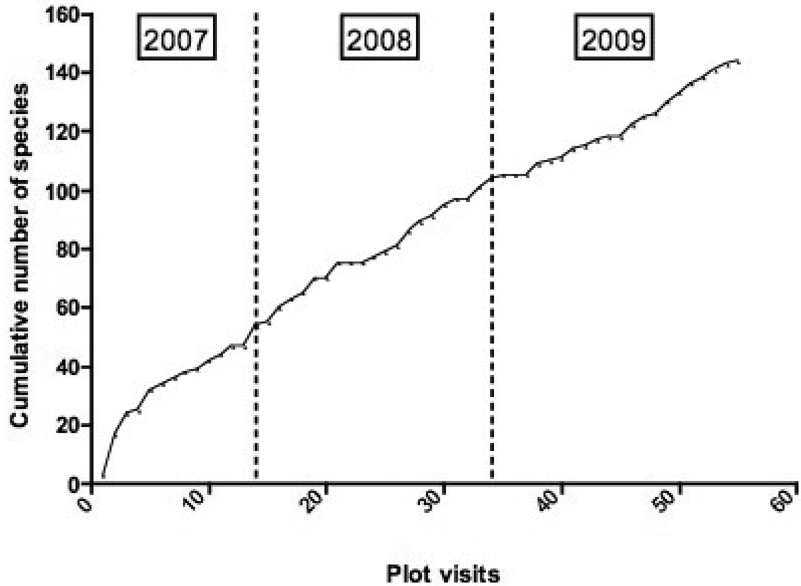

Figure 1: *Cumulative number of macrofungal species recorded over the duration of the study. The years of the study are separated by vertical dashed lines.*

Cortinarius species (*C. cinnamomeous*, *C. obtusus*, *C. anomalus*, *C. acutus* and *C. flexipes*), two *Laccaria* species (*L. laccata* and *L. amethystina*), two *Russula* species (*R. ochroleuca* and *R. emetica*) and the blusher (*Amanita rubescens*). *Heterobasidion annosum* was the only parasitic fungus that was present in more than one plot. Only three wood decay species (*Hypholoma fasciculare*, *Postia caesia* and *Calocera viscosa*) were present in more than four plots.

Abundant and edible macrofungal species

Further details are provided below for macrofungal species that were either (i) very prolific (producing large biomass) species or (ii) species that produce edible sporocarps.

(i) Prolific species in the plots were *Hemimycena gracilia*, *Mycena leptocephala*, *Russula ochroleuca*, *Hypholoma fasciculare*, *Rhodocollybia butyracea*, *Clavulina rugosa* and *Laccaria laccata*. More than 100 sporocarps of these species were recorded from all of the plots (per 900 m^2) over the three years of the study. *Russula ochroleuca*, *Mycena leptocephala*, *Hypholoma fasciculare*, *Laccaria laccata*, and *Rhodocollybia butyracea* were found in more than four of the plots, while *Clavulina rugosa* and *Hemimycena gracilis* were abundant, but found in less than four of the plots.

(ii) Of the edible macrofungal species found in the plots, those that are highly rated by the culinary industry, and were also prolific include the cep *Boletus edulis*,

Table 2: *The most commonly found macrofungal species in the plots, based on the number of plots (and percentage in parenthesis) in which these species were recorded. The functional group (based on primary mode of nutrition) of the species is also given.*

Species	No of plots	Functional Group
Mycena leptocephala	7 (78%)	LD
Laccaria laccata	7 (78%)	ECM
Hypholoma fasciculare	7 (78%)	WD
Mycena vitilis	7 (78%)	LD
Mycena metata	7 (78%)	LD
Russula ochroleuca	5 (56%)	ECM
Laccaria amethystina	5 (56%)	ECM
Mycena rorida	5 (56%)	LD
Postia caesia	5 (56%)	WD
Calocera viscosa	4 (44%)	WD

Abbreviations: LD, litter decay; ECM, ectomycorrhizal; WD, wood decay.

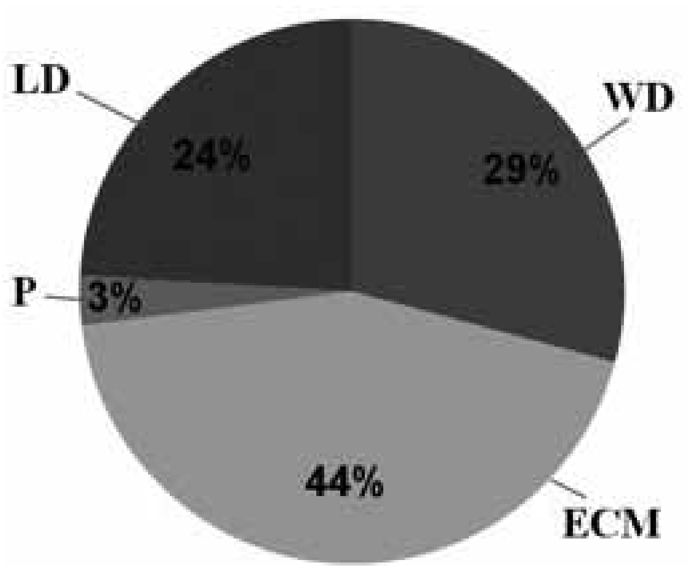

Figure 2: *Functional group breakdown of the macrofungal species (n=144) found in the plots. LD, litter decay; ECM, ectomycorrhizal; P, parasitic; and WD, wood decay species.*

the autumn chanterelle *Cantharellus tubaeformis*, the chanterelle *C. cibarius* and the false saffron milkcap *Lactarius deterrimus*. In particular the autumn chanterelle and false saffron milkcap were found in areas composed of pure Sitka spruce with no other tree species within 5 m, and often in large quantities. *Cantharellus cibarius* was more common near birch trees within a Sitka spruce stand, such as in the younger Chevy chase stand.

Discussion

The fungal biodiversity of Sitka spruce forests in Ireland and other regions

To the authors' knowledge, this is the first systematic macrofungal biodiversity study of Irish Sitka spruce forests. As it was conducted over a relatively short time period (three years), the study may not have revealed the full extent of macrofungal diversity in Sitka spruce forests in Ireland, and further surveying would undoubtedly reveal more new species in these plots. However, work in Britain by Ferris et al. (2000) has shown that up to 80% of the expected macrofungal species are likely to be revealed from three years of intensive sampling, thus supporting the validity of the data collected in this study. Unfortunately however, there are some limitations to the design of this study, a drawback common to most survey studies of this kind. Tree species present (some mixed species stands and some monoculture stands), stand age (stands ranging in age from 18 to 40-years-old), and stand management factors (mixture of thinned and unthinned stands) were confounded, so it is difficult to be definitive as to which site factors had the greatest impact on macrofungal diversity. Nevertheless, this study does provide baseline data that may inform future studies, while also yielding new macrofungal species records for five counties in the Republic of Ireland. Heslin et al. (1992) and Dowding and Smith (2008) have listed some macrofungal species found in Irish Sitka spruce forests. However, the first study by Heslin et al. (1992) was more focused on the below-ground ectomycorrhizal morphotype diversity; while the work by Dowding and Smith (2008) only listed edible and poisonous species. That so many fungal species were found in Sitka spruce forests lends weight to O'Hanlon and Harrington's (2011) hypothesis that much of Ireland's undiscovered fungal biodiversity may be found in forest habitats. It is likely that more new macrofungal species will be discovered if these plots are sampled more intensively in the future. New species were found at regular intervals over a 20-year sampling period in macrofungal studies conducted in forests in Britain and Switzerland (Tofts and Orton 1998; Straatsma and Krisai-Greilhuber 2003). Two of the main reasons for the increasing macrofungal species richness over time in forests are (i) omission of species at sampling due to the sporadic nature of macrofungal fruiting (Krebs et al. 2008) and (ii) changes in the macrofungal community as the forest ages (Smith et al. 2002; Kranabetter et al. 2005). Taking these difficulties into account, it is probable that even with almost constant sampling of a forest macrofungal community, the true species richness of the community may never be revealed using sporocarp-only studies. Another negative aspect of using sporocarps as indicators of ectomycorrhizas is the low similarity between above-ground sporocarp presence and below-ground presence of the ectomycorrhizas (Horton and Bruns 2001). Difficulties aside, sporocarp studies continue to be used to examine fungal ecology and phenology in forest ecosystems (Ferris et al. 2000; Humphrey et al. 2003; Roberts et al. 2004; Kranabetter et al. 2005; Buee et al. 2011). One of the main benefits of sporocarp studies, apart from the ease of data collection, is that only the ectomycorrhizal species active in the ecosystem are recorded. Ectomycorrhizas are dependent on host carbon for the production of sporocarps in natural ecosystems (Högberg et al. 2001); therefore sporocarp presence is directly related to activity in the ecosystem.

The findings of this study agree with previous work in Scotland which indicates that Sitka spruce is an ectomycorrhizal generalist, capable of forming ectomycorrhizas with many native fungi (Alexander and Watling 1987). An interesting phenomenon, known as "host shift" (Watling 1995), can occur when a native fungal species is found in stands of non-native tree species. The ectomycorrhizal species, *Cortinarius rubellus*, is known to have shifted host from its native habitat of Scots pine to plantation Sitka spruce forests in Britain and Ireland. Once thought to be restricted to native pine forests in Scotland, it is now found in Sitka spruce forests in Britain (Watling 1982) and Ireland (Harrington 1994). This macrofungal species spreads by both windblown spores and by underground mycelia. Two scenarios which may explain its presence in plantation Sitka spruce forests are that (i) it was present in a nearby pine stand and entered the plantation from windblown spores, or (ii) the plantation was previously a pine forest and existing mycelia propagules of the fungus remained in the soil after pine harvest to colonise the newly planted forest. Moreover, work in Britain by Humphrey et al. (2003) has shown that distance to nearest existing native pine wood is positively related to the number of rare pine wood macrofungal species found in Sitka spruce plantations.

The large number and quantity of edible macrofungal species found in Sitka spruce forests suggest that the findings may be of economic significance. Smith (2001) estimated that Ireland imports €2 million worth of wild mushrooms per annum. Currently, work is being carried out to investigate the production of wild edible fungi in Irish forests, including Sitka spruce forests (Harrington et al. 2009), and this may reveal even more information about edible fungal species in this forest type. Of the economically damaging fungi found, *Heterobasidion annosum* is the most serious disease of Sitka spruce in Ireland (Joyce and O'Carroll 2002). It and other fungal pathogens are known to infect through cut surfaces of trees (Dowding 1970) and if no preventative measures are taken large economic losses can be expected.

The results of this study show that stands of Sitka spruce in Ireland have more macrofungal species richness (species per m^2) than native Sitka spruce forests in Canada (Outerbridge 2002), yet not as rich as Sitka spruce plantations in Britain (Humphrey et al. 2003) (Table 3). In fact, the fungal biodiversity of Sitka spruce forests in Ireland was found to be as high as native Irish oak forests (O'Hanlon and Harrington, unpublished data). There were strong similarities between Sitka spruce forests in different locations in respect of certain biodiverse genera. *Mycena*, *Cortinarius* and *Russula* were found to be very species rich in this survey (19, 13 and 11 species) and in similar studies from Britain (28, 35 and 16 species) (Humphrey et al. 2003) and Canada (22, 14 and 13 species) (Roberts et al. 2004). There were, however, large differences in the functional group richness of the species found in Sitka spruce

Table 3: *Fungal species richness (number of species) and species per m² in Sitka spruce forests in Ireland, Britain and Canada. The numbers in parenthesis in column 2 indicate the percentage of the total number of species that were found only in Sitka spruce forests.*

Region	Species richness	Species/m²	Source
Ireland	144 (53%)	0.16	This study
Britain	269 (37%)	0.21	Humphrey et al. 2003
Canada	127 (41%)	0.15	Outerbridge 2002

forests in the different regions. Similar to Irish forests, British forests had 41% of the total species richness from the ectomycorrhizal functional group (Humphrey et al. 2003). The ectomycorrhizal functional group richness of Canadian forests was much lower, at just 28% (Outerbridge 2002).

The macrofungal aspect
Although confounding effects in this study design diminish its ability to make conclusions regarding the relationship between macrofungal species richness and site factors, previous research results in the U.K. (Humphrey et al. 2003) and North America (Jones et al. 2003; Luoma et al. 2006) have indicated that fungal biodiversity in managed forests may be increased through: (i) the retention of mature trees after final harvesting, (ii) increasing the amounts and quality of CWD left on site and (iii) through mixed tree species planting. These recommendations are similar to those given for increasing biodiversity of other taxonomic groups in forests (Table 4). Ectomycorrhizal fungi in particular are known to be negatively affected by clear cutting (Jones et al. 2003). Ectomycorrhizas rely on the host tree for a food source, therefore when the host is removed the fungus cannot survive (Hogberg et al. 2001). Retention of mature trees in swathes rather than as single stems has been found to be more beneficial to fungal biodiversity (Luoma et al. 2006). Old growth forests are known to support a different community of macrofungi to young forests (Smith et al. 2002; Kranabetter et al. 2005), therefore retention of mature swathes of forest would also provide a habitat for these old-growth fungal communities to survive in. Increasing the amount and quantity of CWD left on site after harvesting provides a suitable habitat for wood decay fungi. Research in Britain found that the number of wood decay fungal species is positively related to the amount of CWD in the forest (Ferris et al. 2000). Previous research has showed that there is a positive relationship between tree species richness and fungal species richness (Schmit et al. 2005; Ferris et al. 2000). Ectomycorrhizal fungi can be quite specific in the tree species which they form relationships with (Molina et al. 1992), while many decay fungi are restricted in the litter and wood which they can decompose (Ludley et al. 2008). The ectomycorrhizal specificity and preferences of decay fungi both contribute to specific communities of fungi being found in forests, and these communities are related to

the dominant tree species of the forest (Buee et al. 2011; O'Hanlon and Harrington, unpublished data).

The results of this study have shown that Sitka spruce forests in Ireland can support high fungal species richness. Similarly, the biodiversity of other taxa in Irish Sitka spruce forests can be encouraged, as summarised in Table 4. The biodiversity of the insect groups (Table 4) can be increased through retention of mature trees, increasing the amounts of CWD retained and through the provision of more open spaces in the forest stand (Oxbrough et al. 2006, 2010; Gittings et al. 2006; Arroyo et al. 2010). More open spaces also results in increased bird biodiversity (O'Halloran et al. 1998; Wilson et al. 2010; Sweeney et al. 2010b). The promotion of structural heterogeneity, increased volume of CWD in the later stages of decay, and planting of mixed (especially coniferous/broadleaf) tree species forests have been identified as methods for increasing vascular plant biodiversity in Sitka spruce plantations (French et al. 2008). Epiphyte biodiversity can also be increased through the retention of mature patches of plantation forests and the planting of more mixed tree species (especially broadleafed) at the stand level (Coote et al. 2008). The parameters identified as important for increasing the biodiversity of the different taxonomic groups (Table 4) are now requirements of the Forest Biodiversity Guidelines (Forest Service 2000). Parameters would also have a positive effect on fungal biodiversity in Irish forests.

Table 4: *Management parameters identified as important for promoting biodiversity in Sitka spruce forests in Ireland. Column 2 lists the number of species found in Sitka spruce forests for that group and the percentage (in parenthesis) of Ireland's total species richness for that species group.*

		Importance for increasing biodiversity				
Taxonomic group	**Species richness**	**OS**	**MT**	**SW**	**CWD**	**TD**
Spiders[1]	154 (13%)[6]	√	√	x	x	x
Hoverflies[1]	50 (25-50%)[7]	√	x	√	√	x
Beetles[2]	47 (2%)[6]	√	√	x	x	x
Birds[3]	21 (9%)[6]	√	x	x	√	x
Vascular plants[1]	167 (7%)[6]	√	x	x	√	√
Epiphytes[4]	68 (4%)[6]	x	√	x	x	√
Fungi[5]	144 (14%)[8]	x	√	x	√	√

√, effective; x, not effective, less important or undetermined.

Abbreviations: OS, provision of open spaces in the stand; MT, retention of mature trees after harvesting; SW, provision of areas with standing water in the stand; CWD, provision of coarse woody debris of high quality and quantity after thinning/harvesting; TD, increasing tree species diversity at the stand level.

Sources: 1, Smith et al. (2006); 2, Oxbrough et al. (2010); 3, Sweeney et al. (2010b); 4, Coote et al. (2008); 5, O'Hanlon (2011); 6, NBDC (2010); 7, Speight et al. (2006), as cited in Keil et al. (2008); 8, O'Hanlon and Harrington (2011).

Conclusions

The *Biodiversity in Britain's planted forests* project (Humphrey et al. 2003) arrived at similar conclusions to those given in this paper – biodiversity in Sitka spruce forests can be increased through the retention of mature forest patches and increasing tree species diversity. Related research in Britain has identified exotic tree species plantations as having an important part to play in the conservation of native taxonomic groups, by providing a complementary habitat for those groups (Quine and Humphrey 2010). Sitka spruce plantations in particular are capable of supporting native biodiversity, especially if more stands are allowed to reach old-growth conditions (Humphrey 2005), and these forests could also be managed to provide a supplementary habitat for native fungal biodiversity in Ireland.

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Forest Perspectives

Cultivation of Trees at Coole Park Extracts from Lady Gregory's *Diaries* and *Journals*

Selected and annotated by Niall OCarroll

The term 'cultivation of trees' is used since the practice at Coole[1] Park, the Gregory estate near Gort, Co. Galway, was not simply aimed at forestry as it is normally understood (i.e. the production of wood on a commercial basis), but it also involved some elements of arboricultural and aesthetic objectives.

According to the NUI Galway (2009) *Connacht Landed Estates Database* Coole Estate was bought by Robert Gregory (1727-1810) on his return from service with the East India Company, from the Martyns of Tullira[2], Co. Galway, about 1768.

Lady Gregory (1852-1932) was born Isabella Augusta Persse[3] at Roxborough, near Loughrea, Co. Galway. In 1880 she married Sir William Gregory of Coole Park[4], near Gort, who died in 1892.

As an undergraduate student of forestry in U.C.D. from 1951 to 1956, I spent part of my practical year (to gain outdoor practical experience of the work) as a forest worker (forest labourers we were called then) in Gort State Forest from September 1953 to April 1954. My first day was spent with the Forester-in-Charge, Tom Cox and the Divisional Inspector Neil Diver stocktaking tools in the shed which occupied the ruins of the shooting lodge in Chevy Chase. I also spent a day helping to mark a first thinning in a Japanese larch plantation, with the District Inspector Séamus MacMenamin who showed me how to pack the legs of my trousers with newspapers as protection against the rampant brambles. Much of my time was spent lifting by hand beech transplants in the nursery and cleaning broadleaf regrowth in other parts of the woods. I also worked in Garryland[5] thinning the natural oaks, producing firewood, with manually operated two-man and sometimes four-man crosscut saws. In the process I was shown how to sharpen and set the teeth of a crosscut saw, a skill ("saw-doctoring") which I never found any subsequent occasion to use.

Already I had developed an interest in the Irish Literary Revival of the late 19th/ early 20th centuries, so my appointment to Gort was, to me, entirely felicitous. Soon

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1 According to Flanagan, D.& L. (*Irish Place Names*, Dublin, 2002) *'Cúil'* means a 'corner' or a 'nook'…it can easily be confused with *'cúl'*, 'hill'.

2 It is of interest that Edward Martyn (1859-1924), co-founder of the Abbey Theatre with Lady Gregory and W.B. Yeats, who died unmarried, was the last of the Martyn family of Tullira.

3 According to MacLysaght (*The Surnames of Ireland*, 1985) Persse, a variant of the name Pearse, is the name of a landed family established in Co. Galway in 1700, previously in Co. Kildare.

4 1817-92. M.P. for Galway 1857-71, then Governor of Ceylon.

5 Joyce, P.W. in *Irish Names of Places*, Vol.III, 1913, on 'Garryland in Galway; here Garry is not garden but *Garbh; garbhlán*, rough land', a term which accurately describes the terrain.

after I began working in Coole the Head Labourer brought me to the Autograph Tree[6] in the garden. We easily scaled the tall but flimsy netwire fence around it; he handed me a penknife and seemed surprised that I declined to add my initials to the many already there. (Since then the tree has been secured within sturdy railings.) While in Gort I visited W.B. Yeats's restored Tower House (Thoor Balylee) and was disappointed to note its then derelict and dilapidated state – doorless, in use as a shelter for cattle, and one board already removed from the first upstairs floor. Yeats's commemorative wall plaque was sadly prophetic: *'And may these characters remain / When all is ruin once again'*. Later I bought the Lennox Robinson edition of *Lady Gregory's Journals 1916 – 1930*, then generally only available in Dublin second-hand bookshops. So I was pleased more recently to find that the complete Journals had been published with Lady Gregory's frequent references to the woods, which provided the main basis and impulse for this exercise.

All extracts from the journals have been transcribed as published. Additional material is enclosed in square brackets [], as have locations where irrelevant words have been omitted.

It might be noted that the entries relating to the woods occupy a relatively small space in a published version totaling 1,288 pages.

The Early Journals

The earliest published journals of Lady Gregory are in *Lady Gregory's Diaries, 1892-1902* (Pethica, 1996). Here she is already concerned about her son Robert's inheritance. On October 14, 1894 she writes 'I have been very much out and about, looking after woods, gates and fences. I am so anxious to keep the place in good repair for Robert.' And on April 8, 1895 'I hope to save the *home* – the house & woods at least for Robert'.

There are other brief mentions of the woods (in transcribing these extracts I have maintained her practice of punctuation by dash (—) and the use of the ampersand sign (&).

> 8 April, 1895. 'Some of the larch in nutwood[7] a good deal nibbled, but what was last planted, & that in Bull park[8] not touched. They are anointed with Dickson's "preserver" which seems good – "Mike John" [Dooley] is installed as keeper – an addition to expense, but it is cheerful to see him about with dogs (Jap and Rover) and gun – and it was necessary to have some one look after the woods – He has detected 4 lads from Gort cutting down and carrying off trees from Inchy[9], and summoned them last Saturday – but the summons server Mr. Glynn who does not want to quarrel with his neighbours did not appear to prove the service when wanted…and then Arch Deacon Daly informed Mike the case was adjourned - & then he went to take

[6] A copper beech bearing the carved initials of literary guests of Lady Gregory.
[7] According to Smythe (1983) and the Ordnance Survey map the nutwood is a large wood north of the house.
[8] Immediately south of the stable block (Smythe, 1983).
[9] A large wooded area south of the house and beside Coole Lough (Smythe, 1983).

a cup of tea with Mary – and while there a policeman called him back – and said it was coming on – however it was finally adjourned for a fortnight, no one in this country being in a hurry!

31 January, 1896. Have planted about 1400 trees, in nutwood & clump in "45 acres" - Larch [*Larix decidua*], spruce [*Picea abies*] – silver [*Abies alba*] – scotch [*Pinus sylvestris*] – & some evergreen oaks & new lilacs in nutwood – & Frank[10] has been over today & advised me to get 1000 birch, as a man has been over from England buying them at L. Cutra for clog soles – anyway they are very silvery, showing through dark foliage.
February 13, 1896. Nothing new – planted 1000 birch in nut wood - & some dog wood [*Cornus* spp.] & sallys [*Salix* spp.] elsewhere.

15 February, 1896. Church - & went to see old Farrell & engaged him to cut ivy from the trees "by contract" that he can choose his own days and hours.

19 February, 1896. A larch coming out in the woods – Farrell cutting ivy merrily.

21 February, 1896. In the afternoon got Marty & 93 ash saplings he had dug up, & proceeded with him & Cahel to plant them along the walls – at back of Kiltartan chapel - & other wall of park – if they succeed, it will have been a good days work – towards Robert's firing [firewood] in the future.

30 January, 1898. Arranging tree planting – R. and I having marked 30 spruce for the people, & to leave gaps for the shooting, I am ordering 300 spruce, 300 larch, 100 silvers to take their place.

10 February, 1896. I am stronger in body from the rest, but growing dulled in mind so that it is an effort to write an Irish exercise[11] or a letter – however I have finished & sent off a paper on "Tree Planting"[12] to the Irish Homestead.

9 April, 1898. Fine dry weather – I went round the first day with Mike to mark trees – dead and dying ash for the people – firing being very scarce.

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[10] Francis Persse, Lady Gregory's brother.
[11] Lady Gregory made several attempts to learn the Irish language.
[12] Reprinted in *Irish Forestry* 33: 94-98.

12 May, 1901. The little larch trees I last planted are doing well everywhere, but the silvers and spruce have withered up in the cold winds.

16 March, 1903. The place sadly changed by storms of February 26[13] – the accounts of which had disturbed me in London. 10 lime trees down between house and stables - & the big lime to the left (greatest loss of all) & the big evergreen oak in front lawn - & some parts of the wood laid flat.

The main Journals

Lady Gregory's principal Journals (Gregory 1978, 1987) were begun primarily to record the progress of her attempts to achieve the return of the Lane picture collection[14] from London to Dublin. But she also recorded matters to do with the Abbey Theatre, of which she was founder director; Coole Estate and day-to-day trivialities of life and family. She had a particular interest in the Coole woods which she wished to see maintained and improved to be ultimately inherited by her grandchildren. Although by now the ownership had passed to her daughter-in-law it was gradually realized that the resources were not available to maintain the house and estate so the woods were sold to the Forestry Division[15] of the Department of Lands and incorporated into Gort State Forest, Co. Galway. The Coole estate portion of Gort Forest also included the adjoining woods at Garryland.

I have abstracted from the published journals all the references to the Coole woods. The footnotes derive from four sources: the Murphy edition of the Journals (Gregory, 1978, 1987), other published sources, information from Colin Smythe and my personal memories.

Journals Vol. 1. (2 refs.)

24 February, 1923. Yesterday I had a nice afternoon, thinning[16] the plantation in Park-na-Laoi[17].

12 March, 1923. Some hope of peace moves coming to success[18].

[13] Other records suggest 22 February. The widespread fellings caused by this storm led to an immigration of sawmills which then continued to demand further supplies, thereby continuing the serious depletion of Irish woodlands. It was locally named 'the night of the big wind' although not as severe as the original storm of that name on 6/7 January 1839.

[14] Sir Hugh Lane (1875-1915), her nephew, son of Lady Gregory's sister Adelaide, a picture dealer and collector, promised to leave his priceless collection to Dublin but changed his mind when Dublin Corporation failed to provide a suitable gallery and left it to the London National Gallery. After his death on his return to London on the *Lusitani*a in 1915, an unsigned codicil to his will, restoring the collection to Dublin was found but its legality was rejected by the London authorities. A compromise was reached in 1959 by which the collection was divided in two and the halves alternated between Dublin and London for alternating five-year periods.

[15] Sometimes referred to as the Forestry Commission, even by people who should know better. The Forestry Commission ceased to function in Ireland when independence was achieved in 1922.

[16] Colin Smythe (publisher of the Journals and expert on all aspects of Coole and its family), informed me that Lady Gregory did a lot of the work herself, not merely overseeing it.

[17] A narrow strip of woodland southwest of the house and beside the Coole River (Smythe 1983).

[18] A reference to the Civil War which came to an end in May 1923.

I have been a good deal in the woods freeing the little trees in Park-na-tarav[19], and find my love for the wood work has come back as strong as ever, I so hope to save all the woods for the children.

Journals Vol. 2. (66 refs.)

20 January, 1926. Mr. Forbes[20] of Forestry Department came yesterday to look at the woods. M[argaret][21] having offered them and remaining land for sale. He seemed pleased and will recommend the purchase, but would not think of buying the house. I shall be glad if the woods are kept up and improved if they have to go to strangers. And he thought my young plantings very well grown and flourishing. I was afraid they wanted thinning &c, not having been able to look after them of late[22].

5 April, 1926. Once [while on tour with the Abbey Players in the U.S.A.] Mr. Schuman and his daughter were to take me to Thoreau's "Walden"[23] and she [Mrs.Jack Gardner] proposed coming. A delightful day, the drive, the woods; at lunch I was to have my first meeting with green corn on the stalk.

2 February, 1927. This afternoon to see Keller[24] about the sale of Coole. He had been with Hogan[25], and M[argaret] will be disappointed, for the Forestry Dept. (Forbes) will only give £4000, that is, Woods £1908, Land £1600, House £500. Hogan thought it would be raised to £6000 and had proposed this, but Forbes turned it down. But he will see Forbes and press for an increase.

10 March, 1927. Yesterday a telegram to Margaret from Keller saying full price "that is £5000" will be given her for Coole "without conditions". So Coole is gone. But I hope to stay for the summer, it will be a home for the children..

My mind is relieved that the sale has been arranged, for the Forestry people will take care of the woods – yet my heart is a bit sore.

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19 Pairc-na-Tarav (the bull field). An elongated truncated triangular-shaped wood immediately south of the stable-yard (Smythe, 1983).

20 A.C. Forbes, (1865-1950) was appointed Forestry Adviser to the Department of Agriculture and Technical Instruction, Dublin, in 1906. He became Director of Forestry after independence.

21 Widow of Lady Gregory's son Robert, killed in Italy in 1918, while on air patrol (see W.B. Yeats's poem 'An Irish Airman Foresees His death'). Margaret was therefore the legal owner of Coole. (It appears that Robert may not have been the paragon suggested by Yeats. Pethica (2009) has revealed records showing that he (a married father of three) conducted an extramarital affair with a young married painter in London in 1914, causing Lady Gregory to refer to him as 'a cad'.)

22 Lady Gregory was aged nearly 74 years at this time.

23 Henry David Thoreau: Walden; or, Life in the Woods (1854). Describes the building and lone occupation of a hut in the woods at Walden Pond near Concord, Massachussets.

24 A solicitor.

25 Patrick Hogan, T.D. for Co. Galway, Minister for Agriculture 1922-32.

I have written to ask Hogan if he will have the avenue attended to before the children come back for Easter. (30 April 1928. And this had never been done in spite of promises from the Forestry Dept. until the *end* of the Easter holidays *this* year!)

12 May, 1927. 82 Merrion Square[26]. Then to Keller to tell him Forbes, who had come to see me, had said they would take over the place in about two months, and asked if I would consent to be "Caretaker" – apparently instead of "tenant", paying £50 per annum for the house. But it was a hurried visit and I am rather vague, but he will come back for a day or two soon. I asked if he would take Mike[27] on to look after the woods, and he seems inclined to – that would be a great comfort. I asked if he would sell any of the land and he said "No, we have not power to part with it[28]". That is an ease, as others, like Curly, may come looking for it.

11 July, 1927. It was as well I went up [to Dublin], as Keller 'phoned to ask where I was, at Coole or elsewhere, and I went to him and he had Forbes in and we talked about taking over the house and garden, and made a provisional agreement, I to take house etc. and some fields for cows at £100 (it came to more (£117) later). Not a great saving I'm afraid though they must pay rates and taxes. But at any cost I will keep it as long as it can be a happy home for the children. Catherine[29] very happy here anyhow.

27 July, 1927. Forbes here yesterday about the land. We agreed to terms we had talked over except that he won't keep the pump in order. They are not going to cut trees at present, and that is a comfort, timber being at a low price, but will make a nursery at once in comfrey field.

21 August, 1927. And next morning, on top of these guests, came three Land and Forestry Officials to take over woods and land. But they couldn't do it because of thirty acres Margaret had sold to Raftery, from Lake Farm to lake, and this had not been marked on the map as sold. Forbes was indignant; Reed (Land) more gracious, Anderson (sub Land) silent. But it will all come right though causing delay.

[26] W.B. Yeats's address.

[27] Michael Dooley, (1853-1923), Lady Gregory's land steward who lived in the Gate Lodge at Coole (Saddlemyer, 2011).

[28] Authority to sell state forest land was provided for only with the passing of the Forestry Act, 1988 and the establishment of Coillte Teoranta, The Irish Forestry Board Limited.

[29] Grand-daughter. Later Mrs Robert Kennedy (1913-2000) (Saddlemyer, 2011).

15 October, 1927. Two Land Commissioners here today, Crozier[30] and O'Beirne[31] (No they are on the Forestry staff). They asked for the sawpit field[32] instead of the comfrey field for a nursery as it is (as I know) a much better one so I gave it up willingly as I am glad to think they will begin their work so soon. They are selling the disputed land to Malachi Quinn. I wish this had been done long ago but he was hard to deal with, urging for arbitration and so violent in temper. But he had trouble enough to give his brain a twist and I am glad there will be peace now.

20 October, 1927. Today Mr. Reed of the Land Commission and Mr. Donovan[33] of the Forestry Department came and formally took over Coole, took possession. It no longer belongs to anyone of our family or name. I am thankful to have been able to keep back a sale for these years past, giving it into the hands of the Forestry people makes the maintenance and improvement of the woods secure, and will give employment and be for the good and dignity of the country. As to the house, I will stay and keep it as the children's home as long as I keep strength enough and can earn money enough.

21 October, 1927. I told Mike I was afraid he was not being put in charge of the woods as Forbes had encouraged me to think (but had said nothing of in his letters). Poor Mike in his stupid sullen way said "What matter"; and then "I'll get a job in some other place! I've written to Forbes today about him, and meanwhile he is to look after the woods till the Forestry send someone in.

31 October, 1927. Waiting now to see Forbes chiefly on behalf of Mike John.

1 November, 1927. Forbes came in yesterday just as I had written this. The Inspector he says will be at Coole next week, O'Beirne. He can't get a house at present. I begged him to recommend Mike; he wouldn't promise, said he had not the power, but I think he will, he looked kind.

7 November, 1927. Today I have signed the Forestry agreement; rather nervous, but hope it may work out well.

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[30] Director of Forestry, 1931-33.

[31] Michael O'Beirne, A.R.C.Sc.I (Forestry) 1914. District Inspector, Gort. Later Superintendent, Avondale Forestry School. Honorary Member 1950. In the year 1941/42 District Headquarters were transferred from Gort to Galway City.

[32] A roughly square field approximately south by west of Coole house (Smythe, 1983). In 1953-4 the forest nursery was located in the northern half of the field identified as 'the back lawn' by Smythe (1983).

[33] Timothy (O) Donovan, b. 1882. Forester in Charge Ballygar Forest 1920-34 from where 'he advised on private planting in the west'. Honorary Member 1966.

10 November, 1927. M. had a letter from Richard[34] choosing Coole for the holidays, saying he was beginning to wish to see a tree again. I am worried by delay in forestry overseer coming, the avenue in holes and they have agreed to keep it in repair.

14 November, 1927. O'Beirne who is appointed Inspector of this place called on Saturday. I sent Mike round with him and hope he may engage him. I bought a fallen oak for firing[35] for five shillings a new departure! though my planting in the woods came to many hundreds. My anxiety now is to get the avenue mended before the holidays.

1 December, 1927. O'Beirne, the Inspector here this morning, is having the sawpit field ploughed for spring planting and stones broken[36] to mend the poor avenue. And my men are helping this, bringing stones to help Donohue to build the wall and so we shall get rid of gates.

O'Beirne looked in yesterday, and has taken the avenue in hand. A comfort seeing that done and already some employment given, to three or four stonebreakers.

3 June, 1928. I stayed indoors yesterday afternoon […] that I might not embarrass the many groups of boys and girls, young men and maidens, who were walking about passing the house to the woods and lake, by appearing as if to remind them of my ownership—(only by rent now). It is an ease to my mind that this is so, under the Foresters. They have the responsibility for the preservation of the woods. Owners are in the position of Nietzche's Commander— "he who commandeth taketh the burden of them that obey"[37]

13 June, 1928. A young Forester, Mr. Gaynor,[38] came to visit the woods, but the rain kept him in. I gave him Evelyn's *Silva*[39] to look at, and after a while went into the Library and had a long talk with him.

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[34] Lady Gregory's grandson, 1909-1981.

[35] I was told by workers in Coole that whenever an apple tree was cut on the estate the wood was sent to the drawing room where it emitted a pleasant scent while burning.

[36] In the 1950s in Gort Forest a common form of wet-weather work was the manual breaking of stones, with wire gauze eye-protection goggles, in the old barn, then derelict, used for tenant dances in Lady Gregory's time, latterly restored as an audio-visual room.

[37] Quotation from Friedrich Nietzche, German Philosopher, 1844-1900.

[38] Daniel J. Gaynor, 1892-1944. Appointed Forester 1923. His obituary notice (*Irish Forestry* 2: 41) records 'He spent his holidays in an adventurous manner and had travelled a good deal outside Eire, which was probably one reason for his capacity for interesting conversation.'

[39] J.E. Esq.; (John Evelyn). *Sylva, or a Discourse of Forest-Trees, and the Propagation of Timber in His Majesties Dominions*. London, 1664. Colin Smythe informs me that a 'sale of the books at Coole' in 1972 included the 1786 edition, bought by Quaritch, London for £70. (I bought a first edition of Samuel Hayes's A Practical Treatise… from Quaritch in 2001, for rather more than £70.)
For a description of a first edition copy of Sylva with extracts see *Irish Forestry* 31: 171-178.

He has a lovely time at Mount Shannon, his present abode, but has an interest in folk lore, believing (as I do) that even the superstitions have some foundation, perhaps outside the world, and we got on to the foundations of Christianity— "I often wonder whether I would have believed had I lived then that Christ was the Son of God"— and he wondered that the world had been left so long without such a spiritual influence. I read him some scraps of Plato as "Now shall we consider in what way they are to be brought from darkness to light, as some are said to have ascended from the world below to the gods?... The process is not the turning over of an oyster shell but the turning round of a soul passing from a day which is little better than night to the true day of being".

14 June, 1928. Young Gaynor came from his woods inspection, will plant a part of the nut wood between two of my plantings, just what I had intended to do next had I been able to go on with planting, and I'm glad. Also (beginning with Raheen field) pond field. And will not cut any heavy timber at present, and will always spare the fine or exotic trees. All this a happiness, the woods will take on a new vigour & not fade away. He has no books at Mount Shannon & we chose some for him to borrow, *The Downfall* (Zola), and Lord Jim [Joseph Conrad], and Kropotkin's *Memoirs,* and the *Blazed Trail* [Stewart Edward White, 1902[40]], one of those novels recommended by Roosevelt and given me *by the publisher – a novel of U.S.A. forestry; and Erskine Childers' Riddle of the Sands*.

23 June, 1928. A beautiful drive yesterday, [in Co. Wicklow] through hills, with views of distant mountains […] and the Foresters have been working, we passed many plantations.

18 July, 1928. Young Gaynor the forester came and Richard motored him to the train. He is enjoying Riddle of the Sands and had like the Blazed Trail, wondered at it being so well written (on his own subject forestry) a storybook. I told him it was Roosevelt[41] who had recommended it, and the publisher who had heard him do so and sent it and the other books he had recommended, to me next day.

4 August, 1928. The basket maker said to me a while ago "The country is withered out of trees". I am glad our Government is preparing legislation against cutting[42].

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[40] *The Blazed Trail*, by Stewart Edward White tells the story of pioneer lumbermen in the northern woods of Michigan.
[41] Theodore Roosevelt, 1858-1919 26th President of U.S.A.
[42] The control of felling was first introduced in the Forestry Act, 1928.

Michael [Shaw-Taylor] motored me back here. Is vague as to what he will do, […] will sell Garryland[43] to the Forestry Department for £1000, and probably sell land and woods at Castle Taylor but will buy back house and surroundings.

4 November, 1928. Lyon[44] has tempered his Theatre MSS by sending as he had promised a new book on Forestry, *Trodden Gold*[45]. I like it so far; the writer loves trees.

16 November, 1928. This evening I go on reading *Trodden Gold* (a cold giving my conscience an excuse for not going to the Abbey.) The facts he gives about our poverty of trees in Ireland are heart-rending – to me – (I think of Chevy Chase[46], planted by my grandfather or my father in his early days, all but all sold and cut now I think). (19 April, 1929. the Forestry Department have, I'm delighted to know – just bought it). For myself I did my utmost, from the time I began to earn £50 or so in the year, I spent it in planting little patches a few acres, at a time, in the poorer parts of our woods. Robert was glad though I was given the usual warning by others that the country was being sent to the bad by Nationalists, Land Leaguers, Sinn Feiners. And although I had to stop when I took over all the expenses of Coole, my plantings make a good show for their age. And I am happy, very happy, that the Forestry Department has become the owner – "God prosper it". This Trodden Gold is a fine book touching on other things besides this:- "Napoleon…like all outstanding personalities in history did not believe in committees, only in men" […] "Sin is energy developed in the wrong direction" – the right one of course is Forestry!

7 December, 1928. I went out after 12 o'c to the Pairc-na-Tarav, to try for primroses in bud or blow to bring in before frost comes; found a group of men at their meal under a tree, and Mike, who said they have begun clearing the upper part for replanting. It was rather a sudden shock seeing this invasion of the woods' solitude, but Mike says they will not meddle with the thick cover. And I was glad to think that "unemployed" men, ex soldiers most of them – though O'Beirne grumbles at their inefficiency – are earning their 27/- a week. I told Mike what I had come for, primroses, and he said "Ah, there's none, the frost made away with them". But at that moment moving but a step – there was a plant in flower almost under my feet! I brought it in and some others, to finish its flowering indoors.

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43 According to the NUI Landed Estates Database (2009), a Walter Shawe-Taylor was granted almost 1,000 acres in the Barony of Kiltartan in 1667. Garryland, adjacent to the Coole Estate formed part of Gort State Forest in the 1950s.

44 W.G. Lyon, publisher, The Talbot Press, Dublin.

45 *Trodden Gold* by John Mackay (Talbot Press, 1928) author of *Forestry in Ireland* (1934) and *The Rape of Ireland* (1940).

46 In 1953 Chevy Chase was an outlying property of Gort State Forest. It had previously formed part of the Persse (Roxborough) estate.

Figure 1: *Chevy Chase Lodge. Photograph belonged to Lady Gregory, given to Colin Smythe by Major Richard Gregory. Photographer and date unknown. Reproduced by permission of Colin Smythe.*

12 December, 1928. I had been to see Mrs. O'Beirne, in the old Steward's House. Donohue had rebuilt it badly and they are not very comfortable, but she keeps everything tidy and seems a good manager, had brought her two dozen fowl with her. She had been frightened one day by Donohue (who has "gone astray in his mind") coming to the door and demanding entrance, saying it was his house – J.D. supplemented the account – "I was passing myself and I heard him and I came and asked him what did he want and he gave me no answer no more than if he was up in Dublin. But by the mercy of God, Mr. O'Beirne had not his dinner finished and came out, and when Donohue saw him and could not get in he lighted his pipe and went away".

13 December, 1928. I have been this afternoon to Pairc-na-Tarav where the foresters are cutting the ragged useless trees to make a new planting – a great joy to me to see the work beginning again that I had been forced to abandon. And they will plant great spaces, in comparison with my few acres at a time. This will be an interest henceforth. But Jim Mulloo was hurt yesterday by the fall of an oak limb he was cutting but no bone broken.

29 December, 1928. Guy[47] wrote such nice kind words on a card with photograph of the house (he and M. spent Xmas there) "This simple little home of Margaret and hers is always ready for yours. It will always welcome you". So kind, but there is no home for me but Coole, and if I break down, a nursing home.

[47] Guy Gough (1887-1959), Lough Cutra, married Robert's widow Margaret on 8 September 1928.

18 January, 1929. I heard a good many shots yesterday evening as I went to the lake. […] And I was happy that Coole is giving joy again to youngsters of today. […] If I had been able to go on with my little plantings the coverts would be fine as ever now. But that stopped in 1918 when expenses began to fall more heavily on me. I have brought the house safely through but the enrichment[48] of the woods had to be abandoned.

23 January, 1929. Mr. O'Beirne looked in at breakfast time on his way to the woods. I had been to look at the clearing in Pairc-na-Tarav a day or two ago – such a joy to see the work going on *en gros*, [on a large scale] that I had done en Detail [minutely] They have cleared twenty acres there and are about to plant it, as well as Raheen strip and Pond Field, - chiefly with larch [and] spruce, a little beech which he says helps to protect the larch. They will be regularly employing about twenty men, more while planting is going on. Such a help to the neighbourhood, as well as keeping up the tradition of the "Seven Woods[49]"!

5 February, 1929. [While undergoing an operation for breast cancer under local anaesthetic] I tried to keep my mind on the new plantings in the woods, and the happiness the little trees must feel when their roots, dry and packed together from their journey, are spread out in that soft damp leafmould where the clearings have been made, and their branches loosened from the packing. But when a second little avenue of stabs began being made by kind wise Slattery[50] on the old scar, it was rather the spade that came to mind.

8 March, 1929. I had sent to ask Mr. O'Beirne to come and see me, I wanted to know what wages he is giving the men employed in the woods as I would raise Peter and Paddy to the same, they both being vigorous enough for that work. And before he came I was told there is a strike on, he gives 25/- per week, and last week they demanded 27/- (their hours have been lengthened – to 7 o'c) which he refused so they have struck, have not come since except one or two, who with Mike and O'Beirne himself have been going on as best they can, but there are thousands of little trees waiting to be put in and these cannot be handled in time. J. says the strike was got up by a few "bad lads". Coen who

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48 The names of 'the seven woods of Coole' (in anglicised form) are listed by W.B. Yeats in his poem of September 1900 in *The Shadowy Waters*. They are: Shan-walla, Kyle-dortha, Kyle-na-no, Pairc-na-lee, Pairc-na-carraig, Pairc-na-tarav and Inchy wood ('Incha' on Ordnance Survey maps).'

49 Enrichment planting (as a current official FAO forestry term) 'aims to increase the number of desirable plants in the forest with minimal disturbance to the forest ecosystem.'

50 Dr R.V. Slattery, a surgeon at the Richmond Hospital Dublin.

has just come to demand the rates on the little Kincorda field (which is not mine or used by me) says the "lads" who got up the strike are a bad lot, Gort men. Laurence Dooley and others are almost weeping at losing their pay but are afraid to go on. A man at Ballyturin having been fired at and wounded the other day because he went on carting, whereas the strikers there wanted carting put off till they had finished their own work, O'Beirne has now given 27/- with an hour's more work. I have raised mine to 25/- (easier work) and J.D. 27/- and they seem happy.

12 March, 1929. The strike is over, the men at work again.
I've been over to Pairc-na-Tarav; the strike over, groups of lads at work, some planting, some clearing rubbish, to a bonfire, and carts coming for the fuel that is still a godsend. And now six or eight young men on their bicycles whirling past the front door, the breakfast room windows. I called out to them that were these still the disturbed times I should take them for the advance guard of an army.

14 March, 1929. I went to see the planting, now in the pond field, and met a young fellow, a Regan, going home from the work. He looked sad and told me he was setting out next day for Australia – Melbourne. His brother who went there two years ago has found work there and married and sent for him. They are a well-to-do family, living now in Ballinamantane[51], some in the old house. But there seems to be little for these well-to-do families' sons to do, they are above the class of day labourers and there does not seem much else open for which they are fitted. This forestry is the best help yet.

30 March, 1929. I went to see the nursery being planted in sawpit field – there and elsewhere 33 men employed today. And my own three – and two of Raftery's who are whitening the face of the house. Splendid to see so many at work.

12 April, 1929. I finished reading *Maelcho*[52] last night. No, it is not a fine book. The whole later part of the book is of horrors, of the terrible cruelty of the English soldiers, their extermination of the people – and of the trees – the forests.

16 April, 1929. That [grandson Richard and friends riding donkeys], varied by occasional ferretting [*sic*] for rabbits that wouldn't come out

[51] According to Saddlemyer (2011), Ballinamantan (sic) was a dower house opposite the road into Coole. Neither form of the name appears in the Townland Index (Census of Ireland, 1851). Joyce (1869) in his index of root words lists Mantan, Mantach, a toothless person.

[52] A novel by Emily Lawless (1845-1913).

(the Foresters wanting to abolish these enemies of the young trees) or if they did bobbed down again.

18 April, 1929. And after lunch they came out to see out to see the planting of the Forestry nursery – such a happy sight – all those lads at work, one singing, and the tiny trees being put in their lines.

25 April [1929]. A nice letter from Lord Carson[53] approving of delay [in demand for return of the Lane pictures] till after the elections; promising continued help, interested about the planting "which I always thought was a thing to be taken up seriously in Ireland. It is very far advanced on the Duke of Abercorn's estate [Baronscourt, Co. Tyrone.] in the North of Ireland – there it has been carried out by the Government on a very large scale. I think they pay a small rent for the land to the Duke[54] I would like to think of my some day shooting woodcock, especially in Galway".

2 May, 1929. Yesterday I had the O'Beirne children and their mother for the afternoon, Mr. O'B. to tea. He was much delighted, looking through Evelyn's *Silva*, spent his time after tea devouring it.

6 May, 1929. The beauty, the romance of our Seven Woods, the mysteries of our ebbing and flowing lake are dear to me, have been well loved, and are now in hands that will care and tend them it is likely forever.

3 June, 1929. I came back in a hurry from Dublin to settle the great pump question – the old one worn out and on strike – the Galway plumber after a day at it sending an immense list of its requirements – and wanting much help from my men. Millington[55] in Dublin using his knowledge as editor of the *Farmers Gazette* to recommend a new oil one. The Vice-regal car taking me to Government Buildings to appeal to Forbes as head of Forestry for as I said that Department will have a longer life than mine. His rejection of the idea, ending in a promise to send their inspector. Today the arrival of the inspector – with Forbes himself! Inspection of pump, an oil one decided on; cost £60. My offer of £20 towards it coldly received but I think accepted while they had lunch. A great relief; I had shivered at the thought of dealing with the plumber – underground!

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[53] Edward Carson (1854-1935). A native of Dublin. Leader of the Irish Unionists in Parliament (1910), successful in securing the exclusion of the northern six counties from the Irish Free State.

[54] An area of 2,918 acres was acquired by the Northern Ireland Forest Service in November 1920 at an annual rent of 4 shillings (£0.20 sterling) (Kilpatrick, 1987).

[55] Business Manager, the Abbey Theatre.

31 December, 1929. I used to think and say […] that I should like to live to see Richard come of age. And now this has come. […] The coming of age is not now the coming into ownership of his property and home – that were owned by the generations before him. And although I am thankful it is in such hands as those of the Forestry Department there is a little sadness in this.

8 January, 1930. Mr. Robinson, Department of Forestry Engineer – who would not believe when he was choosing a site for the pump that the lake ever rises so high as he was told, came for the night, and this morning inspected it – had to be rowed round it in a boat!

26 January, 1930. A peaceful day except that the grass, on the edge of the drive round the yard is being ploughed up by Mr. O'Beirne's car and I must remonstrate.

28 January, 1930. Such a warm day. I picked a little bunch of violets in the garden. The O'Beirnes here to tea. The little ones happy in the playroom with rocking horse &c and gramophone. And happily I had a box of parlour fireworks for them after tea – a novelty.

28 February, 1930. I explored some of the new plantings in the woods – primroses coming out but the larch has not yet budded. Taking "Old Greeny" - my favourite coat, long condemned by the children, I laid it over the barbed wire before crossing and so came through unscathed.
But my Remington [typewriter] struck work, and at last O'Beirne, having failed to set in going, took it to the Rectory for Mr. Warren's (successful) ministrations.

1 March, 1930. And Huntington[56] having made some slight alteration in proposed codicil making him literary executor [to Lady Gregory's estate] I seized Mr. O'Beirne who called re typewriter, and Ellen, to witness my signature.

13 June, 1930. And yesterday, left alone O'Beirne motored me to Chevy [Chase] for the day. He is looking after a great deal of the work there, preparation for planting. The poor house a ruin[57], the thatched roof fell in some time ago. All lovely still, hill and bog and the trees that escaped the cutters in the war years. The O'Beirnes went to inspect the gangs at work. I sat by the river, where our boy parties used to fish. And

[56] Publisher, Putnam & Co. Publisher of the abbreviated version of the Journals, edited by Lennox Robinson, 1946.
[57] In the 1950s the ruin was in use as a tool house for the Chevy Chase property of Gort Forest. A photograph of Chevy Chase hunting lodge, about 1890, appears in Pethica 1996.

I looked at what might have been a scene from the Canada storybooks. The bridge had fallen, only the great pier in the centre of the river left standing. And presently a lad led a horse to the water and fastened a log, the whole trunk of a tree, to it with a chain, and then rode it through the river to my side, and unchained the log, and went back for another, and so on. I sat for a long time looking at this work and listening to the murmur of the river. A lad I spoke to said he was a grandson of Jimmy Burke who was caretaker when we children used to come and stay at Chevy. They are all delighted at the work that is being given. Then, 12 o'c they stopped to light a fire and sat near it for their meal. And I went back to the car and when the O'Beirnes came we opened my basket and had lunch. There were masses of rhododendrons in bloom.

13 July, 1930. Too wet for church and I am not sorry – for I am very tired having had the O'Beirnes for raspberry picking yesterday afternoon.
[…]
But one thing has cheered me. I asked O'Beirne if the Forestry Department would be likely to use this house should it be given up after my death. He thinks they would use it. They are extending their work – Slieve Echtge [Aughty], Woodford, Connemara – And this place so rear the railway station would be quite a good centre. He asked if someone of my family would not keep it, but I said that is very unlikely. […] I dreaded the likelihood of this home, where so many I have cared for have lived and been happy, falling to ruin, unroofed, unsightly. But as a hive of industry, the woods increasing and flourishing, there would be no degradation, it would have the dignity of a centre of the Forestry that will hold pride as well as future profit for the countryside.[58]
Parnell's Avondale is already used in this way, for Wicklow. And if at night I am still "plagued with aches", this will be a tranquillising thought.

21 January, 1931. I had he best of it for he[59] & I had a good talk on re-afforesting Ireland. He has had a report – a very strong one written on its necessity, he had given me to read. And next day as I left, to take the car to the Talbot Press the first time in green! And went in – asked if Mr. Lyon was there. "He is, and there is no one he would like better to

[58] Following a Government decision the house was sold for demolition in 1941. 'The Irish government had considered using it as a military hospital, but the local surveyors who looked over it considered that it was in such a state of neglect, after being empty for nine years, that the cost of making it habitable again would be too great to justify the expense' (Smythe 1983). Information from Gerry Keane of Keane's Merchants, Bridge Street, Gort, who was one of those sent to assess its condition. 'Evidently the lead must have been stolen recently as Catherine told me [Colin Smythe] that she and her husband had been up there less than 6 months before when it was as dry as a bone'. (Smythe 2004)). The decision to sell was therefore not made by the Forest Service as is often implied.

[59] James MacNeill, (1889-1938), Governor General 1928-32.

see than you, Lady Gregory!"
And when he came in I told him of the G.G.'s interest in planting, & that I would like him to see that fine book printed by them "Trodden Gold". He would not let me buy it, said he would give it – & so I wrote on a slip of paper above their printed "Talbot Press" "Presented to H.E. the Gov General from the (printed) *TALBOT PRESS* through the mediation of Lady Gregory" And I gave it to the chauffeur to take back to the lodge.

24 January, 1931 A letter from the Governor General thanking me for my share in sending him the *Trodden Gold*: "I have had time to do no more than look at it & read a few pages. I hope I have also done something that will please you even more than a sincere letter of thanks for your kindness. Mrs. O'Sullivan, wife of J.M O'Sullivan, Minister of Education, told me that her son[60] was interested in forestry & wanted to be a State forester when he finished his University Course. I thought that you would be pleased, for many reasons, and that Ireland would not be harmed if I had another copy sent to him (young O'Sullivan). The Talbot Press have done so. I am vain enough to think that I have done unobtrusively just what you would wish."

26 January, 1931. EV[ening?] Finding a gate open I walked through Pairc-na-Laoi – all except the few great beeches and except the ash saplings, my own planting – larch chiefly – & the silver – far above my head now & grown up from childhood to adolescence. I looked at them with pride. Some clearing of hazel and of rubbish around is needed & will come in good time.

10 February, 1931. Ld. Monteagle[61] came for a couple of days and I was anxious he sh[oul]d. See the Forestry work – and O'Beirne took him for a 3 & a half hour walk, through Pairc-na-Tarav & to Isabella[62] & to Inchy.

20 March, 1931. And a word about forestry. [In a speech to a University banquet, in London. Details not specified.]

30 March, 1931. And glad as I am that our woods are in the hands of the Forestry Department – their quiet & beauty is being of necessity spoiled – for the sake of more profitable future – & present – planting.

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[60] Sean M. O'Sullivan, (1912-64). B.Agr.Sc. (Forestry) 1934. Chief Inspector, Forestry Division, Department of Lands, 1948-64.

[61] Thomas Aubrey Spring Rice, 1883-1934, 3rd Baron Monteagle of Brandon.

[62] The name 'Isabella' for a section of the woods was still in use in the 1950s, but pronounced (by the forest workers) 'eyes-abella'.

4 April, 1931. For Easter I've sent rhubarb, the first to Mrs. O'Beirne. […]
A little drama this evening. I had been told by two "persons" that Ellen [a maidservant] was receiving young men in the evenings.[…]
May came to the drawing room about 7 o.c. & said two young men wanted to see me – Hayes and Baldwin – the two guests spoken of. I went down. They said they had heard I was told they had been coming here & assured me they had never done so. I said I had never mentioned their names – and asked Hayes if it was not a cousin of his who was in the S. African Police – & he said yes – & I told him of the letter he had written me about his reception by the Pope on his visit to Rome – a private audience at which he had received his Holiness blessing – & had rosaries blessed (as I had done on my presentation to LeoXIII (?) [*sic*]. And I told of the photograph he had sent me of himself standing alone with St. Peters as a background […] So we parted on good terms – they had been glad to see in the papers that I had spoken at the University dinner. They praised the Forestry work, though the poor lad killed by fall of a tree at Athenry was a cousin of one of them. I had heard his father was not given compensation because the boy was under the age when woodcutters sh[ou]ld be engaged. But they said it was all right, his father had got £100 "it was Mr. Hogan managed that". They are to come & see me again when the apples are ripe. Rather a pleasant little meeting – & I repaid for saying I had never mentioned their names as being on Ellen's list.

4 September, 1931. Had O'Beirnes to tea. – a few bunches of grapes ripe enough to please the children. Very lame still.

24 April, 1932. A mild day – and more colour in the beech leaves in Shanwalla.

End of Journal Extracts

The final entry in the Journal is dated May 9, 1932.

Lady Gregory died early in the morning of 23 May 1932 and was buried in the New Protestant Cemetery in Galway (Hill 2005).

In the 1980s ownership of the Coole and Garryland properties of Gort state forest was transferred from the Forest Service to the Wildlife Service of the Office of Public Works (OPW) and in 1996 the Coole Park and Garryland Nature Reserve was constituted. It was not possible to consult later records relating to Coole and Garryland, whether held by Coillte or by the National Parks and Wildlife Service, Office of Public Works.

Acknowledgements

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Library, Astor, Lenox & Tilden Foundations. Reprinted here by permission of Colin Smythe on behalf of the copyright holders. Colin Smythe also provided valuable additional information. Hilda MacLochlainn, Supervisor Guide, Coole Park, supplied up-to-date information on the buildings at Coole.

I thank Maureen O'Flanagan for drawing my attention to Saddlemyer, 2011.

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Four redwoods and Funerals[1]

John Joe Costin
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Foreword

While the contribution of conifers to the native flora is limited to possibly three species, *Taxus baccata* L., *Juniperus communis* L. and *Pinus sylvestris* L (and there is some debate as to whether or not Scots pine is native to Ireland), their contribution to the exotic flora in this Country is in excess of 230 species. This contribution represents the conifers of the temperate regions of the world, China, Japan, Australia, New Zealand, South Africa and western North America, Chile and Europe. They include the common genera of *Picea, Abies* and *Pinus* (Pinaceae) which are grown for timber production and for ornament in gardens, parks and open spaces. Less common and generally confined to specialist collections, such as those at Mount Usher and Kilmacurragh in Co. Wicklow, are members of the Taxodiaceae. The Taxodiaceae comprise a family of 10 genera of evergreen and deciduous trees. The most common is *Sequoiadendron* (giant redwood or Wellingtonia) with their tall spire-like habit visible from a distance above other trees. Of the genera described by John Joe Costin, *Metasequoia glyptostroboides* (Hu & W.C. Cheng) has become an important fast-growing amenity tree. In Dublin there are examples on the Dundrum bypass. In London, a 1 ha garden, Jubilee Park, constructed over a car park, was planted with mature specimens of the tree. A long cry from their native habitat, as described in this article by John Joe Costin.

Mary Forrest
UCD School of Agriculture and Food Science

Seeing a plant growing in the wild in its native habitat deepens my understanding of its growing needs and offers evidence of how it should be used in landscapes. Some plants make an indelible first impression. It may be the location, its companion plants, fortuitous timing, a peak moment in its ornamental phase or simply the circumstances of how the plant revealed or presented itself.

Japanese umbrella pine (*Sciadopitys verticillata* (Thunb.) Sieb.)

What was memorable about the umbrella pine was the sheer sense of its difference. I was looking at a relict that has been around for 250 million years. It has distinctions. It is not a pine at all. It has no immediate relatives, being the sole species in the Sciadopityaceae family. It occupies a botanical family alone. It is like no other plant. It is a remote member of the redwoods (family Cupressaceae) with redwood-like cones.

I did not find it in the wild. Roy Lancaster (former curator of the Sir Harold Hillier Gardens, Hampshire and a renowned freelance writer, plant explorer and broadcaster)

[1] This article is reprinted, following some modification, with permission from the Irish Garden Plant Society (December 2010 issue).

and I were taken by Professor Mikinori Ogisu (Chengdu University, China) to see it growing in small groups on steep, mossy slopes and rocky ridges in a remote wooded area in central Honshu, Japan in the shade of some broadleaved trees. Mikinori said that it grows best where it enjoys high summer temperatures, plenty of moisture, shade, perfect drainage and rich forest soil. We stood in a silence induced by awe of the venerable. Mikinori said that it is not a good competitor in Japan and that the excessive competition drove it out of more favourable sites, but similar to the redwoods it survives in difficult habitats because it can tolerate poor soils. Nevertheless, it has 'travelled' well, is hardy and is a great success in the landscape and gardens of Europe and N.E. America, tolerating even the winter cold of Massachusetts (Mitchell 1987).

Mikinori, a great modern-day ethnobotanist and explorer, was the first foreign botanist permitted to stay in China (following détente in 1973). He has spent a long time in China and completed a floral survey of Mt. Omei, a sacred mountain in Sichuan where he identified 200 endemics among the 2,000 species-rich flora. He showed us that it has two types of leaves, small scale leaves pressed against the shoot and at its end an umbrella-like whorl of 20-30 stiff flat leaves (10-15 cm long). This arrangement inspired its botanical name, Shiados, Greek for umbrella and pitys for pine. He showed that each compound leaf is composed of a pair of fused leaflets, as evidenced by the grooved surfaces that lacked a keel. Distinctive but similar, this ancient type of leaf arrangement has been found in fossil samples.

Its growth habit is distinctive, dark green, lustrous foliage and texture that make it an elite tree. It should be more widely used as an accent plant as it is one that will not outgrow its space. It has a neat, upright, densely clothed, pyramidal habit that does not flatten out to form an umbrella-like canopy, as its common name might imply. Easily raised from seed, it takes about six years to reach 30 cm. Price usually reflects age, but even so it is considered expensive for its size. Prized by discerning gardeners, it does not meet the needs of the large sector of the market that demand "fast growing dwarf conifers", 9 m in 50 years and 30 m in 250.

The umbrella tree is cultivated in 12 of the 30 Great Gardens of Ireland (Forrest 1985). The Tree Council of Ireland (1985) list Champion Trees in:

Location	**Girth (cm)**	**Height (m)**
Glenville Park, Co. Cork	210	14.0
Recess, Co. Galway	124	13.0
Curraghmore Co Waterford	224	16.0

The Curraghmore tree was 14 m tall in 1976 and 30 years later it was 16 m tall, a rate of growth of less than 7 cm a year.

Anthropologists have concluded that man is the only creature that is known to bury its dead. Burial was not for hygiene reasons, but it represented a belief that the death of an individual did not signify the end of his or her life. It also symbolised the preparation for an onward journey. The poor wrapped bodies in cloth or hay; the rich commissioned limestone sarcophagi, in places where trees were not common, such as

Egypt, but the majority used coffins made of wood. Primitive people split a tree trunk and hollowed it out. Particular woods were favoured by different people, the choice of depending on local availability and cultural tradition. Some selected the wood for its aroma, resistance to decay or durability in water.

"What was the coffin?" was, I recall from childhood in Ring, Co. Waterford, a question asked about every funeral. An oak (*Quercus*) coffin was the affirmation of wealth or status. Elm (*Ulmus*) according to Eldin was the traditional timber for coffins in England (Edlin 1964). In tropical Japan and China camphor wood, prized for its scent and durability, was the timber of choice for coffins (Scott 1980). Currently, wickerwork woven from willow (*Salix*) are the coffins of fashion among environmentalists. On botanising expeditions down the length of temperate Japan and across Sichuan in China, we were exposed to the remarkable coffin culture of the indigenous people. Timbers of four different redwoods meet their needs.

The umbrella pine enjoys exclusivity. It is the wood of choice for making coffins for members of the Japanese Royal Family. This designation has symmetry. The oldest trees of one of the most ancient coniferous species are held for making coffins for the oldest imperial lineage (2,500 years). It is a strong, straight-grained, soft, elastic and almost white wood when cut, which matures to a light brown. It is comparable to the best spruces.

***Japanese cedar* (*Cryptomeria japonica* (Thunb. ex L.f.) D. Don)**

The ordinary person's coffin in the subtropical south of Japan is made from the scented wood of the camphor tree (*Cinnamonum camphora* Nees). Elsewhere coffins are made from the timber of Japanese cedar, known locally as the Sugi tree. It is the dominant timber tree in Japan where nearly 70% of the land area is covered in forest, one of the highest proportions of forest cover in the world. They pioneered the concept of forestry as a slow growing crop. Despite Japan's high population density, Japanese people identify strongly with trees.

Many past plant hunting expeditions to the Orient were motivated by profit. Wealth and fame was promised to those who could determine a new use for a plant in the west. Thomas Jefferson claimed that the "greatest service that could be rendered to any country was to add a useful plant to its culture". Each plant collected and catalogued was assessed for its novelty value and especially for its possible utility. The timber potential of exotic conifers was promoted by selecting a common name to show an association with one of the three important, well-known timber conifers in Europe; fir (*Abies*), pine (*Pinus*) or the prized cedar of Lebanon (*Cedrus libani* A. Rich.). The emphasis was on marketing economic potential, not botanical accuracy. Japanese cedar was first described by Kaempfer in Japan in 1697. Two geographical forms are distinguished. *Cryptomeria japonica* var. japonica is the Japanese form (Bean 1970). Robert Fortune, while in China for the Royal Horticultural Society, was the first to collect seed of the Chinese form of *C. japonica var sinensis*. He sent large quantities of seed to England in 1844. Introduced as Japanese cedar, it is in fact not a cedar, but is a redwood that is most closely related to the giant redwood (*Sequoiadendron giganteum* (Lindl.) J. Buchholz).

Cryptomeria is a 50 m tall, neat pyramidal tree in its native forests. In the landscape, its profile is as elegant as the giant redwood and is valued as an ornamental. It is one of the notable trees planted in the precincts of its many Buddhist temples and Shinto shrines. It forms no less than a 32 km-long avenue to the 8th century Nikko Shrine, which is on the east coast, north of Tokyo. It was planted in the mid 17th century when the shrine was redeveloped as the site for a Mausoleum to Tokuyama Ieyasu, the warlord founding-father of modern Japan. Fine specimens of this species growing in our damper coastal counties, according to The Champion Tree records (Tree Council of Ireland 2005) include:

Location	**Girth (cm)**	**Height (m)**
Fota Arboretum Co. Cork	270	34.0
Lough Rynn, Mohill, Co. Leitrim	325	24.0
Curraghmore, Co. Waterford	549	28.5
Cappoquin	519	30.5

Like the umbrella pine, it is the sole species in its family. The wood is scented by volatile oils, is easily worked, durable and highly ornamental in colour and grain. It has never been important as a forest tree in Ireland. It is known to perform poorly on heavy clay soils, and the lack of sufficient summer heat in Ireland may have restricted its use. In the comparative forest tree trial planted from 1904-1913 in Avondale, it suffered extensive frost damage, was of poor form, forked and did not produce sawlog material (Carey 2010).

This species is recorded in 16 of the Great Gardens of Ireland (Forrest 1985). *Cryptomeria japonica* 'Elegans', listed in 21 garden records, is more popular and is the form we normally encounter, selected strictly for its ornamental novelty of its foliage turning purple in winter. Its feathery juvenility is retained permanently. There are many cultivars in Japan but few have attained popularity here. The Irish Champions are:

Location	**Girth (cm)**	**Height (m)**
C. *japonica*, 'Cristata' Castleforbes, Co. Longford	257	24.5
C. *japonica*, 'Viminalis' Lissadel House, Co. Sligo	133	11.0

Cryptomeria japonica 'Sekkan Sugi' (Snowtopped cedar) refers to its new lemon white growth. Is a graceful, slow growing, form with hanging branchlets, with soft, lemon-yellow foliage. Costin's Nursery introduced it in 1982. It is regarded as the best cultivar for Irish Gardens. Our 25 year-old 4 m specimens command attention. The first plant released was a 2 m specimen donated to the RTE Telethon Charity Auction in 1992 and sold for £10,000. That price gave it unwarranted attention exclusivity that effectively discouraged further inquiries or sales.

Chinese fir (*Cunninghamii lanceolata* (Lambert) Hooker)

This species is the most important forest timber tree in China, ranking second only to the bamboo in volumes harvested and in its versatility of use. The highly prized wood is light, soft, fragrant, pale yellow or almost white, easily worked, durable and rot resistant where in contact with soil. Most Chinese are buried in coffins made of its scented wood. We were familiar with its wood in grocery stores of old, as virtually all the tea in China was exported in chests made of its wood. It is the first wood I got to know; a recycled tea chest was the standard means to confine crawling babies in farmhouses long before colourful Mothercare playpens were affordable.

The species name honours James Cunningham, a minor and largely forgotten plant hunter. He is credited with introducing the first plants from China in 1698. He collected specimens of it on the Island of Chusan, near Shanghai in 1701/2. I am of the opinion that he was an accidental botanist. He was a surgeon at the East Indian Co. based in Canton. Officially Britons could not travel outside the warehouse bases to which they imported opium (illegally) into China and from where they exported tea to London. They were incentivised to procure whatever plants they could by the expectant market for exotic plants back in Europe. We can only speculate about the incongruity of the genus name given. It is wrong that so many species were named after European explorers, whereas the names used should have honoured the many great Chinese botanists. The botanical name given to Chinese fir was no exception to this.

China was a conundrum. Undoubtedly it was an Empire, but it was built on religion values and was a system alien to the British explorers. It had an Emperor, a hierarchy and was administered by a meritocracy recruited through a 2000 year old mandarin examination system that selected the best and the brightest irrespective of class, wealth, or place of birth. It would be another 140 years before it was realised that the British tradition of naming new plants after the explorers was insensitive to the feelings of the natives. For example, the Americans took umbrage and resisted Kew Gardens' proposal that one of their great trees should be called Wellingtonia, after an Irish born Duke from Trim, Co. Meath.

The foliage of Chinese fir appears to be prickly, but in fact it is pliant. Superficially, it resembles the monkey puzzle (*Araucaria araucana* (Mol.) K. Koch). It is neither, but is another redwood with similar type cones and the characteristic soft, spongy, red bark. It makes a pyramidal tree to 50 m with horizontal branches pendulous at the extremities. The leaves, with two white stripes underneath, turns bronze in winter, are spirally arranged as is characteristic of all redwoods. Its ornamental disadvantage is that the tree does not shed its five year-old leaves when they die, giving it a detracting ragged but exotic appearance. Like *Sequoia*, Chinese fir trees tend to regenerate at high densities. As with *Cryptomeria* it has the inestimable asset of regenerating by coppicing and the sprouting of new growth after cutting or burning. Thus, the extensive Chinese fir forests in Japan and China regenerate readily.

However, on a number of seed collecting expeditions in the 1980's, Lancaster (1989) observed that it was widely planted in western Sichuan. It grows in central, western and southern China in the mountain valleys of Sichuan, Hubei and Yunnan. Travelling in Sichuan in 1993, I saw extensive forests and clearfell harvesting, an entire 35 km stretch was denuded on the steep slopes on each side of the Yalong River, a tributary of the Yangste. Wind exposure adversely affects the growth of *Cunninghamii*. I observed that some roof tiles on houses were slightly askew and I was told they lay roof tiles on battens but that there was no need secure them with nails because wind speeds were generally low. *Cunninghamii* is also vulnerable to late spring frost damage and grows ideally in warmer and wetter conditions than that provided by the mild and damp Irish climate.

The species is recorded in 10 Great Irish Gardens; Birr, Castlewellan, Dunloe, Guincho, Headfort, Ilnacullin, J.F Kennedy Arboretum, Mount Congreve, Mount Usher and Powerscourt (Forrest 1985). It is grown by Leahy's, a wholesale nursery, who supply stock to Garden Centres. Champion Trees are recorded at:

Location	Girth (cm)	Height (m)
Castle Forbes, Co Longford	74	9.5
Mount Usher, Co Wicklow	308	25.5

Dawn redwood (*Metaseqouia glytostroboides*)

The redwood family that was once widespread throughout the world is now represented by relict species. From the fossil records in North America, the Black Sea area and China, it is known that at least 12 other redwood species existed. One species grew within the Arctic Circle and another was found in Australia. It was in 1941 that Professor Shigera Miki, a Japanese palaeobotanist, identified and named the new genus Metasequoia to describe some fossil found in Japan from the Pliocene period (1.6 - 5 million years ago) that were until then confused with *Sequoia* and *Taxodium*. Its leaves are opposite, whereas they spiral around the stem on other redwoods. Metasequoia fossils have since been found in North America, China, and Greenland.

In 1944 a forester discovered a tree new to him in Sichuan Province (Hawes 1989). He took it to Professor Z. Wang of the Central Bureau of Forestry who was unable to identify it. He took them to Professor W.C. Cheng at the National Central University of Chungking, China. Confused and intrigued, he sent his student Hsuch Chi-Ju to collect more complete specimens, including branches bearing male cones. They realised it was a new species, identical to the tree fossil recently described in Japan. They published their findings and sent specimens to two American tree experts. Ralph W. Chaney, Professor of Palaeobotany at the University of California found the samples remarkably similar to fossils he had found in Oregon. Professor Merrill (Director of the Arnold Arboretum in Harvard University) was the other recipient. Hsuch Chi-Ju returned to measure the tree. It was 37 m tall with a girth of 7 m. On his second visit he was directed to another village (Shu-Se-Pu in the Hubei Province), 48 km away when he found thousands of trees. The villagers fed its foliage to their cattle as fodder!

In 1947 a group of Americans visited the area and fortuitously collected a large number of specimens and a great quality of seed. In early 1948 they distributed seeds to all leading botanical institutions around the world. This may account for the rapid spread of the species worldwide. Within months, Mao's Red Army was in power and travel to the area was forbidden. When exchanges commenced in the late 1970's there were already sizeable specimens in many places. It is now widely planted along roadsides and as a street tree in China.

There is no ambiguity on the botanical identity of the fossil tree, but there is an intriguing question to be answered as to how and why a tree which had a worldwide distribution became extinct except in one small remote mountainous location in SW China. In an attempt to answer this question, since 1973 hundreds of scientists from a range of disciplines descended on the area to study its habitat and people. In 1993 I got an opportunity to travel in this area with Roy Lancaster and Mikinori Ogisu. To do so Mikinori had to procure 13 licences. We were accompanied by two government minders. We had to report each night to the local police station in the area we were in, presumably for safety reasons. There were no hotels in the Yi area. We over-nighted in a network of government hostels built to accommodate visiting mandarins. They were simple, distinctive and their design was as recognisable as the National School in rural Ireland. Each had an open outside stair and hallway, concrete floor and bedrooms with tubular-steel bed frames and wire sprung base with a water jug, basin and chamber pot. We were prohibited from taking photographs of military installations, which included footbridges and graveyards.

Mikinori pointed out that *Metaseqouia*'s distribution in the mountainous SW China is confined within the land area occupied by the Yi people. Numbering 14 million, they are recognised as one of 58 minorities in China and are classified as of Austro-Asiatic origin and speak a distinct language with Tibeto- Burman roots. Tall, thin and narrow headed, their physiognomy is distinct from the dominant Han. Yi society is structured on a caste system, identifiable by a dress code. Their economy was based on barter, using salt as a currency and they practised slavery. Despite Chairman Mao's claim that he abolished slavery, they lived in an autonomous area from which foreigners were excluded. We entered their area via a manned barrier border crossing. We dined with their leader, visited their Ethnographic Museum in Leshan and a Shaman read a religious text for us from a 300 year-old book of parchments. They wash ceremoniously on three occasions in their life; at birth, marriage and death. They are hoe-using farmers, cultivating on steep slopes crops of potatoes, hill rice and buckwheat. We observed them going to the slopes with their 'transistor radio', a songbird in a cage!

Mikinori then made four observations. China had been botanised extensively over the previous 400 years. It seemed plant hunters could not have missed such a distinctive tree, particularly in the two provinces of Sichuan and Hubei. These were and are of primary interest to Europeans, as most of the Chinese plants in our gardens are native to these two provinces. Secondly, Mikinori claimed that plant hunters avoided this area, warned off by their Chinese guides by the fear of enslavement. *Cunninghamii* does not grow in these areas. Thirdly, the Yi people make their coffins from *Metasequoia* wood. Fourthly, to celebrate the birth of a child they take a hardwood cutting of this tree and stick it into the ground. In effect, they plant the tree that will provide the timber for their child's coffin.

Seeds are the most efficient means of propagating most conifers. Few conifers strike from hard-wood cuttings, *Metasequoia* is an exception. Kelly, in trials conducted in

Kinsealy, confirmed that up to 80% of cuttings taken from one or two year-old shoots, rooted within 12 weeks. Although it can readily be raised from seed, hard-wood cuttings are the favoured means of propagating new stock in most parts of the world.

Although the observations described above are intriguing, it is important not to over speculate when there is insufficient evidence to support the claims made. The youngest *Metasequoia* fossils are about 2 million years old. It is thought that *Metasequoia* became extinct in Japan 700,000 years ago. Peking Man, discovered in 1927, places the evidence of the oldest human habitation in China at 350,000 years. So the role of man in perpetuating the dawn redwood in this area still remains to be revealed from anthropological and other records. Human activity can be traced back two million years through Museum-held man-made objects. It is not unreasonable to assume that the study of such objects may yet reveal the answer to this question.

Dawn redwood was coined as a common name for what the Yi called the swamp larch. Like its next of kin (but much younger), the swamp or bald cypress (*Taxodium distichum* (L.) Rich.), it too thrives in water, damp ground and in ordinary soil. It grows much faster than *Taxodium*, it colours well in the autumn, develops a fluted bole like it and forms a distinctive pyramid growth habit. As it ages, it may take on the mature characteristics of a splendid irregular head of the original tree. Its only drawback is that the young leaves are vulnerable to damage in areas prone to late frosts. That was my experience when I planted 200 m long avenue with 3 m tall trees in a frost pocket in Co. Kildare in 1973. My splendid landmark imaginings regressed into the ground within three years.

Sichuan is the most populous state in China. Its land area approximates to that of Japan. Given that the *Metasequoia* native habitat is located on the same latitude (30° N) as New Orleans and Cairo, it would have been adventurous to predict that it might succeed well in the wide range of locations where is has been established. It grows well above 1200m. Its companion trees include *Liquidambar formosana* (L.), *Cercidiphyllum japonicum sinense* (Siebold), *Quercus engleriana* (Seemen) and *Q. glauca* (Thunb.), *Sassafras albidum* (Nutt.) Nees and *Acer palmatum* (Thunb.) *tsuma*. None of these perform nearly as well as *Metasequoia* in our climate.

Mary Forrest confirms the popularity of the dawn redwood, recording it in 26 of the 30 Great Gardens in Ireland. The Champion Tree records confirm that that it grows rapidly and is well suited to Ireland.

Location	Girth (cm)	Height (m)
Mount Usher, Co. Wicklow	211	21.5
Lismore Castle, Co. Waterford	292	15.0
Belfast Botanic Gardens, Co. Antrim	207	16.5
Red Hall, Co. Antrim	270	16.5
Ballylickey, Co. Cork	249	15.5
Headfort Golf Club, Co. Meath	286	19.5
Belvedere, Co. Westmeath	205	18.0
Newbay House Hotel, Co. Wexford	245	17.0

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Return of the Forestry Show: Birr 2011

Donal Whelan and Donal Magner

Approximately 5,000 visitors attended the Irish Forestry, Woodland and Bio-energy Show on the grounds of Birr Castle Estate on May 6 and 7. It had been 14 years since the previous Forestry Show was held in Kinnitty Castle, Co. Offaly, then organised by the Society of Irish Foresters. Even during a time of economic uncertainty, the forestry sector demonstrated that it remains resilient and positive, and highlights the emerging economic importance of the forestry and timber industry.

The Society of Irish Foresters produced a special souvenir edition of its newsletter *The Irish Forester* for the show. It included a site map and background information on the Association of Irish Forestry Consultants (AIFC), which represented the Society and the forest consultancy profession at the show. AIFC welcomed visitors at their stand and distributed the newsletter as well as promoting their website (www.aifc.ie) which Sean Lenihan, Chairman of AIFC said "is the first port of call for foresters, growers, the press and other stakeholders who need the latest information on developments in the Irish forestry and forest products industry". The Society, through AIFC, is represented on many strategic and policy-making forestry forums including the Forest Service Liaison Group, the Forest Policy Review Group and regular meetings between the Forest Service and the Irish Forestry and Forest Products Association, the forestry group within IBEC.

Speaking at the launch of the show, Shane McEntee, Minister of State with responsibility for forestry, said that the event was important in promoting the forestry and bio energy sectors. "Not only does the show allow those in forestry and bio energy to showcase their industries but it provides the general public with a valuable opportunity to get an insight into the sector and gain information on our national woodland resource," he said.

The Irish Timber Growers Association were involved in promoting the Show and also hosted the conference centre, which featured stands from universities and research groups showcasing the economic, environmental and social benefits of forestry. Walk-in displays were hosted by the groups which included the CARBiFOR Project Team from UCD, the COFORD FORECAST Project Team from UCD, the PLANFORBIO Project Team from UCC and TCD, the Irish squirrel and pine marten project from UCG, the Coillte Recreation Team, the Irish Forestry and Forest Products Association, PEFC Ireland and presentations by Forest Service staff on the EU Regulation which lays down the 'due diligence' obligations of operators who place timber and timber products on the market. Sean McGinnis, of *Ecoplan Forestry*, also gave an introduction to Birr Castle Estate woodlands and their management.

Outside the centre, all the major forestry companies were present as well as harvesting and other forestry machinery distributors. The farming community was also well represented through the Irish Farmers Association. *The Irish Farmers Journal* featured a seven-page supplement on the show.

Demonstrations were carried out by harvesting contractors and distributors while the first Irish National Tree Climbing Championships were organised by the Irish Tree Care Association. Sponsored by Husqvarna, the surprise winner of the Masters' Challenge was Philip Annett – a young novice – who held off Bill Blyth who was second, followed by the Stevie Donaghy. The Bwyellwyr Gwynedd Axemen from Wales performed their breath-taking demonstrations of lumberjack skill with axe and crosscut saws.

The Show organiser, David Wilkinson, deserves credit for his input in making the event a success. He was encouraged by the positive feedback from the event and has already committed to organising the next Show in May 2013 and hopes to continue alternating the event every second year with the UK show.

The axemen from Bwyellwyr Gynedd put on a thumping display.

Tom Nixon demonstrated horse logging techniques using his Ardennes heavy draught horses.

Joe Gowran demonstrates charcoal making. He is also involved in coppicing projects such as the ecologically important native woodland St. John's Wood in Co. Roscommon.

John McLoughlin, President of the Society of Irish Foresters (right) with the Green Belt team: Seimié Hagan, Seamus Gavigan Maurice Ryan.

Trees, Woods and Literature - 35

The bushy leafy oak tree
is highest in the wood,
the forking shoots of hazel
hide sweet hazel-nuts.

The alder is my darling,
all thornless in the gap,
some milk of human kindness
coursing in its sap.

The blackthorn is a jaggy creel
stippled with dark sloes;
green watercress in thatch on wells
where the drinking blackbird goes.

Sweetest of the leafy stalks,
the vetches strew the pathway;
the oyster-grass is my delight
and the wild strawberry.

Low set-clumps of apple trees
drum down fruit when shaken;
scarlet berries clot like blood
on mountain rowan.

Briars curl in sideways,
arch a stickle back,
draw blood and curl up innocent
to sneak the next attack.

The yew tree in each churchyard
wraps night in its dark hood.
Ivy is a shadowy
genius of the wood.

Holly rears its windbreak,
a door in winter's face;
life-blood on a spear-shaft
darkens the grain of ash.

Birch tree, smooth and blessed,
delicious to the breeze,

high twigs plait and crown it
the queen of trees.

The aspen pales
and whispers, hesitates:
a thousand frightened scuts
race in its leaves.

But what disturbs me most
in the leafy wood
is the to and fro and to and fro
of an oak rod.

These lines are taken from *Sweeney Astray* by Seamus Heaney, which is based on *Buile Suibhne* (The Madness of Sweeney), a bilingual edition by James George O'Keeffe, first published in 1913. Extracts of O'Keeffe's translation were featured in 'Trees, woods and literature' in *Irish Forestry* (1969). The basis for O'Keeffe's version is a seventeenth century manuscript, composed between 1200 and 1500, but Heaney believes "the thing was already taking shape in the ninth century" (Heaney, 1983).

The Sweeney of the poem was the Ulster King of Dal Araidhe (anglicised to Dal-Arie by Heaney) and son of Colman Cuar. He appears in various guises in the work of writers as diverse as Brian O'Nolan (Flann O'Brien), Tom McIntyre, Austin Clarke, John Montague, T.S. Eliot and Joseph Heller. However, Heaney who was awarded the Nobel Prize for Literature in 1995, is the first poet since O'Keeffe to embark on a major translation.

His interest in Sweeney, which began when he read extracts from Kenneth Hurlstone Jackson's A Celtic Miscellany, prompted him to explore early Irish texts leading to the O'Keeffe's translation (O'Driscoll, 2008): "My encounter first time round was more with the English on the right-hand page of O'Keeffe's edition than with the original on the left."

Heaney (1983) says his "fundamental relation with Sweeney … is topographical". Sweeney's kingdom was located around south Co. Antrim and north Co. Down. For 30 years, Heaney "lived on the verges of that territory, in sight of some of Sweeney's places and in earshot of others – Slemish, Rasharkin, Benevenagh, Dunseverick, the Bann, the Roe, the Mournes" *(ibid).*

He began the work when he set up home with his family in Glanmore near Ashford, Co. Wicklow in 1972. However, other literary commitments intervened and he parked the translation – "sixty pages in the drawer" (O'Driscoll, 2008).

Living close to the Devil's Glen Wood may have influenced his decision to persevere with the translation. He describes his walks in the Devil's Glen as "like fossil fuel, a kind of reserve tank that the spirit can switch over to when its resources are low" (Magner, 2004). During his break from Sweeney, the wood, which is clearly visible from his home, acted as a backdrop to his series 'Glanmore Sonnets' from Field Work (1979):

Out on a field a baby rabbit
Took his bearings, and I knew the deer
(I've seen them too from the window of the house,
Like connoisseurs, inquisitive of air)
Were careful under larch and May-green spruce …

When Heaney moved to Wicklow he was living in "a country of woods and hills," and on the verge of "Sweeney's final resting ground at St Mullins" (Heaney, 1983) in the neighbouring county of Carlow so he always knew he would "come back to it" (O'Driscoll, 2008).

The name 'Sweeney' also resonated with his childhood memories of "a family of tinkers, also called Sweeney, who used to camp in the ditchbacks along the road to the first school I attended" (Heaney, 1983). The name lingered with him for many years even after the translation. In his interview with Dennis O'Driscoll (2008) he discussed how it appears in his "group of poems in *Station Island* called *'Sweeney Redivivus'* where 'Sweeney' is rhymed with 'Heaney', autobiographically as well as phonetically". It was inevitable therefore that he would return to Sweeney (Heaney, 1983): "One way or another, he seemed to have been with me from the start."

The work which is a mixture of poetry and prose begins with the paranoid Sweeney throwing the psalter – belonging to the cleric Ronan Finn – into a lake. He also prevents Ronan from marking out the site of his new church and kills his psalmist. The humiliated Ronan curses him and Sweeney is turned into a birdlike creature. His crazed adventure begins as he flees the Battle of Magh Rath or Moira and spends most of his remaining years living "among dark trees/between the flood and ebb-tide/going cold and naked".

Figure 1: Sweeney at Drimcong *(detail) by Brian Bourke from* Brian Bourke: Five decades 1960s-2000s *(courtesy of The Lilliput Press).*

The extract featured here is a hymn-like roll call of trees and other flora, as the demented Sweeney "made a poem in which he praised aloud all the trees of Ireland". Trees recur throughout the work especially oak, hazel, yew and apple. The originator of *Buile Suibhne* not only knew his trees but also their characteristics, their uses and their place in the landscape.

A few native trees are missing including Scots pine, which may have died out by early Christian times although it featured alongside other 'nobles of the wood' or *Airig Fedo* in the law text on farming and woodlands *Bretha Comaithchesa*, originally composed in the eight century (Kelly, 1997). Elm is also absent. It went into decline 5,000 years ago (Mitchell and Ryan, 1993) although it too appears in *Bretha Comaithchesa* but alongside 'commoners of the wood' or Aithig Fedo' (Kelly, 1997).

The landscape that Sweeney was cursed to wander must have been well wooded so it is a major tree and nature poem. In this regard it stands out in the canon of Irish poetry. Trees and woodlands make only sporadic appearances in Irish poetry especially since the seventeenth century, probably understandable given the decline of Irish forests during this period. Poets have looked elsewhere for their inspiration especially over the past century apart from William Butler Yeats in the 'Coole Park' series and Heaney's own work.

The wider historical and literary significance of *Buile Suibhne* is acknowledged by Heaney as the work dates to an actual event, the Battle of Moira fought in 637 A.D. (Heaney, 1983): "What we have, then, is a literary creation; unlike Finn McCool or Cuchulain, Sweeney is not a given fixture of myth or legend but an historically situated character, although the question of whether he is based on an historical king called Sweeney has to remain an open one."

We are fortunate that a poet of Heaney's stature took the time to engage with *Buile Suibhn*e and that he creates a poem of beauty about Sweeney in all his misery and madness. This is acknowledged by fellow poet Brendan Kennelly (1984): "… it takes a superb poet to capture, in translation from the Irish, the full range of pain and beauty in Sweeney's poetry".

We can but surmise on the influence of the Devil's Glen Wood on Heaney especially in his references to trees and forests. But there is little doubt that he understands their role in our lives and how an outcast such as Sweeney would find comfort in the woods ("Glen Bolcain, my pillow and heart's ease / my Eden thick with apple trees.") or pain ("Tonight, in torment, in Glasgally / I am crucified in the fork of a tree.")

In 1998 Heaney launched the Michael Warren sculpture, *Antaeus*, made from wood and installed in the Devil's Glen Wood (Magner, 2004). His description that day of the role of the tree in mythology and art, made it easier to understand why he prevailed with Sweeney: "Nothing is more like ourselves, standing upright, caught between heaven and earth, frail at the extremities yet strong at the central trunk, susceptible like ourselves to the weather, companionable, a shelter, a thing you can put your back to or lay your body down in at the end."

Donal Magner
Wicklow,
September, 2011.

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Book Review

The Mountain Meitheal Handbook of Trail Design and Construction

Bill Murphy. Mountain Meitheal[1], 2011
96 p. ISBN978-0-9568452-0-7
Price €15[2] (including post & packing), available from
www.pathsavers.org

Bill Murphy's huge enthusiasm for the great out-doors is evident throughout this book which takes the reader on an interesting journey through the development and maintenance of trails on our sensitive Irish landscapes. Bill has rightly adopted many of the methodologies used in America, where similar environmental difficulties have been experienced and dealt with in the past. In addition, the vast experience garnered by Mountain Meitheal during the past decade is also carefully integrated into the handbook.

This book begins with a chapter on trail planning and layout. This, of course, is an essential pre-requisite of minimising future maintenance as well as construction costs. Many of our existing parks and walks were designed without adequate consideration of these costs and if trails become expensive to manage and maintain they will quickly fall into disrepair as over time the unrelenting traffic of feet, tyres, frost, rain and wind all work to erode a trail. All trails, no matter how well constructed, do require maintenance to maintain their surface and structural integrity.

Regarding the management of water, the handbook recommends a simple rule for trail builders: "keep the users on the trail and the water off". This is indeed wise advice in our wet climate and particularly so at higher elevations where the ecosystem tends to be more fragile.

The handbook contains an excellent chapter on bog-bridges and board walks. These are often the only sustainable solution on our many boggy and wet sites, some of which are important conservation areas. Mountain biking is one of Ireland's fastest growing outdoor pursuits and the design and maintenance of mountain bike trails are dealt with in a separate chapter.

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[1] Mountain Meitheal is a group of volunteers drawn from a wide range of outdoor backgrounds, who undertake hands-on trail projects on our mountain and forest areas with the aim of protecting the environment and promoting sustainable outdoor recreation.
Its objectives are simple; to counteract some of the pressures that are evident on Ireland's mountains by working with local stakeholders, including the National Parks & Wildlife Service, Coillte and private landowners.
Mountain Meitheal also promotes the concept of sustainable recreation through the Leave No Trace message and is a member of the Leave No Trace Ireland group.

[2] Special price of €10 plus post and packing for ten or more copies.

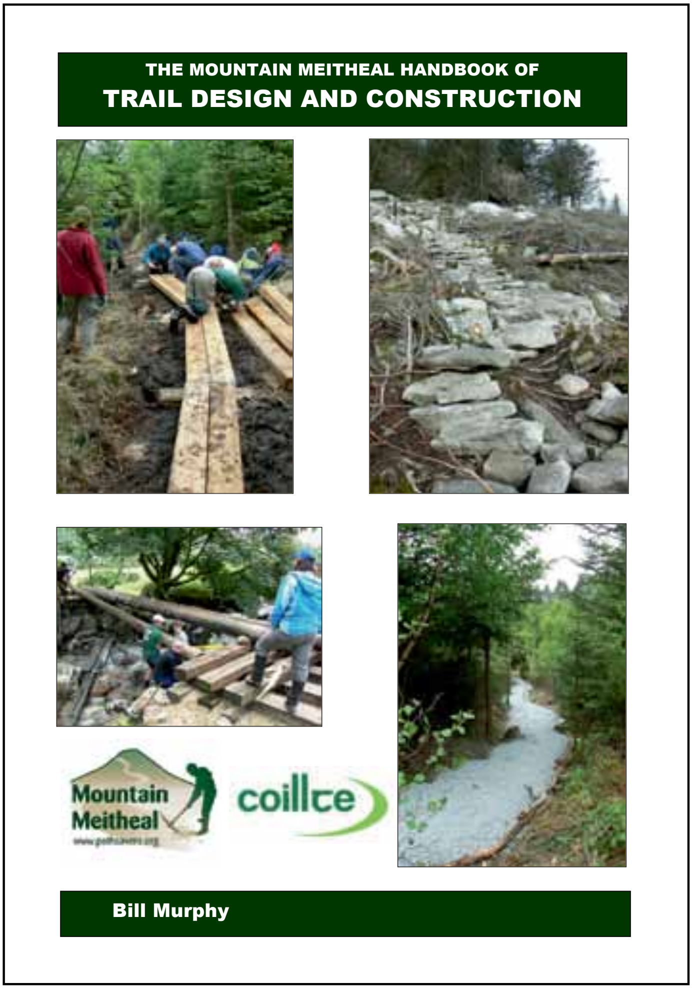


Figure 1: *Book cover with images of trail building*.

We are lucky to have this handbook available to us now as the number of people using our fragile uplands and forests is increasing year on year. Anyone planning to construct a trail should begin by reading this handbook thoroughly in order to ensure that they adopt best Irish and international practice.

John McLoughlin

(John McLoughlin is President of the Society of Irish Foresters and was formerly Chief Environmental Officer with Coillte and Project Manager with the People's Millennium Forests Project.)

Society of Irish Foresters
Study Tour to Bavaria 12 - 16 September 2010

On Sunday, 12 September, 30 members of the Society of Irish Foresters departed for Munich to begin the 67th Annual Study Tour. The group was welcomed at Munich Airport by Frau Gudula Lermer, President of *Bayrischen Forstverein*, the Society of Bavarian Foresters.

Bavaria is the largest state in the Federal Republic of Germany and has a population of approximately 12.5 million. It is similar in size to the Republic of Ireland but it has almost three times the population. The state of Bavaria is heavily forested (36.3% of its land area) and holds 30% of Germany's timber reserves. Norway spruce is the most common species. Nowadays, the main focus of its forest policy is to reduce the reliance on spruce because of the danger of attacks by the spruce bark beetle *Ips typographus*. It is proposed to replace spruce with mixed species crops over time. In 2009, Bavaria's forest industry had sales of €24.8 billion and employed 205,000 people.

Overnight - Mercure Hotel, Freising *Pat OSullivan*

Figure 1: *The tour group outside the headquarters of Bayerische, Staatsforsten in Kelheim.*

Monday, 13th September

The study tour began with a visit to Zentrum Wald-Forst-Holz, a forest/climate research institute located close to Munich. Here we were met by Dr. Wolfgang Falk who explained to us the main impacts that climate change is having on forest practice in Bavaria. This institute has climatic records dating back to 1760 and these records indicate a marked change has occurred in climate since 1980. Detailed records confirm that the mean annual temperature has increased by 2% with an accompanying 10% increase in precipitation.

Forest planning in Bavaria is influenced by the changing climatic conditions being experienced. Norway spruce, an important species in European forestry over the centuries and particularly in Bavaria, is now proving problematic in areas of high temperatures. Norway spruce plantations are under stress from dry summers, increased bark beetle activity and also increasing vulnerability to storm damage. Bavaria has experienced several severe storms in recent years.

To alleviate the malign influence of climate change on forest practice significant changes have been incorporated since 1980. These hazards have accelerated climate driven conversion practices in forest planning.

The predominance of Norway spruce has been reduced and is being replaced by alternative, more suitable species such as beech, Scots pine, oak, European larch, silver fir, sycamore and Douglas fir. It is hoped that these alternative species will produce mixed, well adapted forests in the future. Currently, Norway spruce accounts for approximately 50% of the total forested area in Bavaria while beech, Scots pine and oak are the main species in the remaining area.

The group then departed Zentrum Wald-Forst-Holz and travelled to visit a privately owned forest of high quality spruce and beech. The owner, Baron Freiherr von Gravenruth welcomed the visit of the Society of Irish Foresters to his estate. He is the President of the Bavarian Forest Owners Association and he has been active at national and European level, representing private forest owners and ensuring that there is a forest owner input to forest certification. He expressed some regret that, while the number of private growers in Bavaria is high, they do not communicate well - with the result that the lobbying power of the forest industry is quite weak.

His forest is 1,064 ha in extent. The soil is mainly brown earth and the altitude is 450-550 m above sea-level. The region experiences an average yearly temperature of 7.5^{o}C, in summer the temperatures are in the range 14-15^{o}C. Precipitation is 750-800 mm/year (50% in summertime). These conditions produce a climate which is suited to the growth of forest trees, especially spruce.

This forest has a mixture of tree species, 79% conifers (69% spruce, 7% pine, 2% larch, 0.3% silver fir and 0.3% Douglas fir). Broadleaves account for 21% and comprise 10% beech, 3% oak and 8% maple, ash and cherry. The new management plans are prepared in order to produce stable forest stands taking into consideration the changing climatic conditions; it is thought that a new mixture of 75% conifers and 25% broadleaves will produce these desired stands.

The silvicultural management of the forest is based on natural regeneration. The Forstassessor Michael Reissmann explained the silvicultural management in some detail when he took the party through an area of Norway spruce which had a promising cover of natural regeneration on the forest floor. There is competition from briar growth and grass during natural regeneration and the areas must be monitored carefully to ensure that plants are not suppressed in the early stages by this competitive invasion.

Crown thinning is carried out with the natural regeneration in mind, benefiting the new regeneration as far as possible. The rotation period for a crop of Norway spruce is 90 years, so the natural regeneration is evenly established by that stage and can replace the felled trees. Natural regeneration and selective tree cutting is an important part of the silvicultural management of the forest and the benefits of each, combined with technology to produce a low management cost, are what enables the forest to be managed by one forester, one worker and one secretary!

This visit concluded with a visit to the Baron's castle where we were treated royally and thus ended the activities of the first day of the tour, and the party commenced the journey to spend the night at Ingolstadt.

Figure 2: *Forstassessor Michael Reissmann in Baron Freiherr von Gravenreuth's forest near Affing.*

Overnight - Altstadthotel, Ingolstadt. *Frank Nugent*

Tuesday, 14th September

We headed to Kelheim to visit the Bavarian Forestry School where we were met by Manfred Schwarzfisher, Head of the School and Katharina Fottner who is a forester at the centre. The school, which was established in 2004, has a 600 ha forest which is used for practical training programmes. A total of 2,300 students pass through the school annually on a wide variety of courses.

The Bavarian Forest Administration pays €0.9 million towards the cost of teachers, trainers and administrative staff. A further €0.6 million of funding comes from the Association of Bavarian Forest Owners and this is used to purchase and maintain training course equipment, office equipment and meet some staff costs.

In Bavaria 54% of the forests are private, 31% state owned and the remaining 15% are community or municipal forests. There are 700,000 private growers in Bavaria with forests ranging from <2 ha to 2,000 ha. About 35% of owners are members of forest associations but they tend to own the larger forests and make up 75% of the forest area. However, the average forest size is less than 2 ha.

The main focus of the courses is to teach practical silviculture to forest owners. Timber classification is also emphasised. Chain-saw courses and felling techniques are an integral part of the curriculum, as is skidding with tractors and attachments. Safety instruction is vital as 20 people are killed in forestry accidents in Bavaria every year. The Forest Association's raison d'etre is primarily to sell timber but it also lobbies political decision makers and ultimately to educate forest owners.

There is a trend towards continuous forest cover and the Forest Association is a member of PEFC[1]. The trend towards warmer summers, with a consequent reduction in the amount of water available to spruce, is putting pressure on this species and leaving it vulnerable to attack from the spruce bark beetle. Many owners are abandoning spruce in favour of broadleaved trees which carry higher grants and premiums.

Following a sumptuous meal at the school we departed for the headquarters of BaySF, the Bavarian State Forestry Company in Regensburg where we were welcomed by Dr. Konrad Prelmeier, from the company's public relations department. Bavaria has 2.55 million ha of forests and approximately one third of that (820,000 ha) is owned and managed by BaySF. The company was established in 2004 and has a management structure which is quite similar to that of Coillte. Annual timber growth is 6.1 million m^3; the annual cut is 5.2 million m^3 and they maintain 25,000 km of forest roads. The company has an annual turnover of €305 million and 2,912 employees. Profit for the current year was €35.1 million. There is one big difference with Coillte in that 91% of their income comes from timber sales and BaySF has been directed by its board to retain that position. The motto appears to be *'timber is our business – keep to that'*.

The company is acutely aware of environmental issues and it aims to abandon clear-felling, and instead to practice selective cutting and natural regeneration. The silvicultural objective is for mixed forests adapted to the locality, the climate and the soil. An analysis of the press comments when the company was established showed that 25% of all articles were negative, today following a lot of work in communication only 7% of articles are negative. It was pointed out that forestry suffers from the 'slaughter house effect'; the public likes animals and it likes meat but abhors the slaughter house. Similarly with forestry, people love trees and admire beautiful furniture but are uncomfortable with the harvesting phase.

Looking to the principal threats in the future, BaySF sees climate change as a major challenge, to be met by overcoming the threat of the spruce bark beetle, wind blow and drought. It also fears the rationalisation of the paper industry and Bavaria's dependence on sawmills in Austria. BaySF also envisages greater conflicts between production and conservation and between production and carbon sinks.

[1] Programme for the Endorsement of Forest Certification.

Figure 3: *At the Bavarian forestry school: Manfred Schwarzfisher, Pat Farrington, George Hipwell, Christoph Haas and Dermot O'Brien.*

Overnight - Hotel Donauhof, Deggendorf. *John McLoughlin*

Wednesday, 15th September

The tour now moved into the more mountainous part of Bavaria, close to the border with Austria. We were introduced to Mr Albert Pauli, a senior manager in the Bavarian Forest Enterprise, Mr Franz Pokorny, the Forest Manager, and Ms Barbara Krautlehas, an English teacher who acted as translator for the visit. Mr Pauli explained that until 2005 publicly owned forests were under direct state control but in that year the commercial Bavarian Forest Enterprise was set up to manage these forests. The Ministry of Agriculture still retains responsibility for privately owned forests. The Forest Enterprise has a staff of 3,000 and is responsible for the management of 800,000 ha of forest which are divided into 41 districts. We visited Neuberger Forest District which has a lot of recreational usage. The species composition is Norway spruce 37%, silver fir 14%, beech 14% and oak 8%.

A major concern in Neuberger Forest is the level of attack by the bark beetle on Norway spruce. This insect is indigenous to the area but over the last few years incidences of attack have intensified. The bark beetle only attacks Norway spruce and largely ignores other species. However, since Norway spruce accounts for almost 40% of crops in this area it is a major cause of concern to foresters. Symptoms of a new attack are a brown powder appearing at the base of the affected tree. Beetles eat the bark and it eventually falls off – it does not affect the timber but does, in time, kill the tree. As a result of global warming, beetle attacks are moving higher and higher up the Alps. The beetle does not like cold and wet summers but thrives in warm and dry ones. Their method of dealing with outbreaks is to fell and remove affected trees and also a number of other trees beside them. The timber is sold as minor quality and used for shuttering but is not sold for construction. The lop-and-top is also cleared from the site and together with the bark is made into wood pellets. Insecticide control is used only in cases of very serious attack.

Because of the generally drier and warmer summers due to global warming, it is felt that forests in southern Bavaria are becoming less suitable for Norway spruce. It is also accepted that Norway spruce is at the southern extreme of its natural distribution in any event. The long term aim is to increase the amount of Douglas fir to approx 4%, and also increase the percentages of oak and beech.

Neuberger Forest has an annual production of 20,580 m^3 of which 17,300 m^3 is spruce and fir and approx 3,000 m^3 is beech. Forest inventory is carried out by the Ministry of Agriculture and is based on 8,000 fixed circular plots of 20 m^2. The Felling Plan is drawn up by the district forest manager and is updated every 10 years.

Harvesting is carried out by felling single lines of trees 30 metres apart, with selective thinning between the lines. These lines are referred to as ‘skid lines’ and extraction machinery is allowed along these lines only; this is to limit the extent of soil compaction. Tree felling is primarily done by chainsaw - approx. 66% with the rest carried out by processor. This District employs 40 chainsaw workers on what are known as ‘life time’ contracts.

Continuous Cover Forestry through natural regeneration is practised in this forest district. On areas where there is an insufficient strike of natural regeneration, Douglas fir and oak are planted. After about 6 years, the natural regeneration is reduced to 1,800 stems/ha using brush cutters. Deer are culled annually. The Ministry of Agriculture carries out an annual survey of tree damage and this determines the level of cull for that year.

On our final stop in Neuberger Forest, the group visited a mature stand of beech which had an average age of 135 years and carried a volume of 380 m^3 per ha. Approximately 59% of the regeneration was beech, but the foresters would have preferred to have a better mixture of spruce, fir and beech. The aim is to grow quality beech for furniture and veneer, although the results in this stand were disappointing as quite a number of the mature beech had bark damage which was caused by falling hail and sleet in winter. On average, lower quality beech was being sold for €60 per m^3, furniture quality beech makes up to €120 per m^3, while veneer quality beech can sell for €300 to €1,000 per m^3 depending on its quality.

Overnight - Hotel Donauhof, Deggendorf. *Eugene Griffin*

Thursday, 16th September

On our final day of the study tour, we visited Loher Interiors, an up-market joinery business which specialises in producing very high quality furniture for the aviation, home, office and yacht market. As well as designing and producing the furniture, Loher’s own craftsmen travel to the client’s home, office, aircraft or yacht to install it. The company was set up in 1931 and now employs 180 people. Customers come mainly from Europe, Russia and the Middle East. We saw top quality timber stacked and ready for sawing. The moisture content was maintained at 8-12%. However, the moisture content required depends on the final use, for example wood used for furniture or joinery on yachts may have a higher moisture content. A striking aspect of

Figure 4: *In the 135-year-old beech forest in Neuberger, Passau: Albert Pauli, Franz Pokorny, Pat O'Sullivan, Barbara Krautlehas and Pat Farrington.*

the factory was its conspicuous cleanliness; it looked more like an operating theatre than a joinery factory. The premises are cleaned four times each day and management regards this as critically important.

This industry appears to be recession proof. To date, there has been no fall-off in orders but we were reminded several times that this industry has an unusually a long lead-in time, anything up to two years, so that the worst effects of the current downturn may not have appeared yet. Loher Interiors has three main competitors in this niche business but Loher is the leader in the aviation market as it has the "Competence Certificates" and these are very difficult to attain and hold on to. Looking around the factory one was struck by the meticulous attention to detail of all the employees. Loher Interiors produces its own electricity by burning wood waste and there are plans to build a larger, more modern boiler facility close by.

Next we visited a farm-forest at Rottal-Inn and we were welcomed by Jakob Merk who is the manager of the local co-operative of small scale private forest owners and Lorenz Freiherr Klein von Weisenberg from a neighbouring farm forest organisation. The local co-operative has 950 members who pay an annual membership fee of €20 each. The Bavarian government also pays 35 cent to the co-operative for every cubic metre of timber it sells. In 2009 it recorded sales of approximately 20,000 m^3. However, there are significant challenges. The forests are very small - less than 2 ha on average while the largest would be only 10 ha in extent. Forest owners frequently encounter difficulties with Rights of Way and there are many disputes with neighbours where the co-operative tries to mediate between the opposing sides. In privately owned forests there is now a trend towards a more diverse species composition in the hope of reducing the incidence of attack by the spruce bark beetle. State grants are higher for beech and oak. The site we visited was a pure spruce stand which was being clear-felled because it was damaged by the spruce bark beetle. This site, like many in Bavaria, was too fertile for pine.

The village of Wildthurn was the final stop of our 2010 tour. Here we visited a pure broadleaved farm-forest owned by Christoph Lermer, a brother of our tour leader, Gudula Lermer, which was planted 21 years ago. The entire area of 64 ha was planted and neighbours were at the time bemused at his decision. The area was machine planted using 2,700 plants/ha and plant spacing was 2.5 m x 1.5 m. No herbicides or plastic tubes were used. The owner underestimated the roe deer problem and he had to fence 10 km and also employ very intensive hunting for a period. The grey squirrel was present in the area but it was not a problem. The owner is now making a small income from firewood sales. His plan was to thin approximately 10 ha/annum on a five-year cycle. Herr Lermer has already selected 60-80 final crop trees per ha. He also demonstrated his wood chipper which can process up to 80 m^3 per hour. The wood chips are mostly used to heat his own house and there is a small surplus for sale each year. We then retired to their beautiful house where we were, once again, treated to wonderful hospitality by the whole family. We then boarded the bus for Munich airport and the flight home to Dublin.

John Mc Loughlin

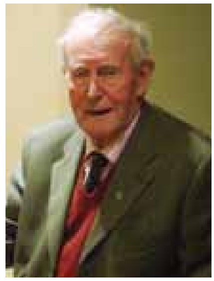
Date	*Recorder*	*Accommodation*
Sunday, 12 September	Pat O'Sullivan	Mercure Hotel, Freising
Monday, 13 September	Frank Nugent	Altstadthotel, Ingolstadt
Tuesday, 14 September	John Mc Loughlin	Hotel Danouhof, Deggendorf
Wednesday, 15 September	Eugene Griffin	Hotel Danouhof, Deggendorf
Thursday, 16 September	John McLoughlin	Tour end. Return to Dublin

Tour Participants

John Bardon, PJ Bruton, Richard Clear, John Conneff, John Connelly, James Crowley, Ken Ellis, Pat Farrington, Jerry Fleming, Gerhardt Gallagher, Tony Gallinagh, Eugene Griffin, John Guinan, George Hipwell, Kevin Kenny, David Knox, Tony Mannion, Eugene McKenna, Willie McKenna, John Mc Loughlin, PJ Morrissey, Liam Murphy, Frank Nugent, Benny O'Brien, Dermot O'Brien, Michael O'Brien, Derry O'Hegarty, Paddy O'Kelly, Tim O'Regan, and Pat O'Sullivan.

Obituaries

Simon Quinn
1921 - 2011



The death occurred of Simon Quinn on January 7th 2011. Simon, who had a long and very fruitful life, both in his forestry career and in his personal life, was born on 30th September 1921 in Farranderry, Castleiney, Templemore in his beloved County Tipperary.

His schooling began in the local national school after which he moved on to the Christian Brother's Secondary School in Templemore. He then progressed to the Forestry School in Avondale where he completed his forestry training in 1941 before beginning his grand tour of many of the forestry centres of Ireland. Included were Durrow, Cootehill, Navan, Avondale (again), Cong, Ballygar, Mountbellew, Kiltullagh, Slievenamon, Glengariff, Cahir and finally Bray, which he reached in 1960. (That was 12 different forests in 19 years, reflecting the attitude of his employers at the time that required foresters to gain experience across the country -whether it made sense or not!) Simon had fond memories of all these areas but had a special regard for some, such as Slievenamon, and not just because it was in Tipperary. He always spoke fondly of his time there and it was always a help for any of his staff to have an association with Kilcash and the Slievenamon area as it guaranteed many hours of reminiscing. On a historical note, Simon's time in Navan was spent on the first survey of private woodlands which was carried out during the war years.

Simon had a very successful career in forestry, achieving the position of Divisional Inspector in the Bray area in 1980 until his retirement in 1986. This gave him the opportunity to put into practise the wide experience he had gained throughout his career.

Simon had an extremely busy life both professionally and personally. He was a family man who took great pride in the achievements of all his children. He had a very special spot for his daughter Geraldine who accompanied him on many walks on the Bray seafront where he walked and swam for many years. He was also a major contributor to the life of Bray. He was active for many years in the Society of St Vincent de Paul where he was honoured with a medal commemorating 50 years of service. He actively participated in other bodies such as; Director of the Sunbeam House Services, Wicklow Association for the Mentally Handicapped and also was one of the first Ministers of the Eucharist in the Holy Redeemer Church in Bray.

In the sporting arena Simon had many interests. He was an avid supporter of Tipperary hurling and delighted in the All-Ireland win in 2010. (This was in spite of his wife, Jojo, being a Kilkenny woman and a member of a famous Kilkenny hurling family.) In his early years he played football for many of the parishes where he lived across the country. He was a long-time member of Bray Golf Club where he and his son Jimmy were the proud winners of the Father and Son Competition. He was also a skilful card-player which he enjoyed all his life, concentrating on Bridge in later years. He played Bridge two to three times a week up to about a month before his death.

Simon was a very caring man who was interested in people. In his working career many young foresters benefitted from Simon's very solid guidance and advice.

To his wife Jojo, his daughters Noeleen and Geraldine, his son Jimmy, son-in-law and daughter-in-law, grandchildren and all his family, we extend our deepest sympathy.

Dermot O'Brien

Eamon Larkin
1949 - 2011

Eamon Larkin passed away on 14th February 2011 after an illness which was borne with the characteristic courage and good humour always associated with him.

Born in Dublin on 24th July 1949, he spent his early years in Clontarf before his family moved to Mullingar and later to Ballinasloe where his early schooldays were spent. In the early 1960's the family returned to Glenageary, Co. Dublin and Eamon continued his schooling with the Presentation Brothers in Glasthule. While his early sporting interests were in hurling and football, he then turned to rugby, playing on the school team and was also honoured by being picked for Leinster. He entered UCD in 1966 and graduated with an honours degree in Forestry.

Eamon's working life began in the Forest Service and he spent three years in the Research Section before moving to Limerick where he worked as Assistant District Inspector and then District Inspector. After four years he moved to become Utilisation Inspector for a further four years. Eamon then took a significant step, moving from the relative security of the Forest Service, to Finsa as Forest Manager. After a number of years with Finsa, Eamon then moved to the Wood Technology Centre in the University of Limerick where he managed research projects and training programmes.

In 1996 Eamon undertook another career change, setting up his own consultancy practice, specialising in Private Forestry Investment and the Wood Processing Sector. He continued there until 2004 when he moved into the property business area with Larkin O'Mahony Auctioneers where he worked with his childhood sweetheart and wife Mary.

In keeping with Eamon's adaptable attitude demonstrated by his career moves, he also had a wide range of hobbies and interests. He was very heavily involved in Limerick Lawn Tennis Club, serving on many committees. His Thursday night doubles were legendary; always ending with some convivial drinks, banter and Eamon's well known and loved sense of humour. He was also very committed to winter sports and enjoyed skiing holidays for many years. More recently Eamon became very interested in Complementary Therapies, immersing himself with typical enthusiasm.

Eamon was always great company with his apparently serious demeanour changing to a broad room-lighting smile as he made some gentle ribbing remark. He had a lifelong interest in DIY and gardening, always with a project in hand, either indoors or outside. We will all miss you, Eamon.

To his wife Mary, his mother, his brothers and sister and to all his extended family we extend our deepest sympathy.

Dermot O'Brien

Paddy McGuire
1922 - 2011

Paddy McGuire passed away peacefully on 26th March 2011, just short of his eighty ninth birthday. He was born on 12th April 1922 in the townland of Tullig, on the Loop Head peninsula in Co. Clare, where his father Arthur had bought a farm on his return from America in 1918. Paddy, or Packie as he was known in Co. Clare, was the third eldest in a family of three brothers (John Joe, Seamus, and Hugh, who was also a forester) and two sisters (Mary and Bridget).

Paddy received his early education at the nearby Cross National School and later at the Christian Brothers School in Kilrush, Co. Clare. He attended Athenry Agricultural College between 1941 and 1942, before entering the Forestry Training School at Avondale, Co. Wicklow on 18th November 1942. Here his class-mates were Denis Conway, Tomás de Gruinel and Finian Moriarty.

On completing his forestry training three years later, he was appointed as a Forest Foreman to Ballybofey Forest in October 1945. Between the years 1945 and 1950 Paddy served as a forester in Ballybofey, Co. Donegal; Enniskerry, Co. Wicklow; Rathdangan, Co. Kildare and Ballymahon, Co. Longford where he met his wife Anne (nee Fagan).

In November 1950, he was appointed Forester in Charge at Ross Forest, Co. Galway and he remained there for ten years until he was transferred to Killavullen, Co. Cork as Forester in Charge -Grade I, in December 1960. Paddy was promoted to Forestry Inspector -Grade III in August 1968 and was assigned to the Acquisition Section in Mullingar, Co. Westmeath. At this time, Ireland's planting programme was expanding rapidly and Paddy's agricultural background, his understanding of the rural psyche and his genuine interest in people, proved invaluable assets in helping to acquire the land required to service the burgeoning planting programme of the following years.

In June 1977, Paddy was promoted again, this time to the rank of Forestry Inspector -Grade II where he was in charge of Work Study in the Mullingar Division.

Apart from his family and his work in forestry, Paddy enjoyed many other interests. He was particularly interested in the GAA and played football with several different counties over a long career. He played at senior county-level with both Donegal and Kildare for brief periods. However, frequent transfers around the country prevented a longer career with either county.

Irish music and set dancing were favourite pastimes of his; and of course there was no music or dancing better than that of Co. Clare! He also had a grá for the Irish language and particularly enjoyed his time in Ross Forest near Oughterard, Co. Galway where Irish was widely spoken and many of the forest workers conversed "as Gaeilge". He also had a great love of the land, the study of soils and plant identification which he used to good effect in his Forester in Charge and Acquisition days.

As well as the love of his native Clare, Paddy had a great fondness for Galway

(Moycullen) and Cork (Killavullen) where he spent much of his forestry career. Both he and his family made lifelong friendships there and he regularly revisited both counties throughout his lifetime.

It was always a particular source of pride for Paddy that no fewer than three of his children (Aiden, Senan and Deirdre) followed in his footsteps and pursued careers in forestry. Aiden is a long serving member on the Council of the Society of Irish Foresters.

A true gentleman who was always willing to offer advice and a helping hand, Paddy was predeceased by Anne, his wife of 52 years, in 2005 and is survived by his children Rita, Imelda, Paddy, Aiden, Deirdre, Senan and Regina. To his family we extend our sincere sympathy.

Pat O'Sullivan

Paddy White
1922 - 2011

Paddy White, who died on 27th April 2011, played a significant role in the development of Irish forestry in a career spanning forty five years. He was the last surviving member of his Avondale class.

Born in Castlebaldwin, Co. Sligo on St. Patrick's Day 1922, he entered Avondale Forestry School in 1941 following his secondary education in Summerhill College, Sligo. The forestry trainees of his period were pioneers venturing on a career which was unusual and a journey which was uncertain. The American poet, Robert Frost, put it well: "Two roads diverged in a wood and I took the road less travelled by, and that has made all the difference".

After his training at Avondale, he served as a Forester in a number of locations, including Newport, Co. Tipperary where he met and married Mary Doheny in 1950. Following periods in Ballynahinch, Co. Galway and Scarriff, Co. Clare, he was promoted to Inspector and served in Land Acquisition in Cork and Limerick. This was a period of rapid expansion –10,000 ha per annum were being planted.

Paddy was appointed Divisional Inspector in Limerick in 1977 and served with distinction there until his retirement in 1987. His success in this post was no doubt helped by his wonderful command of the English language, his strong work ethic and his exceptional administrative skills.

Paddy was a fine Gaelic footballer and had a lifelong interest in all sports. He passed away just two weeks before he was due to officiate as President of the Forestry Golfing Society at its outing in his home club, Castletroy, where he was a former Captain and President.

Before the term "work/life balance" was invented, Paddy had put it into practice. He enjoyed family holidays in Ireland and later abroad, including Kenya, where his son Sean is a forestry consultant. He liked to go fishing in his native Co. Sligo when "the may-fly was up" and played regular, competitive golf up to six months before he passed away. He was an almost daily Mass goer and quietly contributed to charitable work –at one stage visiting prisoners in jail. His memory recall and powers of observation made him wonderful company on social occasions. He could mix easily with all strata of society and was very compassionate towards anyone who had difficulties in their personal or professional lives.

To his son Sean and his daughters, Kathleen, Bernadette, Dolores, Mary, Pauline and Olive, and to his brother Frank, we extend our deepest sympathies.

Ar dheis Dé go raibh a anam dhilis.

Addendum

Mary White

Paddy White's wife Mary died peacefully at home on 9th October 2011.

Mary was a capable, kind and compassionate person who was held in high esteem by all who had the privilege of knowing her.

We extend our sincere sympathy to all their families.

Sean McNamara

Niall O'Muirgheasa
1921 - 2011

Son of Mary and Henry Morris, Irish scholar, educationalist and writer, Niall was born in Skerries, Co. Dublin in September 1921 and educated at Belvedere College in Dublin's north inner city. The family lived in Clontarf from where his regular cycle rides to the Botanic Gardens kindled an early interest in trees. These excursions lead ultimately to a career choice that dominated his life until his retirement in 1986. He graduated with a First Class honours forestry degree from the National University of Ireland in 1945 and was appointed a Forest Foreman in January 1946. His career began in Woodford and he later moved to Slievenamon; the ballad of that name becoming his party piece for decades to come.

In 1948 he applied for an advertised post for Forestry Inspector but his application was rejected. For some reason never fully explained, forest foremen, regardless of academic qualification, were not deemed eligible for a forestry inspector post. Special permission to allow Niall to apply for such a post was the subject of a plea to the Minister (Joe Blowick) by the Departmental Secretary (Tim O'Brien). In 1949 permission was granted and he was successful in the subsequent interview by the Civil Service Appointments Commission. In July 1949 he was appointed a Grade 3 inspector in Mallow and his salary increased from £185 (€235) a year to £378 (€480). He was among the first forestry inspectors to work solely on land acquisition. The price of forest land was determined by the Department of Finance and, as Niall often commented, the maximum price of an acre of forest land seemed to track the cost of a decent pair of shoes! Even in later years when land prices, and those of shoes, rose with inflation, the price of an acre remained uncannily close to a pair of brogues. "No wonder," he said, "Ireland's new forests were banished to the hills and bogs." Undaunted by these constraints Niall enjoyed his days in Mallow with fishing, photography and amateur dramatics filling his leisure hours.

His career took a new turn in 1957 when he was promoted to officer in charge of establishing and overseeing the first detailed forest inventory in Ireland. This followed the realisation among the higher echelons that a forest organisation unaware of its growing stock did not match best international standards. With school-boy zeal Niall dived into the challenge and within a few months his team of two (Tony Hannon and Padraic Joyce) were scrambling to keep up with his ideas of how and what should be done to make the inventory the envy of Europe. In those pre-computer days he adapted the "Hollerith" punch card[1] system to record, and retrieve, the vast array of

[1] Hollerith punch cards were constructed of stiff paper that contained digital information represented by the presence or absence of holes in predefined positions. Now an obsolete recording medium, punched cards were once widely used throughout the 19th century for controlling textile looms and in the late 19th and early 20th century for operating fairground organs and related instruments. They were used through the 20th century in unit record machines for input, processing and data storage. Early digital computers also made use of punched cards.

information gathered. He designed and personally made, the first mapping boards used by the inventory field-foresters using old X-ray films and plywood. Like the count-down to a space shuttle launch, Niall had date lines and deadlines, which he oversaw with unrelenting exactitude.

It was during this time that he organised the Society's 21st Annual study tour which consisted of a grand tour of Ireland in a less-than-grand bus which had seen better days. Undaunted he kept, or attempted to keep, to a strict time-table which frayed the nerves of many!

In September 1964 he returned to acquisition as a Grade 1 inspector. At this time the concept of linking land prices to timber and revenue potential was being developed with Niall playing a pivotal role in its field introduction. Although the new procedure helped to acquire better land, the watchful eye of the Land Commission prevented any meaningful upgrade and lead to individual acquisitions scattered throughout the country. Later on in his career Niall sought to improve this situation by setting a premium for better land within forest clusters, known as "Prime acquisition areas" with a corresponding reduction in land-price outside such clusters. Such an innovation did not however, meet with Department of Finance approval.

His promotion to Senior Inspector in 1975 saw his brief extended to include forest research and forest education and training. With the passing of the Wildlife Act in 1976 this was extended to include wildlife research; an area with which he was never really comfortable.

His promotion to Assistant Chief Inspector 1980 coincided with a focus on the increasing availability of cutaway bog for alternative uses. He sat on an interdepartmental committee on the topic and he fought successfully to have forestry recognised as a viable and legitimate use of such areas.

His final promotion was to that of Chief Inspector in March 1982. The "Western Package" had just been introduced, which marked the very first EU stimulus to private forestry in Ireland. Niall responded enthusiastically and appointed the first forestry professional within the service to work specifically on private forestry. However, this was a time of great financial stringency and severe budgetary reductions. Some of his plans and innovations never materialised. Kinnitty Castle closed as a forestry training centre, land purchase practically ground to a halt while the official mood was gradually moving towards the splitting of the Service into Authority and Enterprise.

Niall always displayed a boyhood enthusiasm for most topics especially beekeeping and fishing. He had a propensity for debate, often heated but never damaging to long-term relationships. Displaying a fertile and agile mind his innovations were often thwarted by "the official line" or experienced difficulties in their implementation. He was highly principled and followed those principles with scrupulous honesty. His attention to detail and tendency to micro-manage was both his strength and his weakness. His sincerity however, was never in doubt.

Niall died on 15th July 2011. He is survived by his wife Maureen, his children Conall, Ciarán, Mary and Eoghan to whom we offer our deepest sympathy.

Fergal Mulloy

Letters to the Editor

Ballynakillew,
Ballinrobe,
Co. Mayo.

The Editor, *Irish Forestry*

Re. Early forestry policy in Ireland

Sir,

A book dealer in Portland, Oregon, U.S.A. recently offered an item entitled Forest Lands and Timber Supply in the Irish Free State. This turned out to be a 10-page extract from the Proceedings of the First International Congress on Sylviculture, held in Rome from 29 April to 5 May 1926, the author being stated as The Department of Agriculture, Dublin.

It sates that the area of woods and plantations in 1918 was 248,878 acres or 1.46 percent of the total area of 17,019,155 acres.

It goes on 'The woodland area is distributed more or less uniformly over the country, and interspersed with agricultural land to an extent which is seldom found outside these islands. While some of the woods have been preserved or created on land of low quality, corresponding to the mountain land referred to above, probably three-fourths exist on demesnes or other holdings, and on land which does not differ materially from the arable land and pasture surrounding them. The chief distinction therefore between woodland distribution in Ireland, and in many parts of Europe, is the total absence in the former of large forests, or tracts of country in which forests predominate… This [hill] land is at present generally made use of for the grazing of sheep and cattle during the summer months, a system which has had a very adverse influence upon forest preservation and development… Hill grazing and burning…are extremely ancient in origin'.

It tabulates the forest classification as of 1916. (Slightly modified. All data in acres).

Crop	**1-25 years**	**26-50 years**	**51-75 years**	**76 years and over**	**Various ages**	**Total**
Conifers	14,633	18,722	12,938	13,243		84,096
Broadleaves	2,399	6,662	10,457	19,815	24,560	66,103
Mixed	3,049	9,812	11,459	20,104	26,770	97,403
					52,979	247,602
Coppice/scrub						4,253

'On a calculation based on general data the reduction in Free State woodlands between 1916 and 1925 was estimated at approximately 20,000 acres (sic)'… Made up as follows:

Area under conifers	decrease of 12, 614 acres (8%)
Area planted after 1916	6,285 acres
Area under broadleaves	decrease of 3,305 acres (5%)
Area under mixed woods	decrease of 9740 acres (10%)

'These figures show a net decrease in the woodland area during a period of 10 years of 19,374 acres, equal to a reduction of over 8%, leaving the total woodland area in 1925 as 228,229 acres, or 1.3% of the total land surface.'

'The species used in afforestation are mainly coniferous, consisting of Larch, Pine, Sitka Spruce, European [Norway] Spruce, and Douglas Fir, the object being to work the woods on an average rotation of about 50 years, and to produce timber suitable for building purposes and other requirements in rural districts. Individual areas vary generally from 300 acres to over 6,000 acres, and the policy in connection with acquisition is to bring, within a radius of five miles or so, a total area of about 5,000 acres, capable of being managed by one forester with four or five assistants.'

So far as I know this is the earliest official statement of the position and policy in relation to forestry in Ireland after independence. At this time A.C. Forbes was Director of Forestry in Ireland and it is certain that, whether this account was written by him or not, it would have received his final approval.

Yours sincerely,

Niall OCarroll.

Ballynakillew,
Ballinrobe,
Co. Mayo.

The Editor, *Irish Forestry*

Re. Staying at Casino in Avondale

Sir,

As a professional forester since I qualified in 1956 and as a sometime (1959-60 and 1969-71) Editor of *Irish Forestry* there is one item which I can now read, and understand. That is the 'Trees, Woods and Literature' feature. Concerning selection No. 34, more information about J.M. Synge's holiday in Avondale is available in the book *'My Uncle John – Edward Stephens's Life of J.M. Synge* edited by Andrew Carpenter (Oxford University Press, 1974). Synge's older sister, Annie, married a Dublin solicitor, Henry Stephens, and their son, Edward, collected all available records of Synge, including his own recollections of the man, with a view to preparing a biography. The resulting unpublished typescript eventually reached the Library of Trinity College, Dublin.

The Stephens family habitually spent summer holidays in the house known as Castle Kevin, near Annamoe, Co. Wicklow. In summer 1897 Castle Kevin was not available and Synge and his mother joined the Stephens family in 'Casino' on the Avondale estate. Stephens's father declined to stay with the group as he 'did not like staying at the steward's house instead of the mansion house of Avondale'. Parnell was dead since 1891 and the main house was empty. The estate had been bequeathed to his wife (formerly O'Shea) and daughters in 1888 but she received nothing. It appears that 'the will had needed to be re-executed after their marriage [in 1891, following her divorce from O'Shea] for it to remain valid'. (Jane Jordan: *Kitty O'Shea, an Irish Affair.* Sutton Publishing, 2005). Avondale was bought by the state for forestry in 1894 and opened as a school in 1904. Mrs. Stephens told her son that the owner 'had been a Protestant who had joined the nationalists and had come to a bad end'.

Casino (literally, Italian for 'a small house') is referred to by Stephens as a 'dower house' while Parnell's brother John Howard Parnell in his *Memoir* (London, 1916) describes it as 'generally the home of the managers of the Avondale estate'.

While the school was located in Avondale House, Casino served as the official residence of the Superintendent.

After the school had moved to Kinnitty Castle, Co. Offaly and Shelton Abbey, Co. Wicklow in the 1950s, Avondale House was redeveloped as a residential Extension School and Casino (a pleasant one-storey over-basement Georgian style house) was demolished to make room for an amenity car park.

Yours sincerely,

Niall OCarroll.