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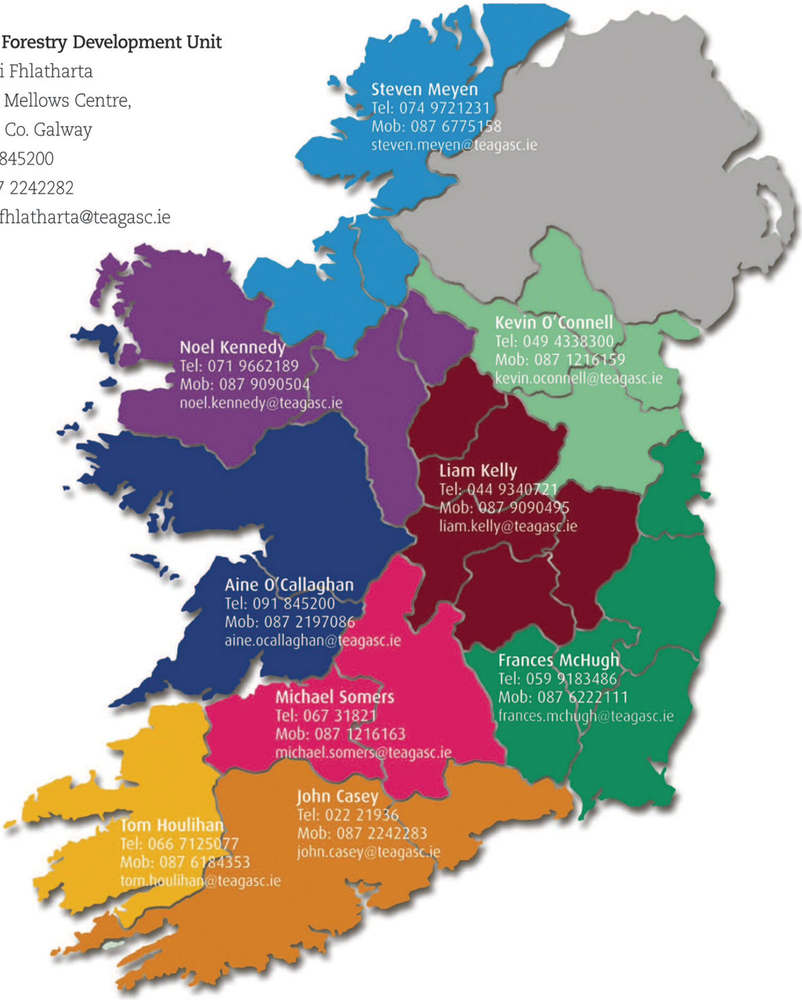

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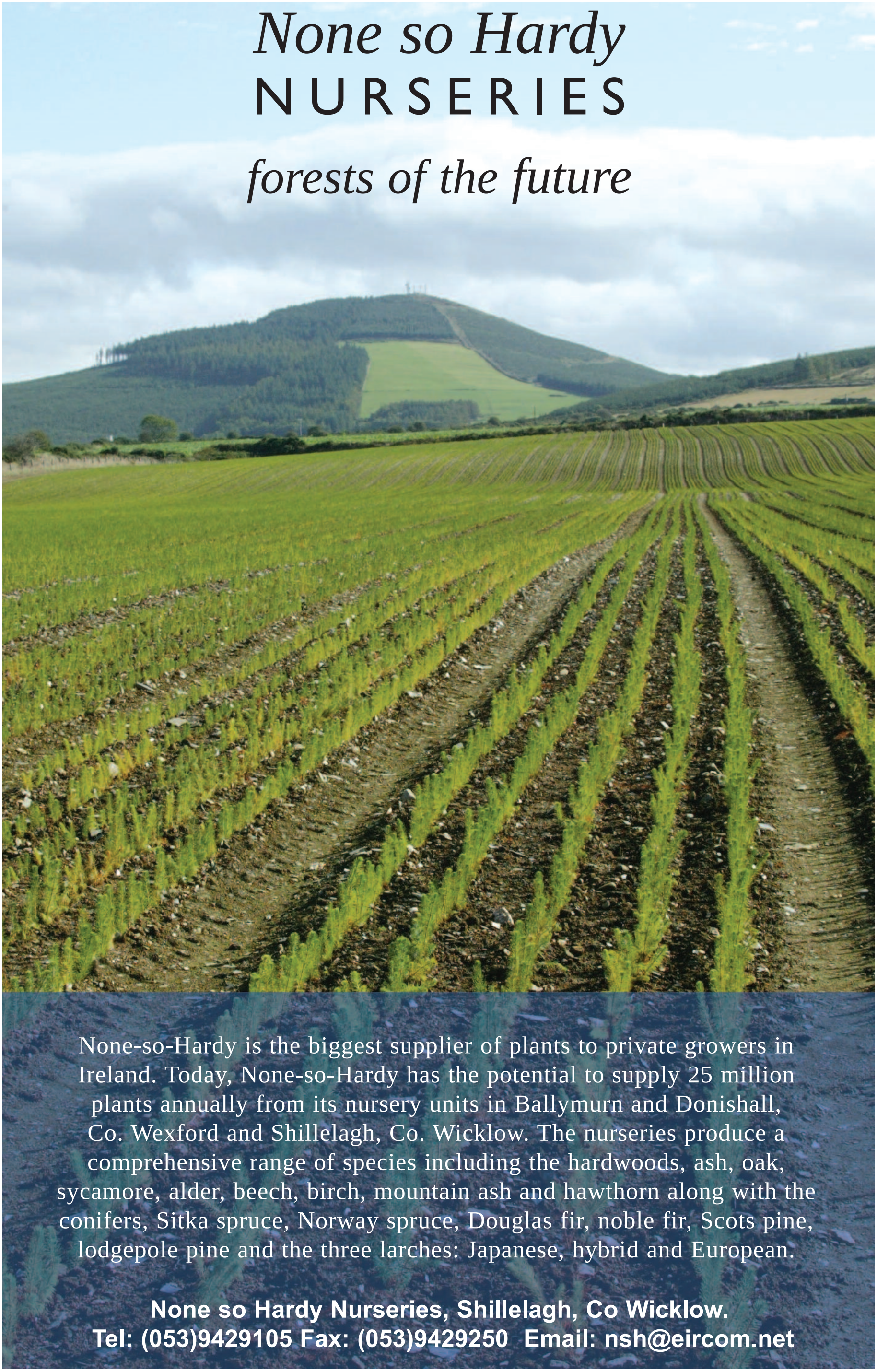
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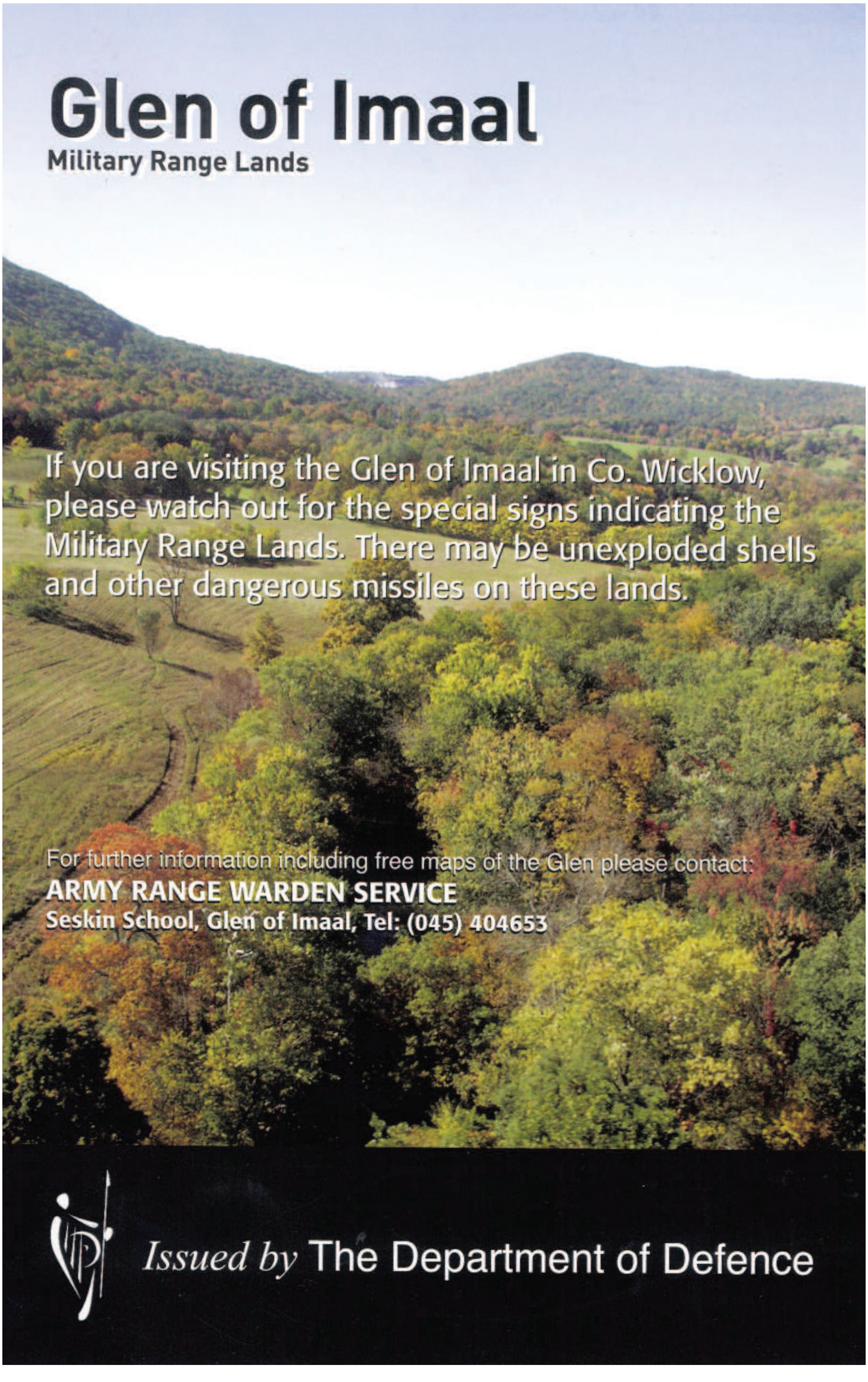
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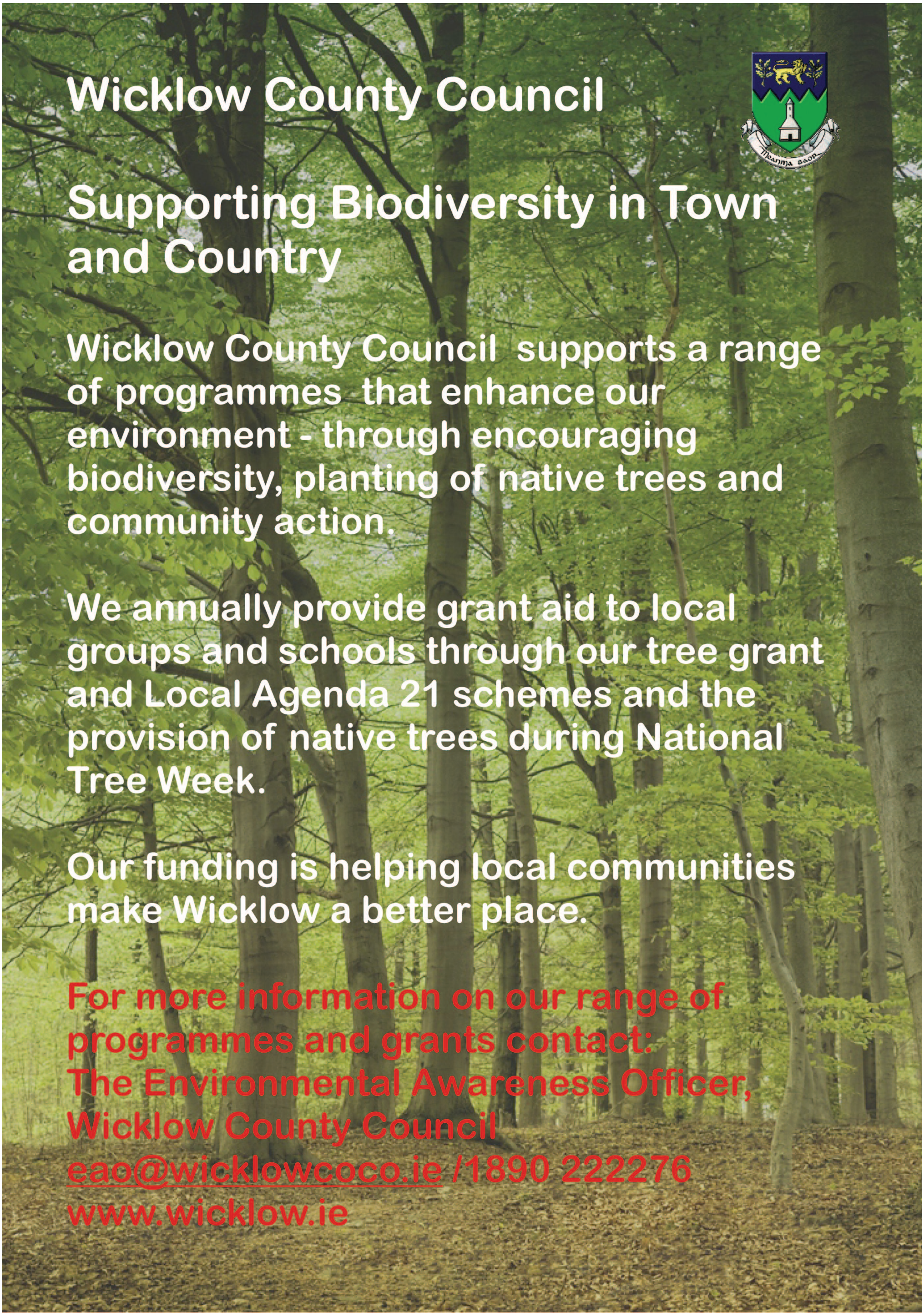
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EDITORIAL

National research priorities

Irish forestry is in an awkward place when it comes to technology. We need it to be competitive, but it is often developed for situations that are not quite the same as we have here. At the same time, investment to make bespoke systems is limited by the scale of the sector itself, and by the level of state investment.

Take the paper on the harwarder in this *Irish Forestry*. It is a promising technology, which links harvesting and forwarding systems in one machine. It may be part of the solution to harvesting more privately-owned forests, many of which are too small to provide enough volume for conventional thinning systems. But the authors were not able to actually test the machine. Relying on models they have shown its promise. But one could ask, so what? Where is the machine?

A better question is: where is the investment, and the will to try-out and further develop the system and others like it? We frequently talk of the knowledge economy, of working smarter, of growing new business out of research and development investment. In that vein, at the end of 2008 the government published *Building Ireland's Smart Economy – A Framework for Sustainable Economic Development.* There are useful things in the report, including a recommendation to: "invest heavily in research and development, incentivise multinational companies to locate more R&D capacity in Ireland, and ensure the commercialisation and retaining of ideas that flow from that investment". Most of the investment is coming from Science Foundation Ireland. The emphasis to date has been on Information and Communications Technology (ICT) and Biotech, with partnerships developed between third level research and multinational companies. More recently, renewable energy has been added to the list of priority areas. It remains to be seen how well the investment will translate into sustainable jobs in the Irish economy.

By comparison with ICT and Biotech, the level of funding for land-based activities such as forestry or agriculture has been lamentably small. Yet Ireland has a huge competitive advantage in dairying and forestry, as well as an established core of world class investigators in both areas. We need to play to those strengths, and drive forward the development of areas where we are already winners. In other words, the hardwarder needs to be tested and further developed in Ireland in co-operation with the Scandinavian manufacturers and scientists who developed the current versions, and then used (or discarded if its performance is not up to scratch). Investment risk needs to be borne by both the state and the private sectors. Other systems, such as laser scanning, are also out there, showing promise, but are suffering from a lack of risk capital and investment to take them to widespread use, not only in Ireland, but abroad.

It is time to refocus and use a larger part of national R&D funding on what we are good at, to use successful sectors such as forestry, not simply as test-beds for answers awaiting questions, but as sectors that need answers to real questions, and which will repay investment.

Increasing the yield and quality of broadleaf planting stock through higher N fertilisation in the nursery

Conor O'Reilly[a], Norberto De Atrip[b], Colin Doody[b], Dermot O'Leary[c], Pat Doody[c] and Barbara Thompson[c]

Abstract

The planting of broadleaf species has increased in Ireland in recent years with a consequent upsurge in the demand for planting stock of common alder (*Alnus glutinosa* L.), downy birch (*Betula pubescens* Ehrh.), and pedunculate oak (*Quercus robur* L.). However, the yield of usable plants and the quality of planting stock produced in Irish nurseries could be improved. The better use of N fertiliser and cloches might help address this issue. To this end, the effect of 40, 80 (standard amount), 120 and 160 Kg N ha^{-1} (applied as calcium ammonium nitrate) on seedling growth and yield in these species was assessed. Seedbeds were sown with seeds of each species and were covered with cloches before seedling emergence had commenced. The cloches were removed in mid June, after which the fertiliser treatments commenced. Fertiliser was applied in five equal quantities at two-week intervals until mid August. Higher N fertiliser than the standard (and the 40 kg N ha^{-1}) amount improved growth and yield in all species. For example, 50, 48 and 67% of the seedlings had a mean height >40 cm in plots that received the highest N level, compared with 30, 21 and 24% in the plots that received the standard amount in alder, birch and oak, respectively. Differences in treatment responses to the two highest N levels were small in alder, but were less clear in birch and oak. Furthermore, seedlings grown at the highest N level also had higher root growth potential (a measure of plant quality) than those grown at the standard level, suggesting that the former plants would probably perform better in the field than the latter ones. The N cost per usable plant was lower for seedlings grown at the higher than the lower N rates in alder and birch, but not in oak, but further testing is needed to confirm this.

Introduction

The planting of broadleaf species in Ireland and many other European countries has increased in recent years. In Ireland, broadleaves accounted for less than 10% of planting in the 1980s and 1990s. Although exact figures are not available, it is estimated that broadleaves may now account for more than 20% of the current planting programme, most of these being produced in bare-root nurseries. There has been a similar increase in the planting of broadleaf species in some parts of North America (Davis and Jacobs 2005). Consequently, there has been a renewed focus on improving the yield and quality of planting stock of broadleaf species in the nursery (Schultz and Thompson 1996, O'Reilly et al. 2005, Wilson and Jacobs 2006).

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Recently, there has been some concern about the quality of broadleaf stock produced in Irish nurseries (O'Reilly 2006). For this reason, a project (QualiBroad, funded by COFORD) was undertaken in an attempt to address this issue for several commercially important broadleaf species: common alder (*Alnus glutinosa* L.), downy birch (*Betula pubescens* Ehrh.) and pedunculate oak (*Quercus robur* L.). The effect of seed factors, seed coverings and sowing date on germination under controlled environmental conditions and in field tests have already been examined in this project (De Atrip and O'Reilly 2005, Özbingöl and O'Reilly 2005, De Atrip and O'Reilly 2006, 2007a, 2007b, De Atrip et al. 2007, O'Reilly and De Atrip 2007). In addition, the impact of cloches and fertilisers on the growth and yield of seedlings in the nursery was investigated; the results from one of these nursery studies are reported in this paper.

Fertilisation is a major issue in the production of broadleaf planting stock and most of the prescriptions used in Ireland have been adapted from those used on conifer crops. Information on the effect of mineral nutrition on the growth of broadleaves in the nursery is limited (Wilson and Jacobs 2006). Most of the anecdotal evidence from Ireland suggests that higher rates of fertilisation would improve seedling growth, but there was no reliable information for most of the important broadleaf species. In particular, N availability may be a major factor limiting growth of seedlings in the nursery, according to one Canadian study (Burdett 1990).

Even if mineral nutrient levels are adequate, it may be difficult to grow broadleaves in nurseries located in areas that have relatively cool summer conditions, such as in Ireland. Broadleaf species appear to be particularly sensitive to environmental conditions (Mason 1994). It normally takes 2 years to produce stock in Ireland that is of comparable size and quality to imported 1-year-old material (Long 2006). Research carried out in Britain has revealed that cloches can be used to improve seedbed microclimate, and thus improve growth and yields in the nursery (Thompson and Biggin 1980, Thompson 1982, Stevenson and Thompson 1985). Cloches are lengths of polythene or fabric raised off the nursery bed, usually supported by wire hoops (Mason 1994). In a previous study, it has been shown that birch seedlings could be grown to target size (>40 cm) in one year in an Irish nursery with the aid of cloches (O'Reilly et al. 2005), and there was evidence that alder and oak would also grow better under cloches (unpublished data on file) than if left uncovered. However, there are also some practical constraints to the use of cloches. It is generally more difficult to apply fertilisers and other treatments to a crop under a cloche. Therefore, it may be preferable to start a crop under a cloche and then remove it relatively early in the summer, when conditions are favourable for growth anyway. Plants grown in this way might respond well to increased fertilisation. For this reason, in this study the effects of N fertilisation levels on plant growth and yield were investigated for alder, birch and oak seedlings that were grown under cloches until mid June.

Materials and methods

The nursery, seed material and sowing

The seedlings in this study were grown at the Coillte Ballintemple Nursery, Co Carlow (52° 44′ N 6° 42′ W, 100 m). The soil at Ballintemple is a sandy loam of pH 5.7, having an organic matter of 6-8%, and sand, silt and clay fractions of 66, 19, and 15%, respectively. The soil was sterilised in early September 2002 and the beds were formed three weeks later. The seeds from a single lot of each species (Table 1) were pretreated according to standard operational procedures. The seeds of alder and birch were soaked in excess water for 48 h at 3 to 4ºC, after which the excess water was drained, and then they were stored at the same temperature until the date of sowing (about 3-4 weeks after soaking). The oak acorns were stored at -3ºC from the date of arrival in nursery (7 October 2002) until the date of sowing. The seeds of alder and birch were covered with 3-5 mm of lime free grit just after sowing on 11 April and 15 April, 2003 respectively. The acorns were drill sown at 20 mm depth on 18 February 2003. Other details of seed viability, sowing rates and target seedling densities are given in Table 1.

Table 1: Seed lots of the alder, birch and oak used in the study in 2003.

Species	*Country and seed zone*	*Viable seeds*	*Sowing rate*	*Target density*	*Sowing date*	*Date cloches erected*
		number kg^{-1}	*m^2 kg^{-1}*	*number m^{-2}*		
Alder	Cork, Ireland 2002 (417)	126,760	280	180	11 April	16 April
Birch	Cork, Ireland 2000 (417)	149,000	600	180	15 April	21 April
Oak	NLS Helvoirt Netherlands 2002 (492)	87	1.5	100	18 February	24 March

Treatments and experimental design

The experiment was laid down as a randomised block design with four blocks (nursery beds), each block containing one replication of each of the four fertiliser treatments per species. Soon after sowing, perforated (P) clear polythene cloches (Sotrafa, Spain) were erected over each bed (each about 150 m long). The cloche was 35 µm thick and had 10 mm diameter perforations, with 200 perforations per m^2. All cloches were removed on 16 June. Each bed was divided into four plots (each approx. 20 m long). Each plot was assigned a different fertiliser treatment at random.

Four different levels of calcium ammonium nitrate (CAN) were applied in equal quantities on five occasions, at approximately two-week intervals from 18 June onwards, ending in mid August. The fertiliser contains 27% N as ammonium nitrate and 5% sulphur. The total amount of N applied was 40 (150 kg CAN ha^{-1}), 80 (300 kg CAN ha^{-1}), 120 (450 kg CAN ha^{-1}) or 160 (600 kg CAN ha^{-1}) kg ha^{-1}, hereinafter abbreviated to 40 N, 80 N, 120 N and 160 N.

Sampling, observations and measurements

Seedling density and height

The number of seedlings at two 0.5 m^2 sampling points, each located about 7 m from plot boundary, was recorded in autumn 2003. The height of 10 seedlings (in a single line in oak) at centre of each sampling point was measured also. The proportion of seedlings >40 cm was calculated from these data, providing information on the likely yield of usable plants. The minimum heights are 30, 40 and 45 cm and minimum diameters are 4, 4 and 6 mm for planting stock of alder, birch and oak, respectively in Ireland (Anonymous 2003).

Other morphological characteristics and root growth potential (RGP)

The effects of treatments on shoot and root dry weights, shoot to root ratio and root growth potential were assessed. This investigation was restricted to the standard (80 kg ha^{-1}) and the highest fertiliser treatment levels (160 kg ha^{-1}) only.

About 50 seedlings were lifted from the centre of each plot in February 2004 for study. The seedlings were bundled separately by plot and then dispatched to UCD where they were held at 0-2°C until the time of processing. The diameter and height of 10 plants sampled at random from each bundle were measured, after which the roots were excised from each plant at the root collar. The weights of the shoot and root of each plant were measured after drying the samples in an oven at 105 °C for 24 h. The sturdiness (height/ diameter) and shoot: root ratio were calculated from these data.

The RGP tests were carried out in early March 2004. The seedlings were planted in 3.5L pots containing a mixture (3:1; vol:vol) of peat and perlite. Each of the 14 pots (replicates) per treatment contained four seedlings, one seedling from each nursery block. The seedlings were allowed to grow for four weeks in an unheated greenhouse (temperatures approx. 15-20ºC during the day, 8-10ºC at night) and were watered every four or five days. At the end of the test, the seedlings were removed from the pots and the roots washed in tap water. The number of new white roots >1 cm long was counted.

Analyses

The data were analysed separately for each species according to a completely randomised block design. Proportion data were transformed to arc-sine square-root values before analysis. Treatment means were compared further using least significant means tests. All significant values reported are $p \leq 0.05$.

Results

Seedling density (Figure 1), mean height (Figure 2) and proportion of seedlings >40 cm tall (Figure 3) varied with treatment. The trend for treatment effects on mean height and proportion of plants >40 cm height was generally similar. Although the absolute increases in all parameter responses were largest in alder and birch, the relative response was similar also in oak. However, there were some species differences, mainly for the effect of the two highest fertiliser levels. For example in alder, there were 391 (160 N), 411 (120 N) plants m^{-2}, significantly higher than the 374 m^{-2} (80 N) and 365 m^{-2} (40 N) in the other treatment plots (Figure 1).

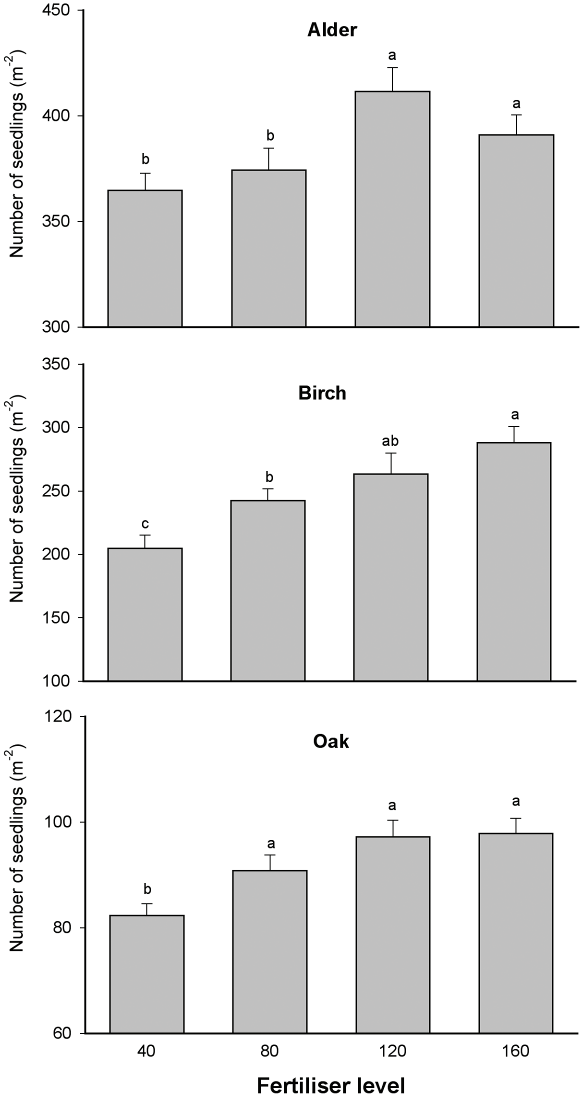

Figure 1: Effect of 40 to 160 kg N ha^{-1} N fertiliser on seedling density in nursery seedbeds of alder, birch and oak. Means with the same letter are not significantly different. Vertical lines are standard errors.

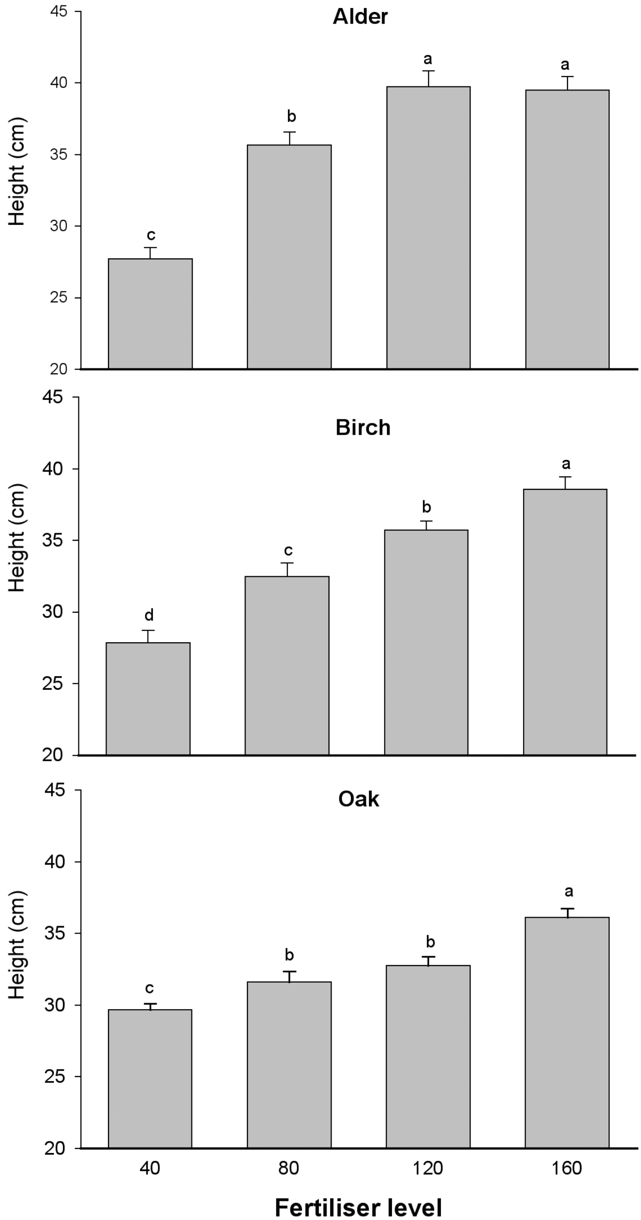

Figure 2: Effect of 40 to 160 kg N ha^{-1} N fertiliser on mean seedling height in nursery seedbeds of alder, birch and oak. Means with the same letter are not significantly different. Vertical lines are standard errors.

Mean height in alder was 39 (160 N) or 40 cm (120 N), significantly greater than the 36 cm (80 N) and 26 cm (40 N) height of seedlings from the other treatment groups (Figure 2).

About 48% (120 N) and 50% (160 N) of the alder seedlings exceeded the target height of 40 cm, significantly more than the 30% (80 N) and 8% (40 N) that were in this category in the other treatment plots (Figure 3).

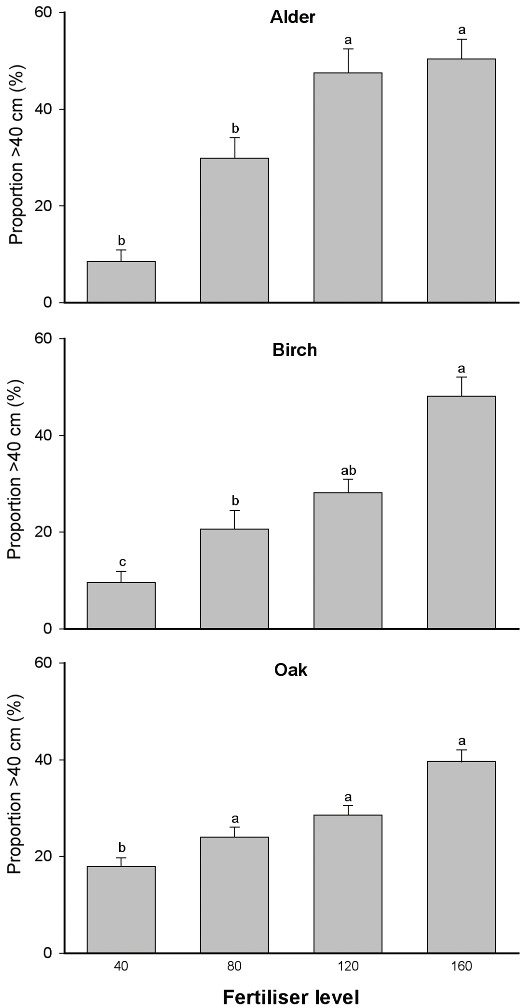

Figure 3: Effect of 40 to 160 kg N ha^{-1} N fertiliser on the proportion of seedlings that exceeded 40 cm height in nursery seedbeds of alder, birch and oak. Means with the same letter are not significantly different. Vertical lines are standard errors.

Since the data for all measurements (Figures 1-3) changed little as fertiliser was increased from 120 to 160 N in alder, this suggests that growth and yield had been maximised. The response also declined, but had not levelled off, as fertilisation level was increased in birch and oak.

Not surprisingly, the trend for the effect of treatments on total number of seedlings m^{-2} >40 cm tall (proportion data adjusted for actual seedling density differences) (Table 2) mirrored that described for a component parameter, proportion of seedlings >40 cm tall (Figure 3). In alder, there were nearly 200 plants m^{-2} in both the 120 and 160 N treatment plots, compared with only 111 (80 N) and 31 (40 N) in the other treatments (Table 2). Treatment differences were larger in birch and oak. In birch, there were 139 plants of that size in the 160 N treatment plots versus only about 20 in plots that received the lowest fertiliser level. The equivalent values in oak were 39 and 15 plants m^{-2}, respectively.

Table 2: Number of seedlings >40 cm tall and amount of N fertiliser applied per usable seedling in each fertiliser treatment.

Rate of N	*Alder*		*Birch*		*Oak*	
	Number >40 cm	*N per plant*	*Number >40 cm*	*N per plant*	*Number >40 cm*	*N per plant*
40 Kg N	31.1	1.28	19.6	2.04	14.7	2.71
80 Kg N	111.5	0.72	50.0	1.60	21.8	3.68
120 Kg N	195.4	0.61	74.1	1.62	27.7	4.33
160 Kg N	197.0	0.81	138.8	1.15	38.7	4.13

The total amount of N used per seedling >40 cm tall differed among species, with oak using the most N. The lowest N per plant was achieved at 120 N in alder, 160 N in birch, and 40 N in oak.

The effects of the highest compared with the standard fertiliser rates on other morphological traits were evaluated also. Seedlings that received the highest fertiliser level had significantly larger shoot dry weight (2.11 versus 1.53 mg) and root dry weight (2.01, 1.55 mg) in alder, whereas seedlings that received the highest N level in birch were significantly less sturdy than the those that received the standard treatment (9.3, 8.5) (Table 3). Seedlings that received the most fertiliser also had higher RGP than seedlings that received the standard amount in all species. For seedlings that received the 160 N and 80 N (standard) treatments, RGP was 57.5 and 34.2 in alder, 30.3 and 12.6 in birch and 17.2 and 7.9 in oak, respectively. None of the other treatments had a significant effect.

Discussion

The main finding of this study was that the application of higher fertiliser levels than the standard (80 N) rate improved the growth, yield and quality of seedlings in all three species. In particular, the RGP of seedlings grown at the highest fertiliser level was greater than in those that received the standard level. In this study, the extra

Table 3: Morphological characteristics and root growth potential of seedlings in plots that received the standard (80 kg N ha^{-1}) and highest level (160 kg N ha^{-1}) of fertiliser. Means that are significantly different (p≤0.05) are indicated (*).

	Alder		*Birch*		*Oak*	
	80	160	80	160	80	160
Diameter mm	4.71	5.17	3.76	3.71	6.06	6.23
Height cm	31.0	35.7*	30.9	32.8	31.0	34.2
Sturdiness[1]	6.65	7.02	8.50	9.30*	5.22	5.52
Shoot dry weight g	1.53	2.11*	1.02	0.96	3.15	3.49
Root dry weight g	1.55	2.01*	0.56	0.53	9.19	8.42
Shoot: root ratio	2.43	1.33	2.12	2.11	0.35	0.43
Root growth potential	34.2	57.5*	12.6	30.3*	7.9	17.2*

[1]*Sturdiness is height (cm) divided by diameter (mm). Low values indicate more sturdy plants.*

nutrient reserves might have enhanced the RGP response for other reasons too, as discussed below. The new standard fertiliser treatment for alder, birch and oak in Coillte nurseries is 120N, a change that was initiated mainly in response to the results of this study.

Both mean height and yield of plants (>40 cm) differed little between the two highest levels of treatment in alder, but not in birch and oak. This suggests that 160 N was close to optimal for growing alder in 2003. It may be necessary to use even higher levels of fertilisation in further studies to determine the level at which the response reaches a plateau in birch and oak. The fact that higher N levels improved RGP is particularly promising. In previous studies, RGP was associated with better field performance in ash (*Fraxinus excelsior* L.) seedlings in Ireland (O'Reilly et al. 2002) and in pedunculate oak and northern red oak (*Quercus rubra* L.) in France (Garriou et al. 2000). Although morphological attributes frequently predict field performance of broadleaved seedlings (Jacobs et al. 2005a), they do not always do so, as found for green ash (*Fraxinus pennsylvania* Marsh) in one US study (Jacobs et al. 2005b). Physiological characteristics at the time of planting also greatly influence field performance in broadleaves (O'Reilly et al. 2002, Mortazavi et al. 2004, Wilson and Jacobs 2006). RGP was the only physiological parameter considered in the present study, although this parameter is often considered the most important one (O'Reilly and Keane 2002).

Although the morphological responses to higher N levels might reach a plateau (as shown for alder in this study), the optimum nutrient concentration in foliage is often reached at higher N levels than is needed for growth (Birge et al. 2006, Salifu and Jacobs 2006). Luxury consumption has little effect on growth, but it increases nutrient reserves; these reserves may be available after planting (Birge et al. 2006). This may partially explain the better RGP recorded for seedlings given the highest fertiliser level (Table 2). However, the RGP response to the 160 N and the standard

(80 N) levels of fertilisation only was evaluated in this study, so it is possible that RGP was maximised at 120 N.

A high proportion of the seedlings in this experiment reached the target height dimensions (>40 cm). These results are particularly encouraging when considered in light of other advances that have been made in seed research in the COFORD-funded QualiBroad project. The newly developed seed protocols should deliver higher, faster and more uniform seed germination in alder, birch (De Atrip and O'Reilly 2005, 2006, 2007a, 2007b, O'Reilly and De Atrip 2007) and oak (Özbingöl and O'Reilly 2005, Doody and O'Reilly 2008) compared with the standard seed pretreatment method. In addition, alder and birch seeds that received the new pretreatments germinated quickly at low temperatures (De Atrip et al. 2007), suggesting that it may be feasible to sow early and thus improve growth and yields. Therefore, it is likely that fertiliser and cloche treatment responses might have been even greater if the seed had received the newly developed pretreatments before sowing.

The number of useable seedlings (defined as proportion >40 cm tall) in the nursery beds at the end of the growing season was greater in those given more than the standard level of fertiliser. Since the treatments commenced well after germination had ceased, it is likely that increased nutrient availability allowed more seedlings to survive in beds that received the most fertiliser. High seedling bed densities increase competition for nutrients and water, potentially affecting post-planting performance for up to five years in broadleaf species (Schultz and Thompson 1996).

The use of higher N than the standard level might reduce total nutrient use in the nursery because less bed space would be required to produce a given number of plants, thus also reducing costs. However, the pattern of response to fertilisation was not entirely consistent among species (Table 2). The lowest N cost per usable plant was achieved at 120 N in alder, 160 N in birch, and 40 N in oak. Nevertheless, the 40 N treatment makes little sense for oak since the amount of bed space required to produce seedlings would be huge, thus increasing other costs. Oak also consumed more N per usable plant than alder or birch. Alder was the least costly, perhaps reflecting the fact that this species can also fix N (Arnebrant et al. 1993). The environmental impacts of fertiliser usage in nurseries has been the focus of attention in other countries (Juntunen and Rikala 2001), and similar concerns might be raised in Ireland. If the total amount of N required to produce a given number of usable seedlings can be reduced, then there would be potential benefits for the nursery environment. However, further research is needed to confirm this.

The exponential method of fertilisation (where fertiliser supply is matched to plant growth) may be superior (and is more environmentally friendly) to the conventional method of application for growing broadleaves (Birge et al. 2006, Salifu and Jacobs 2006), but this method was not evaluated in this study. In particular, there is evidence that seedlings grow poorly if fertiliser levels are too low during the early rapid growth period (Fan et al. 2004). Further studies are needed to examine the use of exponential loading, the relationship between morphological quality and field performance, and on the importance of stored nutrients for performance after planting in the field.

Conclusions

The results of this study showed that higher N fertiliser levels than the standard amount resulted in better growth and yield of seedlings in alder, birch and oak (which had been covered with cloches until mid June). The response differences between the two highest N levels (120 and 180 N) were small for most parameters in alder, suggesting that the optimum level was close to 120 N, but the trend was less clear for birch and oak. Further studies are needed to refine these prescriptions, especially to take account of year-year variations in weather conditions and plant size at time fertilisation commences. In addition, studies are needed to determine if seedlings grown under high N levels in the nursery will perform well in the field.

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Modelling the effects of floodplain woodland in flood mitigation A short-term case study

Jerome O Connell[a]

Abstract
Three floodplains were selected for study in the Mawddach catchment, just north of the town of Dolgellau in Central Wales. Vegetation cover scenarios were modelled for each site using the hydrodynamic model River 2D. The first two sites provided no real potential for using floodplain woodland in flood mitigation, although modelled water depths increased by up to 50 cm due to the presence of dense vegetation on the floodplain. At the third site, dense woodland, with an average basal area of 0.10 m^2/m^2, reduced modelled peak discharge by 45 m^3sec^{-1} when compared with grassland. This also delayed peak discharge by more than 30 minutes and created a backwater effect that increased water depths by more than 1.2 m for a distance of 1.3 km upstream of the floodplain. Two other vegetation scenarios, sparse and clustered woodland, were also modelled for the third site. Although sparse woodland had just 45% of the basal area of the clustered woodland, it had a similar effect in mitigating modelled flood levels downstream.

Keywords
Hydrodynamic modelling, floodplain woodland, soft-engineered flood defences

Introduction
Floodplain woodlands are highly dynamic ecosystems, subject to complex but critical flooding events (Hughes and Rood 2003). They are typically a mosaic of vegetation communities of varying age. Natural floodplain woodlands are rare in Europe; and are listed in Annexe 1 of the Habitats Directive as "a priority forest habitat type" (Hughes and Rood 2003). Their characteristics and role include high biodiversity and productivity, mitigation of diffuse pollution, contribution to landscape diversity, and flood control (Tir Coed 2001, Kerr and Nisbet 1996, Thomas and Nesbit 2007).

Role of floodplain woodlands in flood control
The potential of floodplain woodlands for flood control has been examined and demonstrated at several sites throughout central and eastern Europe (Poulard et al. 2003), as well as in the UK (Thomas and Nesbit 2007). The role of such habitats in flood control could be increasingly valuable given the predicted impact of climate change in increasing rainfall intensity. Extreme flood events in the UK are predicted to become 10 to 50 times more frequent by the year 2090 (Friends of the Earth 2000). Currently, the Environment Agency (EA) of England and Wales spends an average of £260 million per year on costal and river flood defences. The Department of the

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Environment, Food and Rural Affairs (DEFRA) budgeted £436 million for flood management activities in 2007/08.

The use of floodplain woodland for flood control may prove to be effective from both an environmental and an economic viewpoint. Furthermore, the move from hard engineered structures such as dykes and dams to sustainable and environmentally friendly methods of flood control such as floodplain woodland is evident throughout most of Europe, often coming under the description Integrated Flood Management (Dworak and Hansen 2003).

The principal hydrodynamic factor involved in flood mitigation in floodplain woodland is hydraulic roughness (Fisher and Dawson 2001). Allowing the floodwaters of a river surge to spill onto a natural floodplain will greatly increase the temporary storage capacity of a river. Floodplain woodland vegetation offers one of the highest natural friction coefficients in a riparian landscape, and therefore is one of the most effective natural vegetation types at reducing velocities and retaining flow, thereby dissipating subsequent downstream discharge rates (Arcement and Schneider 1990). Factors that affect the ability of floodplain woodland to contribute to flood amelioration include vegetation density, stem distribution and floodwater depth (Environment Agency 1997). Vegetation, especially if it is erect and flexible, will create local turbulence, and so reduce the magnitude of instantaneous velocity due to a drag force on the moving water (Environment Agency 2003). As velocities are reduced, water depths and flood extent increase, thereby attenuating the peak of the flood through temporary storage on the floodplain. While the level of attenuation depends on local topography, soil type and other factors, the overall result is often a reduction in the peak discharge of the river downstream, manifested as the outflow hydrograph assuming a more gradual curvature (Thomas and Nesbit 2007).

Methods

Site characteristics

In June 2004, three sites located on the river Mawddach (Figure 1), north of the town of Dolgellau in central Wales (52°47'48" N, 3°52'35" W) were selected for hydrodynamic modelling. The sites varied in size, shape and topography and are referred to here as Floodplain 1, 2 and 3, based on their location on the river system.

The Mawddach catchment covers a significant proportion of the Harlech Dome, a geological folding sequence of lower Palaeozoic rocks, consisting of one of Europe's best examples of Cambrian, Ordovician and Silurian strata (Hall and Cratchley 2005). The catchment is bounded to the east by the Aran Fawddwy massif and to the west and north by the Harlech Dome, which forms a watershed just south of Llyn Trawsfynydd. The Harlech Dome consists of numerous fracture zones with the general orientations north/south and south-west/north-east. Such fractures have implications for the drainage patterns and orientation of streams within the Mawddach river system (Hall and Cratchley 2007).

Aran Fawddwy, 504 m above sea level, is located at the highest point of the Mawddach catchment, with the town of Dolgellau located 8 m above sea level. The catchment has a total area of 164.58 km^2. The hydrological influence of several other tributaries was taken into account (Figure 1) when modelling floodplains 2 and 3, which made catchment area difficult to quantify.

The River Mawddach has an overall length of 14.2 km, with an average drop of 35 m per kilometre. The rivers within the Mawddach catchment exhibit a range of morphological characteristics within the general downstream progression of reach types: colluvial, cascade, step pool, plane bed, pool riffle and dune ripple (Hall and Cratchley 2005).

Floodplain 1

Floodplain 1, located in Tyddyn Gwladys, was the smallest and highest of the three sites examined in the catchment. The floodplain area was 0.4 ha, with a river length of 370 m. The inflow boundary was located 500 m downstream from the Environment Agency's rain gauge station. The river channel mainly comprised large cobblestones and boulders, with some areas of rock outcrop (Figure 2). The bed profile was relatively uniform, with river channel width ranging from 7–12 m and depth from the top of the bank to the river bed ranging from 1.5-3.5 m.

The vegetation of Floodplain 1, which is part of the Coed y Brenin forest, was comprised almost entirely of a mix of mature, semi-natural woodland and conifer plantations (Figure 3), with some regeneration occurring under canopy gaps in

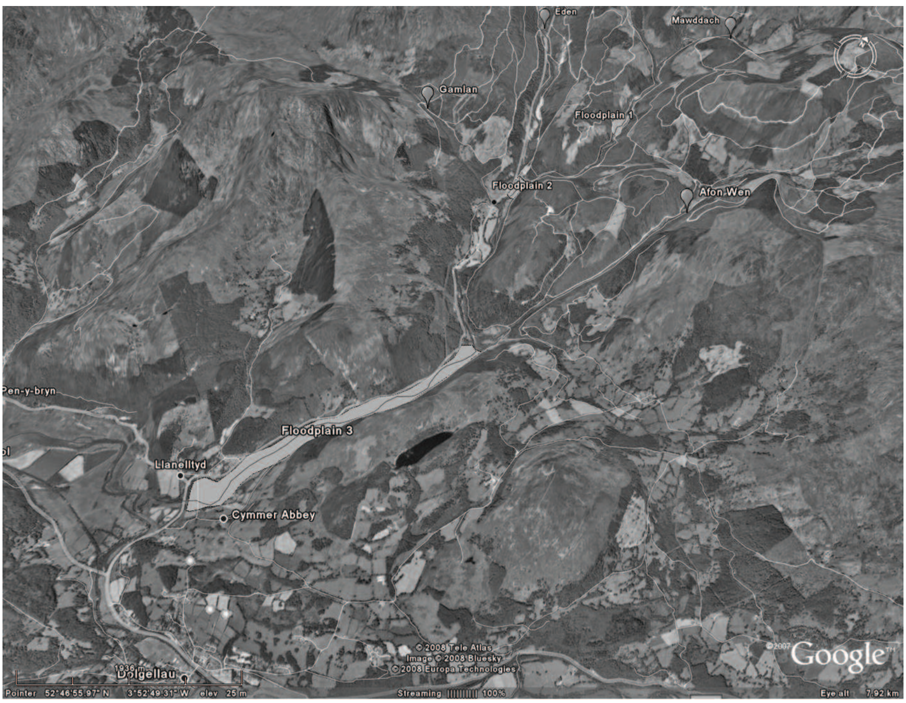

Figure 1: Location and spatial extent of the three floodplain sites on the River Mawddach. Permission granted by Google Earth™ mapping service.

Figure 2: View upstream at the inflow boundary of Floodplain 1.

Figure 3: Typical vegetation structure in Floodplains 1 and 2.

mature woodland. Vegetation density was assessed in accordance with Arcement and Schneider (1990), with the average ranging from 0.011 m^2m^{-2} to 0.265 m^2m^{-2}.

Vegetation plots (with larger sized plots in less dense vegetation) were established at each site. The number of plots was dependent on vegetation type and its apparent density.

Floodplain 2

Floodplain 2, located in Cefn Deuddwr, was 27.2 ha in area. It was located at the confluence of the Eden and the Mawddach rivers, 2 km downstream from Floodplain 1. The profile of the riverbed upstream of the confluence was a mixture of rock outcrop and constricting gorge sections (3-6 m wide) as well as a 4 m high waterfall (Figure 4). A large open flow channel occurs downstream of the confluence, which in turn carries most over-channel flow. Vegetation was of a similar age and type to Floodplain 1, with average density ranging from 0.018 m^2m^{-2} to 0.082 m^2m^{-2}.

Figure 4: Floodplain 2, view upstream with bridge and gorge section in background centre and the open flow channel in the foreground.

Floodplain 3

Floodplain 3 was considerably larger than Floodplains 1 and 2. It comprised a 3.7 km stretch of the River Mawddach, from the confluence of the Wen and Mawddach rivers, to the tidal point of the river, located just west of the bridging point of the A470. This area was a natural floodplain basin, located at the mature stage of the

Figure 5: A location 800 m upstream of the outflow section of Floodplain 3, showing typical topography and vegetation at the site.

River Mawddach, with a floodplain area of 100.8 ha. Its location has important considerations for over-channel flow potential, as the undulating topography of the surrounding landscape aids in the storage of excess flow from the river (Figure 5). Vegetation was mainly grassland with short (0.25 km) stretches of mature oak (*Quercus petraea*) and sycamore (*Acer pseudoplatanus*) located close to the river bank.

Hydrodynamic modelling

Based on previous studies (Thomas and Nesbit 2007, Ghanem et al. 1995, Waddle et al. 1996), the 2D Depth Averaged Model, River2D, developed by Steffler and Blackburn at the University of Alberta <http://www.river2d.ualberta.ca>, was chosen as the preferred hydrodynamic model as it provided an acceptable level of accuracy, modelling capability, presentation, and user-ability.

River 2D is a two dimensional depth averaged model, based on finite element solution of governing equations. Roughness coefficients are expressed as effective roughness height. This method of expressing roughness tends to be more accurate than Manning's n, because it remains constant over a wider range of depths (Blackburn and Steffler 2002). Calibration of the model is achieved by adjusting the roughness values and transverse eddy viscosity distributions until the water depths and discharge of the model is equal to that of the outflow hydrograph. River 2D is made up of three sub programmes; R2D Bed, R2D Mesh and River 2D 0.90 (see Blackburn and Steffler op cit. for further detail).

Topographical data
Elevations were determined using an optical level, with a 50 m Digital Elevation Model (DEM) used in areas of uniform topography. Interpolation between points of known elevation and distance from a fixed datum was used to provide a topographical representation of each site. Points (or fixed nodes) were a maximum of 10 m apart in flat topography and up to 0.5 m apart in undulating terrain (for example near the river bank). The location of points (with respect to other points) was sketched in the field, with at least two (often three) known distances to each point, as well as an elevation with respect to the datum being noted. The x, y and z coordinates obtained in the field were transferred into R2D Bed for triangulation (Blackburn and Steffler 2002).

Because of the uniform topography of Floodplain 3, and the large scale of the study area, a 50 m DEM was used to obtain the over-bank elevation data. However, the relatively coarse resolution of the DEM necessitated additional field surveying adjacent to the river channel to achieve a sufficient topographical representation of the site.

Manning's roughness (n) values
Roughness or friction values are also assigned in R2D Bed, with the variation in friction values being directly attributed to the number of fixed nodes (points obtained in the field). Field vegetation density measurements were converted to Manning's roughness values using Arcement and Schneider's (1990) equation:

$$(n) = no\sqrt{}(1+Vegd(C^*)(1/no)^2(1/wlh)(h)0.75$$

where no is the number of roughness values for the floodplain,
Vegd is the vegetation density,
C* is the drag coefficient for vegetation,
l and w are the length and width of the vegetation plot and
h is the hydraulic radius, equal to water depth on the floodplain.

Friction values for the riverbed were evaluated in the field using Arcement and Schneider's (1990) tables for assessing the roughness values (n) of the riverbed and floodplain. Roughness height is calculated in R2D Bed via the roughness converter. Roughness height (ks) is a function of Manning's roughness (n) and water depth (R) with:

$$k_s = \frac{12R}{e^m}$$

Arcement and Schneider's (1990) tables include friction values for variations in channel cross section, the effect of obstructions in the riverbed and the floodplain, vegetation density, the degree of river meandering and the degree of topographical irregularity. The values are dimensionless coefficients, and with the exception of vegetation density, are based on observation.

Computational mesh
R2D Mesh is the subprogram used to create the computational mesh for calculating water depth and velocity (Figure 7). The density and location of floating nodes is critical and will have a direct effect on the accuracy and performance of any hydrodynamic model (Steffler and Blackburn 2002).

R2D Bed uses a Quality Index (QI) value to determine the accuracy of the computational mesh. A QI value of 0.5 is typical of a natural environment (Steffler and Blackburn 2002). Table 1 outlines the computational mesh properties of the three floodplains.

Table 1: Computational mesh properties of the three floodplain sites.

Floodplain	*Floating Nodes*	*Elements*	*QI Value*
Floodplain 1	1333	2551	0.359
Floodplain 2	573	1055	0.449
Floodplain 3	1995	3674	0.376

Model calibration
On 3 July 2001, the Mawddach catchment and surrounding areas experienced a severe flood event. The storm was tracked across the Irish sea early in the morning, by 16.30 hours it was centred over the northern half of the Mawddach catchment, releasing up to 34 mm rainfall per hour in the Wnion catchment alone (Barton 2002). Figure 6 shows the discharge rate for the river Mawddach during the 3 July event, which had an estimated return period of 200 years.

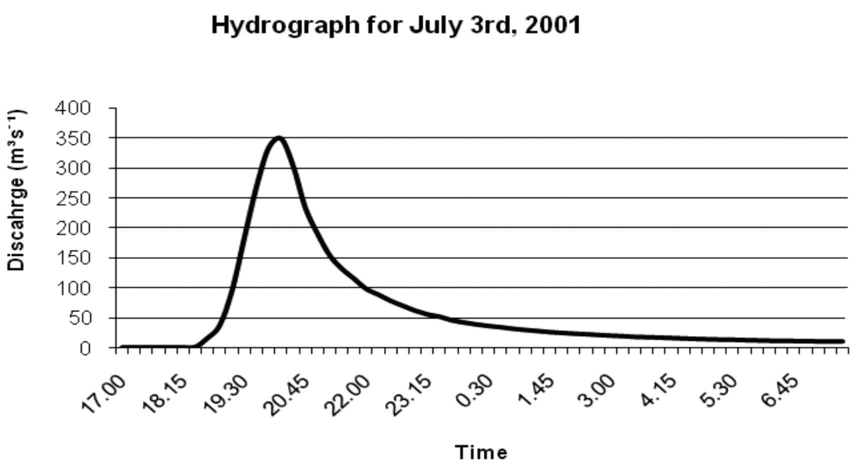

Figure 6: Stage hydrograph for river Mawddach for 3 July 2001 recorded by Environment Agency, 500 m upstream of inflow of Floodplain 1.

The vegetation scenarios of Floodplains 1 and 2 were calibrated by running the 3 July hydrograph (Figure 6) in order to achieve existing hydrodynamic conditions by adjusting the turbulence parameters (bed and transverse shear) in River 2D, until modelled water surface elevations were equal to observed flood debris lines and photographs of water levels from the July 2001 event. In River 2D, the transverse shear parameter (_3) of the eddy viscosity coefficient (Boussinesq type) was primarily used to adjust water surface elevations during the calibration process, as this was the dominant flow parameter when dealing with a submerged floodplain (deep water, high transverse velocity and reticulation). Once calibrated, Floodplains 1 and 2 produced _3 values of 1.20 and 1.35, respectively.

<u>Model simulation</u>
River 2D is essentially a transient model, but provides for an accelerated convergence to steady-state conditions. It has several simulation parameters including: time increment, goal time increment, maximum number of iterations, solution tolerance, and implicitness. The time step increment was set at 100 seconds and the solution tolerance was set between 0.01 and 0.05, depending on the RAM requirements of the site in question. The maximum number of iterations is the maximum number of Newton-Raphson iterations per time interval per node in the computational mesh, and was set at 10 for all three sites.

Inflow and outflow conditions have several options in River 2D. Inflow had a time varying discharge (hydrograph). The outflow condition was based on a depth/unit discharge relationship. Once the model was calibrated, a transient (unsteady state) simulation was run using the 3 July hydrograph.

There was more than 2 km between sites 1 and 2, but the outflow hydrograph from the calibrated simulation of Floodplain 1 was used as the inflow hydrograph for Floodplain 2, as the deep gorge between the two sites meant that the variation in flow was minimal. The _3 value remained unchanged while modelling the various vegetation scenarios, with the exception of grassland, where it was changed to 0.1, to reflect the effect of grassland on turbulence (Blackburn and Steffler 2002).

Because of the absence of an inflow hydrograph for Floodplain 3, as well as the lack of detailed evidence of flood extent for the 3 July flood event (debris lines and photographs), it was not possible to calibrate the model for the site. Instead, Floodplain 3 was treated as a test site, with the outflow hydrograph of Floodplain 2 being tested on four vegetation scenarios for Floodplain 3.

<u>Vegetation scenarios</u>
Once model calibration was complete, three different vegetation scenarios were assessed for Floodplains 1 and 2: dense woodland, grassland and the calibrated scenario. Floodplain 3 had four vegetation scenarios: dense woodland, sparse woodland, clustered woodland and grassland.

Table 2 shows Manning's roughness for the riverbed and floodplain of the three sites. The calibrated scenarios were a result of vegetation density analysis of Floodplains 1 and 2. The dense, sparse and clustered woodland and grassland

Table 2: Manning's roughness for riverbed and floodplain vegetation cover scenarios.

Site	*Scenario*	*Manning's n*
Floodplain 1	*River bed*	0.058-0.072
Floodplain 2	*River bed*	0.039-0.080
Floodplain 3	*River bed*	0.039
Floodplain 1	*Calibrated*	0.104
	Grassland	0.035
	Dense woodland	0.207
Floodplain 2	*Calibrated*	0.105
	Grassland	0.035
	Dense woodland	0.208
Floodplain 3	*Grassland*	0.035
	Clustered woodland	0.207
	Dense woodland	0.207
	Sparse woodland	0.112

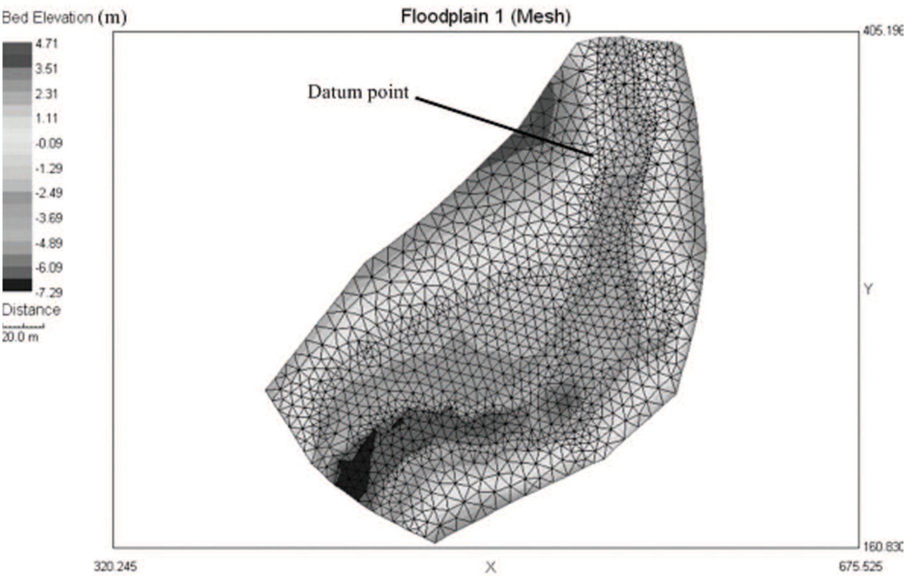

Figure 7: Shaded topographical representation (relative to the datum point) of Floodplain 1 with the overlying computational mesh. Datum point indicates 0 elevation of topographical data.

scenarios were obtained from Arcement and Schneider's (1990) Manning's roughness tables. The clustered woodland scenario in Floodplain 3 had the same roughness as the dense woodland scenario; however the vegetation was distributed throughout the floodplain in clusters rather than as a continuous cover (Figure 8).

Figure 8 shows the distribution of clustered woodland in Floodplain 3. The ks values are relative to a 2 m water depth, which was calculated from records and observations for the floodplain and adjacent areas, during and after the 3 July 2001 flood event (Barton 2004, Hall and Cratchley 2005). CS2 and CS4 indicate the location of cross sections 2 and 4, with results presented in Figures 12, 13 and 14.

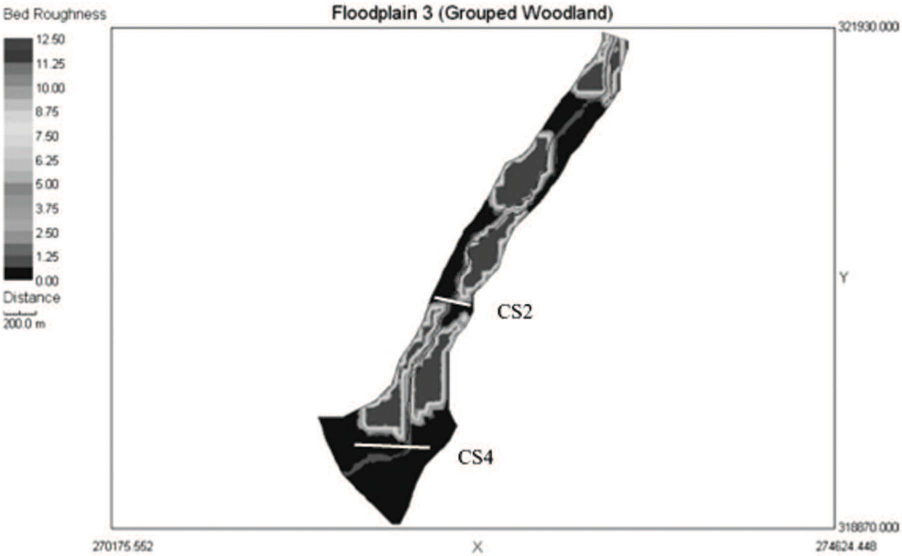

Figure 8: The distribution of Manning's roughness height (ks) with respect to a water depth of 2 m for the clustered woodland scenario in Floodplain 3.

Results

Results of each simulation were obtained by taking cross sections at hydrologically important locations (for example at the outflow boundary) within each reach (Figure 8), with the model producing numerical values for water surface elevations (m above OD) and discharge (m^3sec^{-1}) as the simulation progressed. Water is displayed in m (Figure 12).

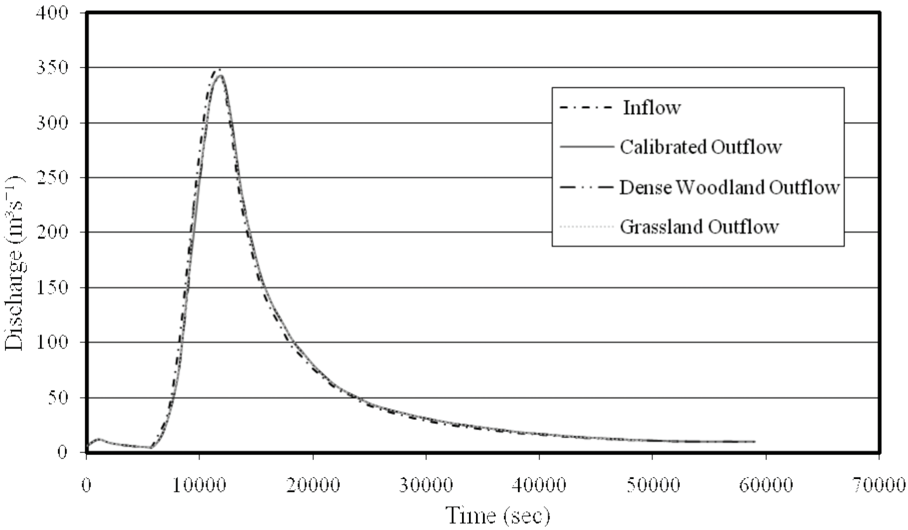

Figure 9: Modelled inflow and outflow hydrographs for the three vegetation scenarios in Floodplain 1.

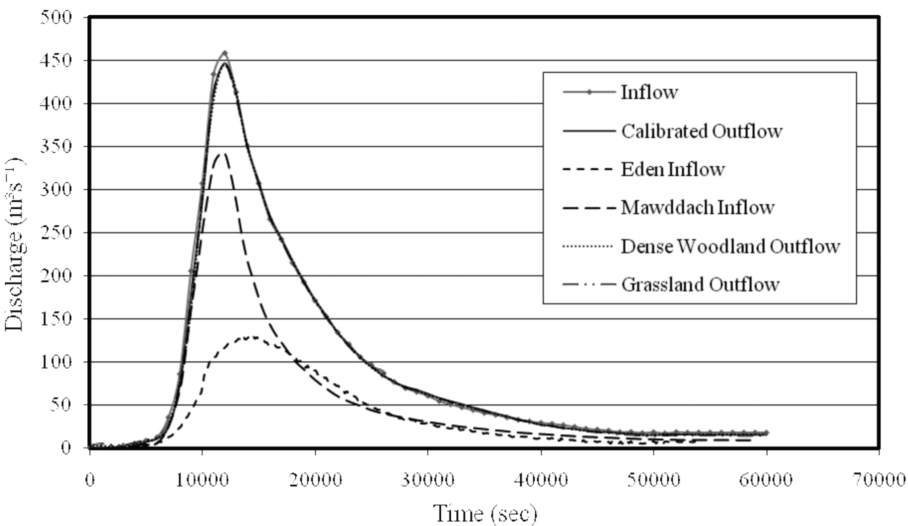

Figure 10: Modelled inflow (cumulative and individual) and outflow hydrographs for the three vegetation scenarios in Floodplain 2.

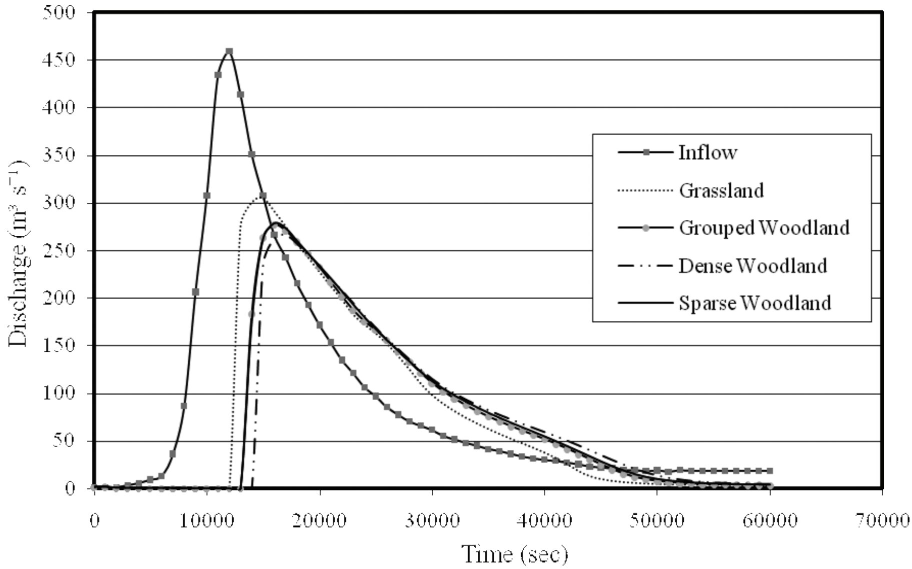

Figure 11: Modelled inflow and outflow hydrographs for the four vegetation scenarios in Floodplain 3.

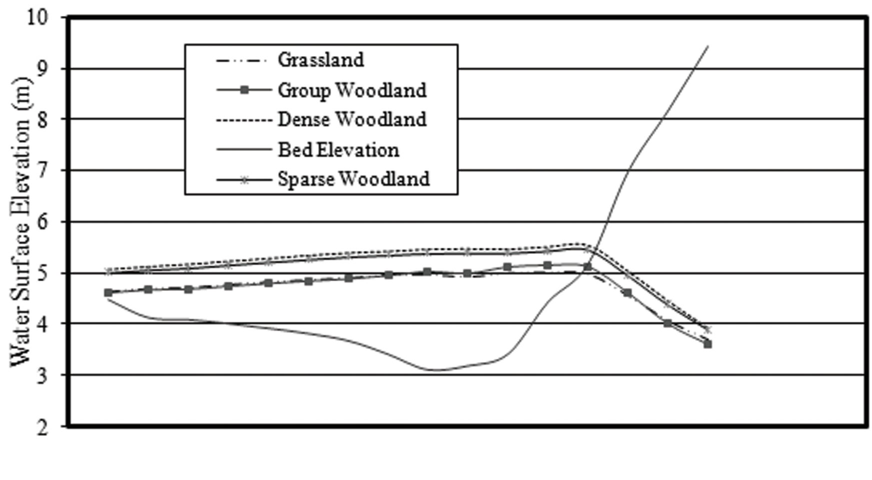

Figure 12: Modelled water surface elevations above OD at cross section 4 at the peak of the flood for the four vegetation scenarios in Floodplain 3. See Figure 8 for cross section location.

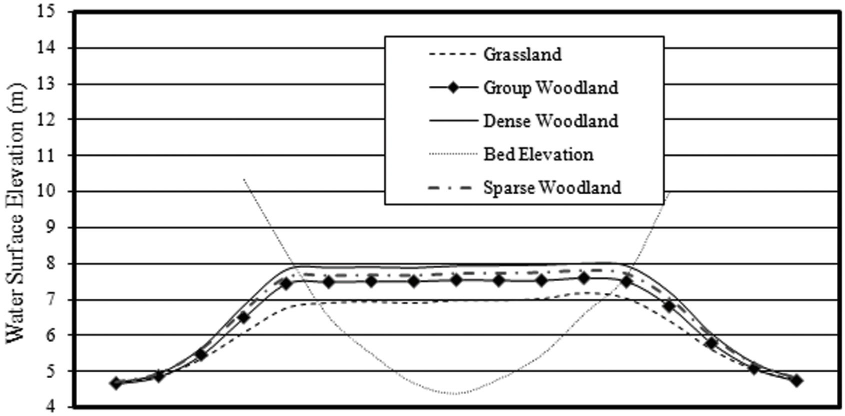

Figure 13: Modelled water surface elevations above OD at cross section 2 at the peak of the flood for the four vegetation scenarios in Floodplain 3. See Figure 8 for cross section location.

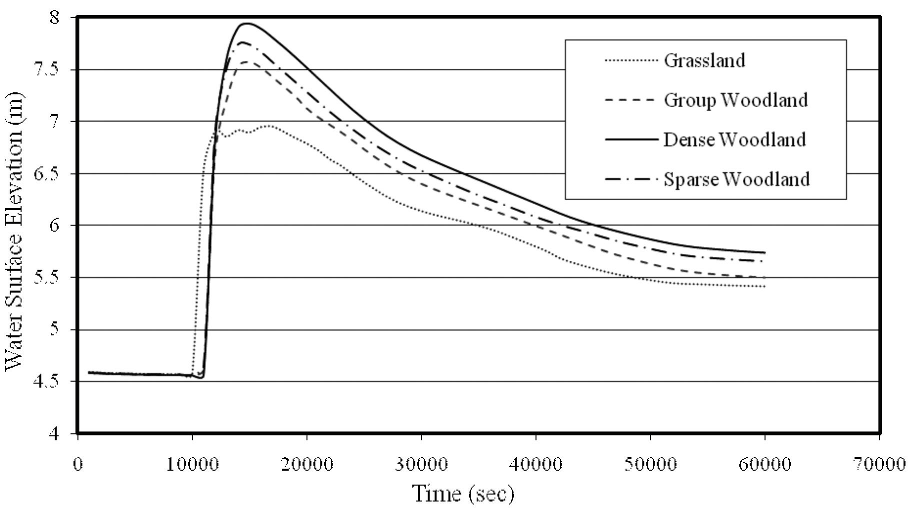

Figure 14: Modelled water surface elevations above OD for the four vegetation scenarios at Point 7 (located at the centre of CS2) in Floodplain 3.

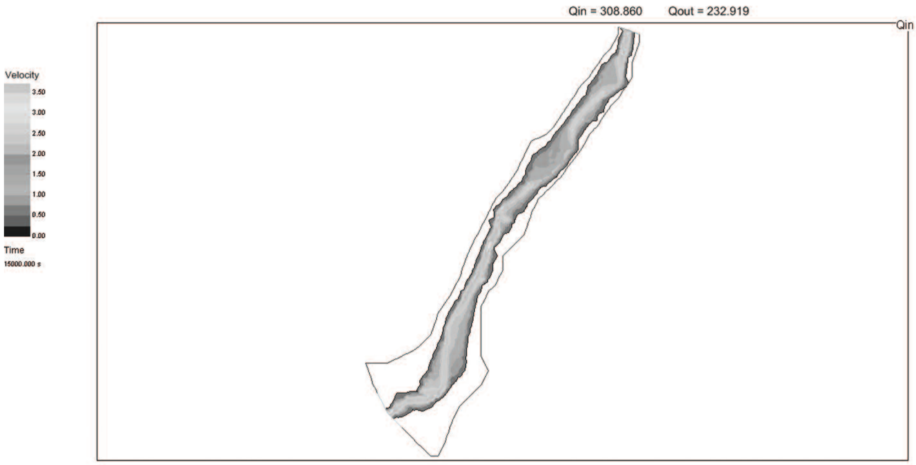

Figure 15: Modelled velocity distribution (ms^{-1}) across Floodplain 3 at and around the peak of the flood for dense woodland. Qin and Qout are inflow and outflow rates in m^{3}sec^{-1}.

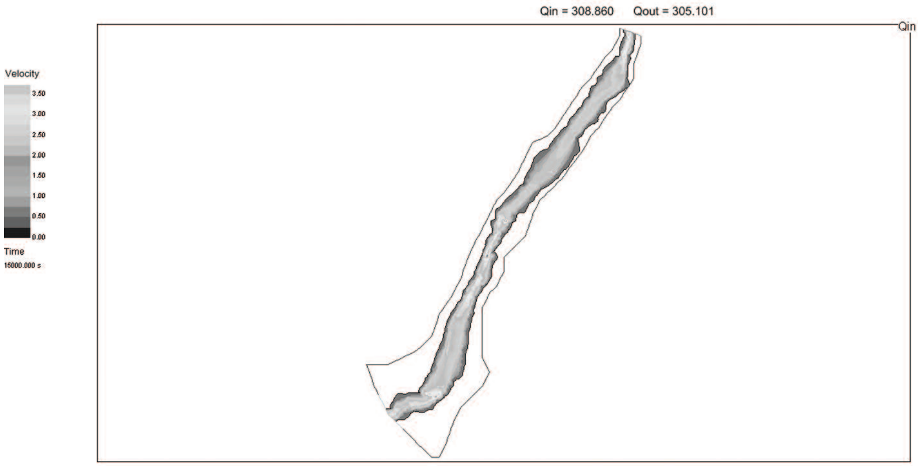

Figure 16: Modelled velocity distribution (ms^{-1}) across Floodplain 3 at and around the peak of the flood for grassland. Qin and Qout are inflow and outflow rates in m^{3}sec^{-1}.

Discussion

Floodplains 1 and 2

It is evident from Figures 9 and 10, as well as from water surface elevations, that Floodplains 1 and 2 had similar inflow and outflow hydrographs. For either reach to be effective in flood mitigation, the outflow hydrographs of the more heavily vegetated scenarios (for example dense woodland) should produce a more attenuated (less flashy) form, with a lower peak and slower response time, relative to the inflow.

None of these characteristics were detected in either reach. A scenario such as dense woodland should also produce higher water surface elevations and lower discharge intensities than a scenario such as grassland. This was not the case in Floodplain 1, where modelled water surface elevations never increased more than 5 cm during the peak of the flood, when compared with dense woodland and grassland. The homogeneous nature of the water surface elevations resulted in almost identical outflow hydrographs for the various vegetation scenarios in Floodplain 1, with grassland producing a peak discharge of 342 m^3s^{-1} at approximately 20.45 hours and dense woodland producing a peak discharge of 341 m^3s^{-1} some 15 minutes later. While some mitigation did occur, it was small, as illustrated by the closely aligned outflow hydrographs in Figures 9 and 10. Preferential flows rates between the river and the floodplain are to be expected, but because Floodplain 1 had a very small area, the ability of the floodplain to store water was limited, as well as the fact that the river channel is quite deep at this location, as it took 35% (or 125 m^3s^{-1}) of the peak of the inflow hydrograph to overtop the river bank. A similar pattern was found in Floodplain 2, with water surface elevations only varying by 10 to 25 cm for the vegetation cover scenarios.

Floodplain 3

Water surface elevations modelled in Floodplain 3 were far more variable in response to the inflow hydrograph than in the other floodplains. Figure 12 shows that the dense woodland scenario resulted in water surface elevations some 65 cm above that of grassland and clustered woodland. Results were consistent at each of the cross sections within the reach. Figure 13 shows water levels about the peak of the flood at cross section 2 (see Figure 8). Dense woodland leads to modelled water depths of over 1m greater than grassland. Figure 14 gives water surface elevations at the centre of cross section 2 for the duration of the flood. Here grassland resulted in lower modelled water surface elevations (maximum 6.95 m) when compared with dense woodland (maximum 7.92 m). Another point to note is that floodwater first encountered grassland, and subsequently the other vegetation types. This led to the delay in the occurrence of peak water depth, as the more heavily vegetated scenarios held back the river surge more effectively than grassland.

Modelled water surface elevations in dense woodland were 1.05 m higher than grassland at the inflow boundary at the peak of the flood. This difference may be attributable to the backwash effect of the dense woodland scenario, as the hydraulic roughness would not have influenced water depth at the inflow boundary. In fact, the backwash effect was detected for over 1.3 km upstream of the inflow boundary. Such a large increase in water depth and subsequent upstream water volume may have implications for infrastructure, housing and landuse potentially impacted by backwash, and will be an important consideration for future floodplain woodland projects (Thomas and Nesbit 2007).

Figures 15 and 16 show the difference in velocity between dense woodland and grassland at the peak of the flood, indicating that grassland may lead to higher water velocity throughout the site, approximately twice the velocity of dense woodland.

Because grassland has much higher velocity rates than dense woodland, the resulting outflow hydrograph will be more closely related to the inflow hydrograph (Figure 11), resulting in a much more intense and flashier flood event and. Increased turbulence induced by erect rigid vegetation, such as trees and shrubs, will reduce downstream flow velocity through conversion of linear kinetic energy into turbulent motion (Fischer-Antze et al. 2001). The reduction in down-channel flow and increase in cross-channel flow will increase water depths in and around the floodplain, employing a temporary storage area for the peak of the flood event, thereby reducing peak surges downstream of the floodplain.

For Floodplain 3 sparse woodland resulted in higher modelled water surface elevations at all cross sections, when compared with clustered woodland. This appears counterintuitive, as sparse woodland had half the basal area of clustered woodland. However, the velocity discharge maps indicate a lack of a continuous turbulent/transverse flow regime in the clustered woodland scenario, which may limit its potential to mitigate flood events, when compared with sparse woodland. Clustered pockets of dense woodland may simply constrict flow, thereby increasing velocity locally, with little effect on outflow pattern.

Dense woodland reduced modelled peak discharge by over 45 m^3s^{-1} compared with grassland. Sparse and clustered woodland led to similar results. The discharge from grouped woodland at the peak of the flood was 32 m^3s^{-1}less than grassland, not as effective as dense woodland, but it would also seem to provide significant flood mitigation. Overall, grassland cover seems to lead to higher discharge velocities compared with woodland, from the onset of the flood. However, the modelling indicates that after the peak, subsequent discharge from the woodland types begins to equal and exceed discharge from grassland. This may be a result of woodland holding the peak of the flood on the floodplain until the floodwaters begin to recede, with a gradual release of surface storage into the river.

Conclusions

Floodplains 1 and 2

Figures 9 and 10 indicate that Floodplains 1 and 2 offered little potential for flood mitigation: water depths showed little variation between the modelled vegetation types. This was probably due to the topography, size and location in the river system of the floodplains. The short reach of Floodplain 1 (370 m) would promote only temporary turbulent flow. As discussed, the river bank in Floodplain 1 was relatively high; it took 35% (or 125 m^3s^{-1}) of the peak of the 3 July 2001 flood for them to be over-topped.

Despite the undulating topography of Floodplain 2, it provided little potential for flood mitigation mainly, as in the case of Floodplain 1, because of its small size relative to potential high flows. Modelled velocity discharge indicated complex hydrodynamic effects operating over this reach, especially during extreme flood events.

Floodplain 3

Floodplain 3, on the other hand, did show divergence between the four vegetation types. The topography of the reach is a typical floodplain, and its width varied from 50 to 250 m, with a reach of 3.7 km.

The clustered woodland scenario in Floodplain 3 resulted in modelled water surface elevations being 25 cm lower than in sparse woodland, despite having twice its basal area. As already mentioned, the location of the woodland clusters can have significant effects on the outflow hydrograph.

An unbroken stretch of rigid vegetation, leading to transverse/turbulent flow, is critical to the reduction of flow velocity in a floodplain. A high vegetation density on the floodplain resulted in a backwash effect (detectable 1.3 km upstream in Floodplain 3), which could have consequences for infrastructure and housing that would otherwise be unaffected by flooding (Thomas and Nesbit 2007). However, a reach with a low vegetation density in the floodplain will have obvious consequences for downstream flood mitigation; therefore site specific analysis of the most appropriate vegetation density is important to estimate the effects on water level and discharge rate.

Although the use of floodplain woodlands in flood mitigation does show potential, more detailed analysis is needed on the hydrodynamic influence of the Mawddach tributaries on the downstream hydrographs. It is unlikely that floodplain woodlands alone will be the complete answer to the increased flood risks accompanying climate change. Nonetheless, the introduction of strategically placed weirs and other man-made structures would increase over-bank water depths, thereby increasing the potential of the floodplain to ameliorate peak flows (Hall 2008). The reduction of 45 m^3s^{-1} in modelled peak discharge between grassland and dense woodland for Floodplain 3 was considerable, as well as the 30-minute delay to peak discharge. Such reductions and delays in discharge are likely to considerably aid in flood control for towns further downstream, such as Dolgellau.

Coupled with this is the fact that floodplain woodland provides increased habitat biodiversity and enhanced landscape and recreation amenities for local communities. Furthermore, because of high growth rates, a coppice system with the potential for biofuel production could be practised in such a landscape. However, the effect of such silvicultural practices on hydrodynamic properties needs to be further investigated.

The use of floodplain woodland as an environmentally sustainable and perhaps financially effective means of flood defence has potential. Any flood defence system is however site specific, particularly floodplain woodland. Further work needs to be done in quantification of the hydrological influence of vegetation type on floodplain overflow. The use of high resolution topographical data such as LIDAR would aid in modelling larger study areas with greater accuracy.

The location of floodplain woodland in a river system appears to be important in flood mitigation efficiency. Further work needs to be done on establishing a relationship between floodplain woodland location and flood amelioration potential.

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A feasibility study on the performance of a harwarder in the thinning of small scale forests in Ireland

Joe Codd[a] and Maarten Nieuwenhuis[b]

Abstract

Private forest plantations in Ireland, if properly managed, have the potential to generate significant amounts of harvestable timber over the coming decades. However, the average size of private plantations is just 9 ha, therefore the identification of compatible, economic harvesting systems requires careful consideration.

A feasibility study was carried out to compare the machine operation and movement costs for a harvester-forwarder system and a harwarder system (an integrated harvester and forwarder on a single machine base) for projected harvesting over the period 2020-2025 in a selection of privately-managed forests in Co Wexford. Sensitivity analysis was carried out to determine the combination of factors that could make the harwarder system more cost-effective than the harvester-forwarder system.

The results showed that if the harwarder and the harvester-forwarder systems are used on all sites, and if stands with attributes that favour the harwarder system are not pre-selected, the harvester-forwarder system was more cost-effective. However, the harwarder was more cost-effective on sites with small harvesting volumes (<100 m^3). With a reduction of 10% in the operating cost of the harwarder system (representing the expected rapid technological and operational development of this new concept), both systems broke even, while, if only those sites with smaller harvest volumes were considered, the harwarder system would outperform the harvester-forwarder system. Management of the forests to establish tight harvesting clusters, by changing the thinning year of some of the stands, produced a marginal cost advantage for the harvester-forwarder system.

Keywords:

Harvesting, thinning, harwarder, small scale forestry

Introduction

The forest cover of the Republic of Ireland is approximately 700,000 ha or 10% of the land area (Forest Service 2007). Coillte (The Irish Forestry Board), the largest forest landowner in Ireland, owns 440,000 ha (Nieuwenhuis and Nugent 2000, O'Carroll 2004), with owned by companies, institutions and private landowners account for the remainder.

The public sector (Coillte and the Northern Ireland Forest Service) currently accounts for 95% of the annual harvest volume, with the private sector supplying the remainder (Bacon et al. 2003). However, it is anticipated that this situation will change over the next 15 years, with the private sector contribution set to increase to almost 25% (Phillips 2004a). A significant proportion of this increase will come from thinning of small sized private forests (Gallagher and O'Carroll 2001).

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Thinning is the most effective process that the grower possesses for manipulating the development of forest plantations and the quality and log size of the final crop (Savill et al. 1997). Thinning operations can be either mechanised or motor manual. In mechanised short-wood thinning, a harvester fells, delimbs and crosscuts the stem into product assortments, e.g. pulpwood, pallet wood, stake wood and sawlog (usually based on the top diameter, length, and quality of the log). The material is then extracted to roadside by a forwarder. This is the most common system used in Ireland and accounts for approximately 95% of mechanised thinning operations undertaken (Phillips 2004b). However, high harvesting cost and low value output are typical of first thinning. Current silvicultural practice in Ireland entails frequent light thinning operations (resulting in low harvesting volumes), which compounds the challenge of prescribing cost-effective thinning methods (Lilleberg 1997). Small stem size, low volume removal per hectare, the high number of remaining trees, the often dense non-marketable undergrowth, and the frequent movement of machines between harvesting sites, results in low machine productivity and low value production (Hurley et al. 2002).

The location, size and quality of privately-owned forests will significantly determine the economics of the small-scale private forestry sector (Redmond et al. 2003). Timber sale size and location in relation to other contracted harvesting operations, is seen as a major factor influencing the efficiency and cost of the operations. Sale volumes are often small and isolated, and distributed among many timber procurers employing different harvesting and haulage contractors. In addition, many privately-owned forests are located in relatively inaccessible areas with poor infrastructure, while the average size of private forests is just 9 ha (Farrelly 2007), which is significantly smaller than the Coillte average. This has the potential to reduce the profitability margin for privately-owned forests during all forestry operations, including harvesting.

A number of factors contribute to roundwood harvesting and extraction costs. These include the size of the plantation, ease of access, type of machinery used, and the competence of the machine operator (Phillips 2004b). Higher harvesting costs are incurred (Kellogg and Bettinger 1994) where:

1. harvested volumes and tree size are small,
2. access is poor,
3. areas are isolated and
4. site conditions are difficult.

Machine relocation costs can also add significantly to unit costs (€ m^{-3}), particularly for harvesting small volumes. The economic viability of the harvester-forwarder system is highly dependent on machine utilisation levels and productivity rates (Eliasson et al. 1999). However, where the harvest volume per site is small, the utilisation rates will be low, since frequent relocation of machines to new sites will be required. Figure 1 illustrates how the machine relocation component cost varies with the level of harvest per site, and demonstrates the need to develop harvesting systems to cope with sites with low harvestable volumes.

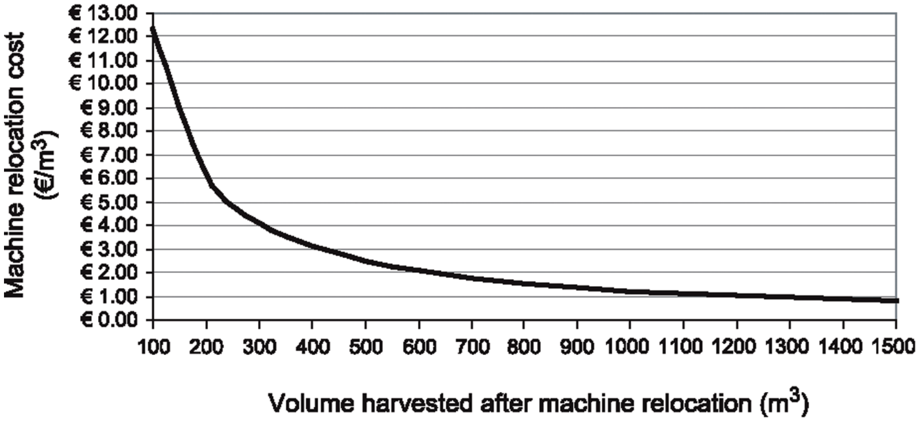

Figure 1: Variation of the machine relocation component of unit harvesting cost with harvested volume for a harvester-forwarder system (adapted from Kellogg and Bettinger 1994).

An example of such a harvesting system is the harwarder, which combines harvester and forwarder functions on the same base machine. Harwarders have not been used in Irish forestry to date.

The harwarder is seen as a way to reduce harvesting costs (Hallonborg and Norden 2000). A rapid development of the harwarder concept is taking place in Sweden and Finland (Siren and Aaltio 2001, Andersson and Eliasson 2004). In 2000, a new prototype equipped with a rotatable and tiltable load carrier was built in order to enhance the possibilities for processing logs directly into the load carrier (Wester and Eliasson 2003, Bergkvist 2008). It can be argued that complexity in harvesting is reduced by hardwarder use, as harvesting and forwarding is integrated on the same unit and therefore only one machine needs to be relocated. Furthermore, roundwood is presented at roadside soon after the commencement of felling, thereby minimising supply lead-in times. A further advantage is that one machine captures, processes and transmits all production data (Gellerstedt and Dahlin 1999).

The objective of this study was to compare the harvesting operation and machine movement costs for a harvester-forwarder system with a harwarder system, for a specific Irish harvesting programme in privately-owned, small sized forests in Co Wexford, Ireland. Sensitivity analysis was carried out to determine which combination of factors (thinning volume, tree size, machine cost, movement cost and movement distance) could make the harwarder system more cost-effective than the harvester-forwarder system.

Materials and methods

Forest harvesting sites were located in Co Wexford, in the south-east of Ireland. All were managed by Green Belt Ltd. The projected thinning programme for the selected forests scheduled for the period 2020-2025 was used to determine the harvesting locations and stand characteristics for the study. The study procedure was as follows:

1. locate forest sites managed by Green Belt Ltd. in Co Wexford (planted between 1999 and 2004) and determine their national grid coordinates,
2. determine the year of first thinning and forecast total thinning volumes and the average stem sizes to be removed from the forests over the period 2020-2025,
3. determine cost functions for the harwarder and the harvester-forwarder systems from literature,
4. determine machinery movement or relocation costs for both systems, based on the proximity of the sites to each other,
5. calculate total production costs for all thinning years together for the forwarder and harvester-forwarder systems,
6. evaluate unit costs (per m^3) for the harwarder and harvester-forwarder systems,
7. determine the point where the cost of the two systems was the same, and the more cost-effective system, under default variable settings,
8. conduct sensitivity analysis to determine the impact of the input variables (harvest volume, machine cost and thin year) on where the cost of the two systems became the same.

Methods were developed using literature, through personal communication with contractors and from Green Belt's GIS and databases, and tree species certification maps. Thirty four forests were included, comprised of 79 sub-compartments, and an overall total area of 265 ha.

The notional area of plantations was reduced by 15% to account for unplanted areas such as roads, ridelines, landings etc. As dynamic yield models for Ireland were not available for all the species included in the study, standard Forestry Commission (FC) yield models (Edwards and Christie 1975) were used to forecast stand development. The conifer stands in the study were planted at 2 x 2 m spacing and managed using an intermediate thinning intensity. The closest approximating yield models were applied depending on tree species. For example, the models for 1.8 m spacing for Japanese larch and hybrid larch, and 1.7 m spacing for European larch, both for intermediate thinning, and the model for 1.7 m spacing and crown thinning for Douglas fir were used. For the alder and oak sites, the combined sycamore, ash, beech (SAB) yield model was used.

Year of planting, site number, sub-compartment number, species, area, and yield class for all 79 sub-compartments were tabulated in an Excel spreadsheet. Additional data were extracted from the FC yield models: year of first thinning, the volume to be thinned (m^3 ha^{-1}) and the average stem size of the thinned material (m^3).

Determination of machinery relocation/movement costs

The cost of moving machines depended on the distance between sites and the number of machines to be transported. National grid coordinates for each site were obtained from the OSI Discovery Series map (1:50000). Using the coordinates, the distance between any pair of sites could be calculated. Data were sorted in order of the expected year of thinning and within each year, and the shortest path between forests was determined (using an Excel macro). Movement cost from one site to the next could then be calculated for the harwarder system and the harvester-forwarder system, using the costs in Table 1.

Table 1: Machine movement costs associated with the distance between sites (from Browne 2005).

Distance	*Harwarder*	*Harvester-forwarder*
km	*Cost €*	
<20	75	150
20-40	85	170
40-60	100	190

Development of machine operating cost functions

As there were no harwarder productivity or cost models available for Ireland, models developed for Finland were used (Talbot et al. 2003). The tree sizes in the study were similar to those used in the development of the Finnish models. As the Finnish study provided only contained graphs, these were transformed to tabular data, and the production cost (€ m^{-3}) was regressed on average stem size for each stand, for both systems.

The equation obtained for the harwarder system was:

$$Y = 14.62 - 0.03337x + 168.32\left(\frac{1}{x}\right)$$ and

for the harvester-forwarder system:

$$Y = 8.86 - 0.01192x + 294.44\left(\frac{1}{x}\right)$$

where y is the production cost (€ m^{-3}) and x is the average stem size of the stand (dm^3).

Determination of machine operation costs

The volume to be thinned (m^3) in each stand was determined from the yield models (Hamilton 1975) and site data. Using thinning volume (m^3) and harvesting cost (€ m^{-3}) the total production cost for the systems was calculated. Total thinning programme cost was determined as the sum of the total production cost and the total movement cost, summed over all the stands under consideration. Unit costs (€ m^{-3}) were calculated for both systems by dividing the total thinning volume, over all years, into the total thinning programme cost of each system. As the thinning programme time period was relatively short (6 years), undiscounted costs were used.

Analysis of harvesting scenarios

The costing procedure was applied to 13 scenarios (Table 2). These were selected based on variation in the harvesting volumes per site and in the harwarder cost. The variation in volumes was used to identify the scale of operations at which the two systems were most economic, while the variation in the harwarder cost was used to simulate the further technological and operational developments in harwarder design and manufacturing, as the system is still in a developmental stage. The final scenario was used to investigate the benefit of allowing stands to be thinned earlier or later than the prescribed thinning year.

Table 2: Harvesting scenarios analysed.

Scenario	*Harvest volume m³*	*Harwarder cost*	*Flexibility in thin year?*	*Sites thinned per year 2020 – 2025*
1	no restriction	standard	no	8, 18, 17, 12, 11, 13
2	<150	standard	no	5, 16, 12, 9, 8, 7
3	<100	standard	no	3, 13, 7, 9, 8, 6
4	<50	standard	no	2, 9, 2, 8, 5, 2
5	no restriction	- 10%	no	8, 18, 17, 12, 11, 13
6	no restriction	- 20%	no	8, 18, 17, 12, 11, 13
7	<150	- 10%	no	5, 16, 12, 9, 8, 7
8	<100	- 10%	no	3, 13, 7, 9, 8, 6
9	<50	- 10%	no	2, 9, 2, 8, 5, 2
10	<150	- 20%	no	5, 16, 12, 9, 8, 7
11	<100	- 20%	no	3, 13, 7, 9, 8, 6
12	<50	- 20%	no	2, 9, 2, 8, 5, 2
13	no restriction	standard	± 1 year	10, 17, 15, 12, 9, 16

Results

Scenario 1

Summing the total production cost and the total transport cost, a total programme cost was calculated for both systems (Table 3). The resulting unit cost of the harwarder was €1.77/m^3 higher than that of the harvester-forwarder system.

Scenarios 2, 3 and 4

Scenarios 2, 3 and 4 included only sites that could be thinned between 2020 and 2025 and that had a thinning volume per site less than 150 m^3, 100 m^3 and 50 m^3, respectively. The total costs of movement for the harwarder and harvester-forwarder systems in scenarios 2, 3 and 4 are presented in Table 3. The cost (€ m^{-3}) of the harwarder system was lower than that of the harvester-forwarder system when the systems were used on sites with a harvest volume of 100 m^3 or 50 m^3 (Scenarios 3 and 4), while in scenario 2 the two system costs were only marginally different.

Scenarios 5 and 6

Scenarios 5 and 6 included all sites that could be thinned between 2020 and 2025. In these scenarios the cost of the harwarder system was decreased by 10% and 20% respectively, to simulate the rapid development of the technology. The cost (€ m^{-3}) of the harwarder system was lower than that of the harvester-forwarder system if the cost of the harwarder was decreased by 20%. When the cost of the harwarder system was decreased by 10%, the two systems had the same cost (Table 3).

Scenarios 7, 8 and 9

Scenarios 7, 8 and 9 were a combination of scenarios 2 and 5, 3 and 5 and 4 and 5, respectively. These scenarios included all sites that could be thinned between 2020 and 2025 that had thinning volume less than 150 m^3, 100 m^3 and 50 m^3 respectively, and the cost of the harwarder was decreased by 10%. The cost (€ m^{-3}) of the harwarder system proved to be lower than that of the harvester-forwarder system for all 3 scenarios analysed (Table 3).

Scenarios 10, 11 and 12

Scenarios 10, 11 and 12 were a combination of scenarios 2 and 6, 3 and 6, and 4 and 6, respectively. These scenarios included all sites that could be thinned between 2020 and 2025 that had thinning volumes less than 150 m^3, 100 m^3 and 50 m^3 respectively, while the cost of the harwarder was decreased by 20%. In contrast to scenario 1, but similar to scenarios 7, 8 and 9, the harwarder system proved to be more cost-effective than the harvester-forwarder system in all three scenarios (Table 3).

Scenario 13

Scenario 13 involved moving the thin year of stands forwards or backwards by one year, to create tight clusters of stands in each year. When the thinning ages of various stands were changed by one year, the difference in cost (€ m^{-3}) between the harwarder and harvester-forwarder systems did not change greatly from scenario 1 (Table 3).

Table 3: Results of the analysis for thirteen harvesting scenarios.

Scenario	*Harwarder cost*	*Max. harvest volume per site*	*Total volume harvested*	*Harwarder*		*Harvester-forwarder*		*Difference in unit cost*
				Total cost	*Cost per m^3*	*Total cost*	*Cost per m^3*	
	%	*m^3*	*m^3*	*€*	*m^3*	*€*	*m^3*	*€ m^{-3}*
1	100	no restriction	14,008	230,637	16.46	205,823	14.69	1.77
2	100	150	3,471	65,254	18.80	63,770	18.37	0.43
3	100	100	2,088	42,083	20.15	42,953	20.57	-0.42
4	100	50	785	17,423	22.20	18,622	23.72	-1.53
5	90	no restriction	14,008	207,945	14.84	205,823	14.69	0.15
6	80	no restriction	14,008	185,153	13.22	205,823	14.69	-1.48
7	90	150	3,471	58,983	16.99	63,770	18.37	-1.38
8	90	100	2,088	38,101	18.25	42,953	20.57	-2.32
9	90	50	785	15,775	20.10	18,622	23.72	-3.63
10	80	150	3,471	52,688	15.18	63,770	18.37	-3.19
11	80	100	2,088	34,103	16.33	42,953	20.57	-4.24
12	80	50	785	14,122	17.99	18,622	23.72	-5.73
13	100	no restriction	14,008	225,107	16.07	200,094	14.28	1.79

Discussion and conclusions

When the harwarder and the harvester-forwarder systems were compared based on all sites, the harvester-forwarder system was more cost-effective. However, the harwarder was as, or more cost-effective on sites with small harvesting volumes, having the same cost as the harvester-forwarder system where harvesting volumes were between 150 m^3 and 100 m^3, and being cheaper where volumes were 50 m^3 or less.

The systems had the same cost if there was a decrease of 10% in the production cost of the harwarder system over the full range of tree sizes and harvest volumes. If the production cost decreased by 20%, the harwarder system became more economical, being more than €1.50 m^{-3} cheaper. As outlined previously, these cost reductions simulated the rapid technical development of the harwarder system currently underway.

Scenario 12 resulted in the greatest cost difference between the two systems - the harwarder system was €5.70 m^{-3} cheaper (maximum harvest volume was 50 m^3 and the harwarder production cost was reduced by 20% (Table 3)).

Reduced relocation times are a primary advantage of the harwarder systems. This makes them suitable in forest operations involving lower object-volumes (small areas with light or early thinnings), or more frequent and longer relocations. The importance of relocation cost is illustrated in scenario 3, before transport costs were taken into account the harvester-forwarder system was more cost effective, however after these costs were accounted for, the harwarder system became more attractive.

In carrying out this study, a number of factors were excluded from the analysis. Fixed costs such as overheads (insurance, taxes, etc.) and depreciation were not charged while machines were being moved. To calculate such costs, the total distance travelled under each scenario would have to be determined and expressed as total travel time, depending on route and truck classification. A cost per hour could then be allocated to travel time between sites. Fixed costs during travel time for the harvester-forwarder system, involving two machines, will be higher than the harwarder; and if included would favour the harwarder system over the two machine combination.

The integration of many functions on one base machine often impairs its utilisation and cost efficiency (Silversides and Sundberg 1989). A multi-function machine can become more expensive than a combination of several single-purpose machines. High hourly costs are assigned to work cycles (such as forwarding in case of harwarders) that can be done by a simpler and less expensive machine. In addition, a multi-function machine resembles a system of machines, where waiting and blocking times between the machine elements reduce overall productivity of the system (Silversides and Sundberg 1989). These disadvantages must be compensated by other parts of the work sequence, such as in the relocation of machinery and in the overheads needed for the management of operations. If work sequences can overlap and several operations can be conducted simultaneously, the efficiency of the machine improves in the actual operation at the site. This is evident with the harwarder, as discussed in Tarleton and Phillips (2003), where the ability of the integrated machine to process logs directly onto the bunk provides it with an advantage that more than compensates for its reduced harvesting efficiency. In addition, as indicated, relocation of machinery is cheaper when only one machine unit has to be moved.

The productivity equations for the harvesting systems were derived from a Finnish study (Talbot et al. 2003) and may not be directly applicable to Irish conditions. As no Irish data existed for harwarder productivity, the use of equations from the literature was the only way to approach the study. However, the scenario analyses are of relevance to the development of the Irish harvesting infrastructure.

As noted by Russell and Mortimer (2005), if roundwood is sold at roadside, a timber purchaser would usually buy a minimum of 35 m^3 (one truck load). One of the scenarios was based on sites with a thinning volume less than 50 m^3. In this scenario the harwarder system was cheaper to use than the harvester-forwarder system. However, there were sites included with less than 35 m^3 roundwood, which most likely would not be purchased and the cost advantage of the harwarder in this scenario is theoretical.

The combinations of variables that made the harwarder system more cost effective than the harvester-forwarder system were small tree sizes and small thinning volumes in small areas, with long transport distances. The reason longer transport distances favour the harwarder system is evident from Table 1, while a similar trend was observed by Hallonborg and Norden (2000).

The current sustained research and development work by major manufacturers, focusing on integrated machines, is evidence of a general recognition of the potential that these machines hold for future harvesting operations. Based on the results obtained in this study and expected further development in technology, the hardwarder has the potential to be more cost-effective than the harvester-forwarder system where tree size is small and site volumes are low, requiring frequent movement of the machine(s) from site to site.

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Sustainability of Irish forestry – current status and future prospects

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Abstract
Irish forestry is currently undergoing rapid expansion and it is government policy to increase the forest area to 1.2 million ha by 2030. This is intended to enable the forestry sector to achieve 'critical mass' in terms of timber production and to have an internationally competitive processing sector. However it is also recognised that forestry should maximise national wellbeing and be compatible with protection of the environment. Growing public awareness of, and concerns about, the non-timber benefits and impacts of forestry have led to the concept of sustainable forest management. Criteria and indicators of sustainable forest management have been developed and these can be used to measure progress. This paper reviews the recent economic, social and environmental performance of Irish forestry. It considers future sustainability under a business-as-usual scenario and identifies possible opportunities and threats. It concludes by identifying policies and measures that could lead to a more sustainable future for the forestry sector.

Background
The notion and theory of sustainable development has entered into common parlance since it was defined in the Brundtland Commission's *Our Common Future* as "development that meets the needs of the present without compromising the needs of the future generations to meet their own needs" (Brundtland 1987). Since then it has been the subject of considerable research and debate and, even though it is subject to varying and even contradictory interpretations, it is now recognised as a desirable objective by individuals, societies, economic sectors and the global community.

Forestry is based on the management of biological resources and it is appropriate that it be managed on a sustainable basis. Indeed this has long been recognised by foresters thorough the concept of sustained yield. However, recent decades have seen growing societal awareness of the non-timber benefits of forests such as biodiversity, water quality, carbon sequestration and recreation (Farrell and Byrne 2002). Forestry has also been associated with negative environmental impacts such as concerns about biodiversity, water quality, landscape quality and cultural heritage. In addition, there are increasing concerns about the negative impacts of tropical deforestation.

It is against this background that the concept of sustainable forest management (SFM) has emerged. In Europe, the concept was developed through a series of Ministerial Conferences and was concluded at the Third Ministerial Conference on the Protection of Forests in Europe in Lisbon in 1998. The process defined SFM and developed criteria for it. Each criterion has a series of indicators against which progress can be measured over time. In Ireland a national framework for SFM was

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realised with the publication of the Irish National Forest Standard (Forest Service 2000a) which outlines the criteria and indicators for the implementation of SFM. This is supported by the Code of Best Forest Practice (Forest Service 2000b), which describes all forest operations and the manner in which they should be carried out in order to be consistent with SFM. Further support is provided by environmental guidelines in relation to water quality (Forest Service 2000c), archaeology (Forest Service 2000d), landscape (Forest Service 2000e), biodiversity (Forest Service 2000f), harvesting (Forest Service 2000g), aerial fertilisation (Forest Service 2001), and forest protection (Forest Service 2002).

This paper aims to review the current economic, social and environmental performance of the Irish forestry sector, identify the challenges and opportunities facing the sector, and consider what policy mixes, including investment, would improve the future sustainability of the future.

Forestry and forest policy

Forests cover 697,730 ha or 10% of the land area of Ireland (Nieuwenhuis et al. 2007). The majority of forests are coniferous plantations, with the principal species being Sitka spruce (*Picea sitchensis*). Coniferous forests account for some 80-85% of the forest estate with the balance comprised of broadleaved and mixed woodland (Nieuwenhuis et al. 2007). Since the mid 1980s government incentive schemes have led to increasing private sector afforestation and currently 30.4% of all forests are in private (mostly grant aided) ownership (Nieuwenhuis et al. 2007).

The Irish Government's forest policy was most recently defined in its 1996 strategy, *Growing for the Future* (Department of Agriculture, Food and Forestry 1996). The objective of the strategy was to expand forestry so as to maximise its contribution to national and social wellbeing, compatible with protection of the environment. The strategy adopted the target of afforesting 25,000 ha per annum up to 2000 and 20,000 per annum thereafter, up to the year 2030. This would increase the forest area to 1.2 million ha by 2030 (or 17% of the country's land area). This rate of afforestation was designed to lead to a 'critical mass' of wood production of 10 million m^3 per annum, which would provide economies of scale to allow Ireland to develop an internationally competitive wood-processing industry.

Current economic performance of the forest sector

In a recently completed study, Ní Dhubháin et al. (2006) estimated that in 2003 direct output in the forestry sector was €255.4 million. Of this, €134.5 million represented gross value added (GVA), which was 0.12% of Gross National Product (GNP). For every €1 million in expenditure a further expenditure of €0.85 million is generated in the rest of the economy. Therefore the overall value of forestry to the Irish economy in 2003 was €472.4 million. Ní Dhubháin et al. (2006) further estimated that direct output in the wood products sectors (i.e. panelboard mills, sawmills and other wood products excluding furniture) was €975 million. Of this €312.3 million was gross value-added (GVA) representing 0.27% of GNP. When the indirect and induced impact of the three wood products sectors were taken into account the total value to the economy of the three sectors was €1.65 billion, nearly 3.5 times the forestry sector figure of €472.4 million.

The afforestation targets of the 1996 strategy have not been realised, with afforestation during 1996-2003 being 71,669 ha below the target (Bacon and Associates 2004). Moreover, afforestation is now almost completely carried out by the private sector. Afforestation has been dominated by coniferous species – principally Sitka spruce. Although Government policy has set a target of 30% for the mix of broadleaf species in planting, during 1996-2003 only 15.6% of planting was broadleaf.

Environmental economists often assign approximate values to non-marketed goods by inferred values or other means that attempt to describe the value that a society derives from an environmental good. Bacon and Associates (2004) calculated the value provided by Irish forests in terms of recreation; carbon sequestration; biodiversity and conservation; landscape; water supply, quality and flood control; health; and heritage and found that the non-marketed value of forestry could amount to €88.4 million per annum.

Although the forestry sector is excluded from the European Union greenhouse gas Emissions Trading Scheme, the economic value of the contribution of carbon sequestration by forests to meeting Ireland's Kyoto commitments can be estimated by comparison with the market price for carbon credits. For example, Byrne and Milne (2006) estimated that afforestation since 1990 would create a net carbon sink of 0.8 million tonnes of carbon per year during 2008-2012. At a carbon value of €15 per tonne this would have a value of €12 million per annum.

Using a model developed in the UK, Bacon and Associates (2004) estimated that there were a total of 11 million forest visits in 2004 and valued this at €37.6 million per annum using 2004 prices.

The impact of forestry on biodiversity depends not just on the species planted and the habitats it provides, but also the use to which the land would have been put if it had not been afforested. Bacon and Associates (2004) provided a "conservative" estimate for the value of the increase in biodiversity of €1.6 million per annum for every 20,000 ha planted, assuming that 10% of the forest estate meets certain minimum standards in biodiversity enhancement. Bacon and Associates (2004) concluded that forestry in Ireland had failed to realise its potential to enhance the landscape, whereas it has a small but negative impact on the value of water supply and quality.

Current social performance of the forest sector

Ní Dhubháin et al. (2006) estimated that in 2003 direct employment in forestry was 3,780 jobs, with every 100 jobs providing an additional 90 full-time equivalent jobs in other sectors of the economy. When indirect and induced effects were taken into account the total employment supported by the forestry sector was estimated to be 7,182 jobs. Direct employment in the wood products sectors was 6,870 jobs and this increased to 12,246 jobs when the indirect and induced employment impacts were taken into account.

The total market for sawn wood in Ireland is estimated at 1.65 million m^3 per annum. However, Irish-produced timber does not cover all categories of use demanded by the market. For this reason, the market that is accessible to Irish timber is smaller, approximately 1.14 million m^3 per annum. Irish timber has a 65% share of the accessible market and dominates the pallet and fencing markets (Bacon and Associates 2004). There has been significant investment in the sector in recent years, with over €100 million being invested in technology and additional capacity since 1999. In the past four years sawn output to the Irish market has increased by 37% and at 361,000 m^3 per annum; exports to the United Kingdom (including Northern Ireland) have doubled.

Xenopolou (2004) found that there are over 250 full-time businesses in Ireland that use homegrown hardwood, employing about 800 people on a full-time basis. There are also over 1,000 people who work with homegrown hardwoods on a part-time basis. Even still, demand for homegrown hardwoods exceeds supply, suggesting that the potential of Irish-grown hardwood has not been realised.

Current environmental performance of the forest sector

Since the early 1990s there has been considerable improvement in the environmental performance of the Irish forestry sector. Results from studies in the United Kingdom showed that forestry may have adverse effects on water quality. Subsequent studies in Irish forests found that forestry could have adverse effects on water quality in regions with low acid buffering capacity (e.g. Galway-Mayo and Wicklow), although this was not evident in Munster (see Giller and O'Halloran 2004 and references therein). Clearfelling and reforestation has been associated with increased levels of phosphorus in blanket peatland streams (Cummins and Farrell 2003). The introduction of guidelines in relation to water quality, harvesting and aerial fertilization will have helped to ameliorate these impacts. In addition, criteria and measures relating to water protection are set down in the Irish National Forest Standard (Forest Service 2000a).

Ireland is a signatory to the United Nations Convention on Biological Diversity (CBD) and is committed under Article 6B to "integrate as far as possible and as appropriate, the conservation and sustainable use of biological diversity in relevant sectoral or cross-sectoral plans, programmes and policies." Criteria and measures relating to biodiversity are set out in the Irish National Forest Standard (Forest Service 2000a). Prior to 2001 there was little direct investigation of the implications of afforestation and forest management for Ireland's flora and fauna. Research to collect relevant information has been ongoing since 2001 (Wilson et al. 2005). Management and planning guidelines in relation to forestry and bird diversity have been published (O'Halloran et al. 2002).

Ireland is also a party to the United Nations Framework Convention on Climate Change and its Kyoto Protocol. Under the terms of the Kyoto Protocol, carbon stock changes which occur during 2008-2012 as a result of afforestation, reforestation and deforestation since 1990 can be used to offset greenhouse gas emissions at the national level, including carbon dioxide (CO_2) (Byrne and Green 2004). As part of its Kyoto obligations, Ireland is committed to limiting its greenhouse gas emissions to 13% above 1990 levels by 2008-2012. Forestry has the potential to make a significant contribution to the achievement of this target and this has been recognised in the National Climate Change Strategy (Department of the Environment and Local Government 2000). Achieving this requires the development of a greenhouse gas inventory for Irish forests that meets international reporting requirements (Penman et al. 2004). Since the first assessment by Kilbride et al. (1999) there have been large advances regarding our understanding of carbon stocks and fluxes in Irish forests (e.g. Gallagher et al. 2004; Black and Farrell 2006; Byrne and Milne 2006). However, considerable information gaps remain, particularly in relation to soil carbon stocks and turnover rates, the carbon sequestration status of peatland forests, broadleaf plantations and non-CO_2 greenhouse gases.

All stages of the forest cycle, from afforestation to clearfelling and subsequent replanting, have an impact on the visual character of the landscape. The perception that coniferous plantations are monotonous, visually intrusive and detrimental to the traditional character of the landscape has arisen. This is particularly so in areas where forests are young (Kearney and O'Connor 1993, Ni Dhubháin et al. 2006). Given the current and expected future rate of afforestation there is a need to ensure that forestry will complement Ireland's landscape heritage. The Forest Service Landscape Guidelines (Forest Service 2000e) seek to ensure that planning and establishment of forest in the landscape is addressed adequately. Adherence to the guidelines is mandatory. Afforestation is prohibited in protected areas of landscape listed in the 1977 Inventory of Outstanding Landscapes (An Foras Forbartha 1977). All landscape aspects of forestry development must be compatible with County Development Plans. Furthermore, all afforestation projects covering areas over 70 ha require an Environmental Impact Assessment and are subject to planning permission. Projects covering more than 25 ha are referred to local authorities.

Ireland has a rich archaeological heritage that is an important source of historical information and an important educational and recreational resource. Careless or unplanned forestry development can have a negative impact on over-ground and underground archaeology. The Forest Service Forestry and Archaeology Guidelines (Forest Service 2002d) assist non-archaeologists involved in forestry development to identify archaeological sites and sets out procedures which should be followed in order to avoid site disturbance.

Future issues and challenges

The current rate of afforestation is about 13,000 ha per annum. If this trend continues, about 1 million ha, or 14-15% of Ireland's land area, will have been converted to forest by 2025. Even though this rate of afforestation is below the government target of 20,000 ha per annum, afforestation represents the single biggest land-use change over the past decade.

The challenges facing Irish forestry can be divided into two broad areas, economic and societal. First, the low rate of planting, which has fallen below the government targets every year since 1996, may mean that the national forest estate will not have the economies of scale to compete internationally (Bacon and Associates 2004). Second, the Irish forestry sector is not yet fulfilling its potential to provide environmental and other goods to society. The importance of the environmental and social dimension of forestry has grown, mainly as a result of instruments such as the Kyoto Protocol, support for the principles of SFM and changing societal views on forests and the practice of forestry. Unfortunately, the emphasis of the 1996 government strategy (Department of Agriculture, Food and Forestry 1996) on timber production has led to a concentration on fast-growing conifer species and an under-realisation of the contribution of forestry to sustainable development more generally.

Bacon and Associates (2004) identified several reasons for the low rates of afforestation over the period since 1996, including competition for land use, lack of skills and reluctance among farmers to commit agricultural land irreversibly to a single crop. In general, forestry is challenged by uncertainties, for example regarding the availability of markets for thinnings from the private sector. If markets are not developed, then crops will go unthinned, which will in turn act as a disincentive to plant, leading to further reductions in afforestation. Government support will be necessary to compensate for such uncertainties. Under the new Rural Development Regulation, however, government subsidies for afforestation are scheduled to decline from 100% to 70% of the cost of afforestation in designated ‘advantaged’ areas and to 80% in designated ‘disadvantaged’ areas, and the payment period for annual premiums will be reduced from 20 to 15 years (Fennessy 2005). These changes will reduce planting levels substantially in the absence of any additional government funding.

The forestry sector is exposed to increasing competition from wood supply from new European Union member states, which generally have lower costs and prices. Ireland’s competitive advantages are being eroded by increased costs across the sector, although costs could be reduced through reform of the timber sales area and in the areas of harvesting and transport (Fennessy 2005). A further challenge is the relatively small size of many private sector plantations, which are on average 8 ha in area but include many forests of 2-3 ha.

The ability of the private sector to achieve certification that their forests are managed and harvested according to sustainability criteria is also important, since many panel-board mills and sawmills now require roundwood to be sourced from independently certified forests (Anon. 2005).

Direct employment in forestry in 2003 was 10,650 (Ni Dhubháin et al. 2006) but difficulties are being encountered in attracting and retaining new forest workers. Fennessy (2005) cited the lack of nationally accredited forestry training courses allied to proper career structures, similar to those in other countries, which could attract and retain the young people needed to raise productivity and international competitiveness of the forestry sector.

Forests can provide vital public goods and services, but in the Irish forestry sector there is a risk that these services will be lost or underprovided because they are undervalued. Incentives need to be put in place so that the non-market benefits of forests will be realised.

A major uncertainty into the future is the effect of climate change on Irish forests (Purser et al. 2005). This has the potential to create new threats – such as new kinds of pests and unfavourable growing conditions. National research in this area is needed to investigate these potential effects.

Future trajectory under business-as-usual

It is projected that the amount of forested land will double by 2025 but that the value of forestry and wood output will increase at a slower rate (Fennessy 2005). Both Bacon and Associates (2004) and Fennessy (2005) emphasise that the Irish forestry sector will fail to realise its full potential to contribute to sustainable development in the absence of new financial incentives and other policies to reward private foresters for the non-marketed goods like carbon sequestration, biodiversity conservation and recreation that forests provide.

Afforestation

Bacon and Associates (2004) predict that annual afforestation will rise to the Government target of 20,000 ha due to the reform of the European Union Common Agricultural Policy (CAP) and other factors. Common Agricultural Policy reforms have attempted to simplify the system of farm supports and increase the incomes resulting from payments to farmers while reducing the costs of the farm budget and reducing distortions in product markets. The most significant effect is to 'decouple' payments and production, allowing farmers to choose the productive output of their land while still receiving CAP payments. Depending on the level of payment to farmers, CAP reforms are expected to lead to increased afforestation as payments are no longer directed at specific production like livestock and as land leased for production is released for alternative uses (Bacon and Associates 2004).

Nevertheless, afforestation has consistently fallen short of government targets under the 1996 strategy (Department of Agriculture, Food and Forestry 1996). If afforestation continues at the current rate of about 13,000 ha per year, by 2025 up to one million ha of land, amounting to some 15% of the total land area of the country is likely to be converted to forests. Approximately two thirds will be privately owned forest, mainly owned by farmers, with the balance in public ownership. Private forests are expected to be small and scattered and have an average size of just 8 ha (Fennessy 2005). By 2025 grants for afforestation and annual premiums may have been substantially reduced or even discontinued (Fennessy 2005).

Economic trends

According to Fennessy (2005), the Irish forestry sector is expected to harvest 6 million m^3 of roundwood annually by 2025, with roughly equal amounts being produced by the private and public sectors. Output in 2025 is expected to be about 75% sawlog and 25% pulpwood. The real price of roundwood in 2025 may be lower than current prices, and the forest contracting and other support infrastructural services may be operating at marginal profitability. The residential construction industry might expand its use of timber frame to 50% of new construction (in 2005 it was 27%), but the share of the construction market supplied by domestic sawnwood is likely to be limited. According to the Foresight 2025 report (Anon. 2005), the forestry sector has the potential to provide sustainable employment for up to 20,000 rural dwellers and also contribute to farm incomes. This depends on training for those engaged in forest management, harvesting and transport, and processing (including farmers as well as those employed in the sector), as well as a mix of state and private funding and investment and sustained funding for a strategic research programme.

Projected environmental trends

The Irish forestry sector can expect a continued emphasis on the environmental benefits of forestry and their integration with forestry's socio-economic functions. The development of the Irish National Forest Standard (Forest Service 2000a), the Code of Best Forest Practice (Forest Service 2000b) and the suite of supporting guidelines has helped to strengthen the environmental performance of forestry and this will continue in the future. However, given the current and projected future rate of afforestation it is necessary that these guidelines, as well as current legislation and forest practices, be reviewed and enforced in order to ensure successful implementation of SFM. Ongoing research will enable assessment of guidelines and identify changes which will improve the environmental performance of Irish forestry. Increasing emphasis on environmental issues at national and European Union level will further stimulate the need for sustainable development. Certification will remain an important issue and will become increasingly important for the private sector as timber output from these forests grows.

A number of current initiatives will assist the implementation and delivery of SFM. The National Forest Inventory will provide an up-to-date assessment of the national forest estate and will be a vital resource in planning future management. In addition, the forthcoming Indicative Forest Strategy will assist in the assessment of the potential for forestry development in a particular area, taking into account environmental and other constraints. Potential changes in forest management will have positive environmental benefits. These include continuous cover forestry, which, in contrast to clearfelling, involves the use of silvicultural systems whereby the forest canopy is maintained at one or more levels without clearfelling (Forestry Commission 1998). This practice is already being set up at demonstration level by Coillte (Ni Dhubháin et al. 2005) and will deliver potential benefits in terms of biodiversity, water quality, landscape and amenity. If the rate of broadleaf afforestation stays at current levels, there may continue to be an overdependence on exotic conifers. Continued population growth and increasing affluence is likely to create greater demands for amenity services from forests. However, the ability of the forestry sector to provide these services will depend on continued and increased financial support from government as well as on the willingness of the public to pay for these services. Financial support will also be required to maintain and expand the current rate of broadleaf planting.

Carbon sequestration in forests will make a significant contribution towards the meeting of Ireland's commitments under the Kyoto Protocol. The maintenance of the carbon sink in the medium to long term requires an ongoing programme of afforestation, however. For this reason, the current rate of afforestation should be maintained until at least 2035. Research will continue to inform our understanding of carbon sequestration in Irish forests and to underpin international reporting commitments.

Forestry is likely to play an increasing role in bioenergy production. This will involve utilisation of forest residues and recovered wood. If properly supported through financial incentives this will assist in the reduction of greenhouse gas emissions and reduce dependence on fossil fuels. Furthermore, the replacement of fossil fuel intensive products, such as concrete, with timber products can assist in the reduction of greenhouse gas emissions.

Policy changes likely to make trajectory more sustainable

Irish forestry is well placed to become more sustainable in the future, but this depends on changes and developments in policy. A fundamental requirement is that the value of public goods provided by forestry (as well as other sectors) be quantified and priced and that their full value to society be included in the process of policy formulation (Fennessy 2005). The National Forest Inventory (Nieuwenhuis et al. 2007) will provide an essential resource in planning and executing SFM, but it is essential that this be repeated at 5-10 year intervals in order to provide up-to-date information for management and planning and to assist in charting progress towards more sustainable forestry. The main national contributions of the forestry sector will be in public goods provision, for instance recreational uses, carbon sequestration and biodiversity conservation. This will require financial incentives for the public goods provided by forestry, as well as increased and sustained investment in nationally accredited forestry training courses, technology research and development (Fennessy 2005).

Bacon and Associates (2004) presented three sets of projections for the long-term sustainability of the Irish forestry sector. If the current rate of afforestation of about 13,000 ha per annum percent continues, the period 2030-2040 would see a major increase in output of timber for processing followed by a sharp contraction in output by over 25% after 2040. Increasing the rate of afforestation to 20,000 ha per annum would provide a much more stable level of timber output into the future. For this reason, Bacon and Associates (2004) concluded that afforestation at a rate of 20,000 ha per annum is the most appropriate minimum target to secure a sustainable commercial processing sector.

Such a rate of afforestation might secure the economic sustainability of the forest sector, but it is equally important that afforestation and forest operations in general have due regard for the natural and cultural environment, in particular biodiversity and archaeological features. Although Forest Service guidelines have been developed for a range of areas, including archaeological protection, biodiversity conservation and water quality, there is a need to check whether the guidelines are achieving their objectives. Where necessary this should be carried out by establishing monitoring mechanisms and targeted research projects. Furthermore guidelines may need to be tailored to specific needs such as regional differences in geology, soils and climate, as in the case of the water quality guidelines.

Given the long-term nature of forestry there is a need for studies on the impact of projected climate change on the productivity and viability of Irish forests. Forestry has a central role in the achievement of national compliance with the Kyoto Protocol. The potential role of forests in any post-Kyoto international agreements on climate change will be closely linked to the continued achievement of afforestation targets. Continued research will be required to meet international reporting requirements and to advance understanding of carbon cycling in Irish forests.

Forestry can also play a significant role in renewable energy and financial support for this is likely to increase. With the growing interest in green energy, many of the 30,000 part-time farmers that Ireland is expected to have in 2025 as well as a number of the projected 10,000 full-time commercial farmers, will be producing wood biomass as an important component of their farming enterprises.

The environmental contribution of forests will require further government support. For example, forests could be supported under the EU Natura 2000 programme, which provides funding for areas that have been designated as special areas of conservation. Fifty percent of proposed Natura 2000 sites have forest areas. Traditional commercial agriculture and forestry is not possible on Natura 2000 sites, but economic activities such as leisure, tourism and hunting are possible. The aim is to achieve multi-functional forestry on these sites. This means that the non-timber benefits of forestry are emphasised and landowners are compensated for the loss of timber or other land use related revenue. According to Bacon and Associates (2004), Ireland could gain additional support from the European Union for forests that place more emphasis on the management of plantations and the environmental impact and non-market benefits of forests, along the lines of the Native Woodland Scheme but such an approach would be at odds with the current focus on increased timber production. Changes in silvicultural practices, such as the adoption of continuous cover forestry, could play a significant role in promoting SFM.

Certification of Irish timber will be essential for the future competitiveness of the Irish wood-processing industry. Although Coillte forests are certified under the Forest Stewardship Council standard, attention will also focus on private sectors forests, as these plantations approach maturity and are harvested. The ability of the private sector to achieve forest certification is important since many of the panel board mills and sawmills now require roundwood to be sourced from forests that have been independently certified as well managed (Fennessy 2005).

The future competitiveness of the forestry sector will require greater cost efficiencies throughout all segments of the wood supply chain, as well as significant investment in research and development. With regard to the farm forestry sector in particular, the development of cost-effective harvesting and transportation systems is essential.

A further possible source of value from the forestry sector lies in non-wood forest products. Such products include foliage and forest tourism. Support for the development of this sector could help to compensate investors during the long period before forestry generates returns from harvesting wood.

Overall a number of initiatives are required to make the forestry sector more sustainable in the future. Among these are the following:

- commitment from Government to longer term multi-annual budgeting for the sector and continued investment in afforestation;
- comprehensive designation of forest land-use at a national level;
- management planning in all forests supported by regularly updated Forest Service inventory and area related databases;
- financial incentives designed to ensure that forestry continues to provide public goods, notably carbon sequestration, biodiversity conservation and recreational uses – promotion of public goods – should be integrated with nationally accredited forestry training courses and technology research and development;
- continued development of training and education programmes for forestry professionals, farm foresters, forest operatives and contractors;
- government support for more sustainable silvicultural practices such as continuous cover forestry;
- support for the development of markets for non-wood forest products;
- support for continued upgrading of the sawmill sector and small scale hardwood based industries;
- encouragement of investment in forestry by private sector companies and pension funds;
- integrated support for wood energy by government agencies and departments;
- management informed and led by research and development findings and continued investment in research and development.

Conclusions

Irish forests currently cover some 10% of the national land area and it is government policy to increase this to 17% by 2030, to provide a critical mass that will support the development of an indigenous wood-processing industry. Based on current trends the target for afforestation will not be met without additional policies and measures. The contribution of the forestry sector to sustainable development will also require explicit and financial government support for the social and environmental benefits provided by forestry.

Irish forests are managed in accordance with the principles of SFM as described in the Irish National Forest Standard. This is supported by the Code of Best Forest Practice and a suite of environmental guidelines. There is a need for ongoing review and enforcement of these guidelines in order to ensure that the implementation of SFM is improved. Management planning should be supported by regularly updated forest inventory data and ongoing research related to all aspects of SFM. Continued growth of the sector, in a manner consistent with SFM, will require financial support from the government. Private sector afforestation will decline if there is a reduction in current grants and premiums. Linkages with other sectors of the economy, such as bioenergy, tourism and amenity should be encouraged. Although the non-timber benefits of forestry are recognised by SFM there is a need for these to be valued appropriately.

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The breeding bird community of Balrath Wood in 2007

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Abstract

Balrath Wood is a small mixed broadleaf/conifer plantation which is managed with a view to enhancing biodiversity. Two ridelines were created in the 1970s to increase the attractiveness of the wood to both resident and migrant bird species. In order to assess the effectiveness of ride management, avian species richness, abundance and diversity in three discrete habitats at the site were estimated from data collected during a survey of the site in the summer of 2007, and compared with similar data collected in 1996.

The break in the canopy arising from the two ridelines at Balrath has allowed for the growth of a variety of herbaceous species and shrubs that provide additional cover and food for birds and enhance the positive edge effect on species diversity in the woodland as a whole. Bird species richness increased from 20 to 23, and bird diversity at the site increased from 12.2 to 13.4 by inclusion of ride habitats. These results indicate that current management practices, including ride management, have been successful in maintaining and enhancing avian diversity at Balrath Wood. Continued management of rides is essential to preserve their conservation value as the effects of forest management on bird communities are often short in duration.

Keywords

bird diversity, conservation, forest management, ridelines

Introduction

Balrath Wood (locally known as Knockcomra wood) extends over 21 ha and is located 40 km north of Dublin City in Co Meath (National Grid reference N 99 64). It is a young mixed conifer/broadleaf woodland dominated by native broadleaf species such as oak (*Quercus* spp), ash (*Fraxinus excelsior*) and alder (*Alnus glutinosa*). Conifer species include Norway spruce (*Picea abies*) and grand fir (*Abies grandis*). The forest was planted in 1969 on the site of a former mixed broadleaf woodland. Some trees from the original crop, such as horse chestnut (*Aesculus hippocastanum*) and oak are scattered throughout the site.

The Tree Council of Ireland and Meath County Council are responsible for the management and upkeep of the woodland. A management plan (2005-2014), aimed at maintaining a quality broadleaf woodland for nature conservation and as a recreational resource, has been agreed by Balrath Woods Preservation Group, Coillte, Forest Service and Meath County Council.

Mixed conifer/broadleaf woodlands, such as Balrath, are important habitats for birds and allow the development of more diverse avian communities than those

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supported by conifer-dominated plantations (Donald et al. 1998, O'Halloran et al. 1998, Walsh et al. 2000, Díaz 2006, Archaux and Bakkaus 2007). Structural features in woodlands are of particular significance for bird diversity and include rides, open ground, margins and buffer zones and specimen trees. Ridelines – rides – are (usually) straight-line paths or tracks within woodland, primarily opened to compartmentalise forest for management purposes; they are also valuable for biodiversity due to their capacity to enhance the plant and animal diversity when maintained as open habitats (Warren and Fuller 1993, Peterken and Francis 1999, Oxbrough et al. 2006, Smith et al, 2007).

Birds are an important component of overall biodiversity, and rides increase their diversity due to their enhancement of positive edge effects on species richness (McCollin 1998, Mitchell et al. 2006). Management at Balrath has emphasised sustainable biodiversity, and the attraction of a greater variety of bird species. To promote avian species diversity two rides (each c. 20 m wide) running diagonally across the site and intersecting at its centre were created during the early 1970s (Figure 1). These have remained unplanted since their creation to provide habitat diversity within the site and are a focus of attention in the current management plan (Barron and Perrin 2007).

Open areas make up 10% of Irish forests, with rides comprising almost 18% of open area (Forest Service 2007). Assessment of the avian diversity at Balrath Wood provided an opportunity to quantify the bird diversity associated with rides in a mixed conifer/broadleaf woodland and to assess the effectiveness of habitat management practice at Balrath. To this end, a monitoring schedule was established with a 10-year survey interval to improve understanding of the bird community and how it will be affected by management. The avian community was initially surveyed during the 1996 breeding season; the 2007 survey reported here being the second of the planned series.

Figure 1: Open area at the intersection of the two rides at Balrath Wood.

The objectives were to assess the bird population of three managed sub-habitats during the 2007 breeding season, to compare results with the 1996 survey and to assess the management implications of the findings.

Methods

The methods used followed those used by Duffy et al. (1997) during a preliminary investigation of the site. The three habitat types surveyed during the summer of 2007 were as follows:

1. ride – two open, unplanted linear stretches running north-west to south-east and south-west to north-east through the site,
2. wooded – the internal woodland where canopy cover was unbroken,
3. edge – the boundary between woodland and surrounding farmland.

Ten line transects (Bibby et al. 1993) were identified to estimate bird communities in the habitats (Figure 2). Transects varied between 300 and 560 m, depending on the length of the section being sampled. Four transects were located along the rides (R1, R2, R3 and R4), four traversed the woodland between the rides (W1, W2, W3 and W4) and two followed the external boundary of the wood (E1 and E2) (Figure 2). Breeding bird surveys were conducted on the mornings of 29 April and 10 June 2007 in order to detect both early and late breeding birds, and to ensure that late-arriving migrants were included (Coombes et al. 2006). On each sampling occasion all line transects were surveyed between 0600 and 1030 hrs BST. Separate dusk surveys were conducted on the 28 April and 9 June in order to detect nocturnal species. Only the ride transects were walked on these occasions due to the difficulty

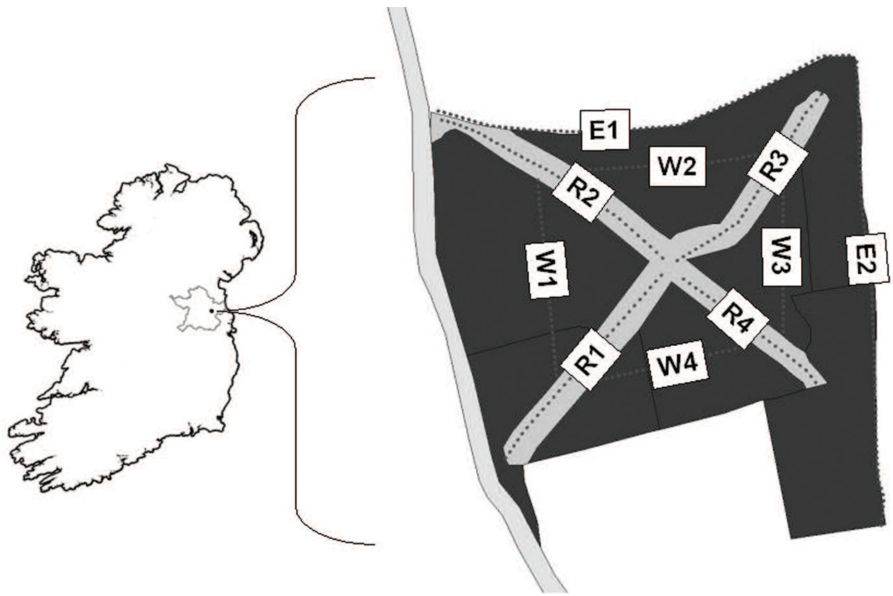

Figure 2: Map of Balrath Wood showing the survey transect locations (R = ride habitat, W = wooded habitat, E = edge habitat). Site area 22.3 ha.

of navigating through woodland at night. All surveys were conducted in good weather conditions (dry with light winds), within the range of conditions suitable for bird surveys as defined by Bibby et al. (1993). All birds seen or heard within 30 m of either side of the transect line were recorded. On transects which followed the woodland edge (E1 and E2), only birds on the woodland side were recorded. Flying birds were excluded unless obviously using the site. Due to the close proximity of the different habitat types it was not feasible to use the band system recommended by Bibby et al. (1993). Binoculars (10 x 40 magnification) were used to aid species identification.

The maximum count value of each species from the two survey days was used in data analysis. This provided a realistic representation of numbers present, as underestimation is likely when working with mean values. The density of birds recorded in each habitat type was calculated by dividing the maximum number of birds in each habitat type by the transect area surveyed (i.e. transect length multiplied by transect width) and expressed as mean number of birds per hectare in each habitat type.

Bird diversity was estimated using the Shannon Index (H) and Simpson's Index of Diversity (Reciprocal $^{1}/_{D}$) which account for both abundance and evenness of the species present. These were calculated as follows:

$$H = -\Sigma\, p_i \ln p_i \qquad (1)$$
$$D = \Sigma\, p_i^2 \qquad (2)$$

Where $p_i = n/N$, and n = number of birds of each species and N = total number of birds.

Results

Twenty three bird species were recorded at the site during the 2007 breeding season, with 18 individual species recorded in the ride habitat, 20 in the wooded habitat and 16 in the edge habitat (Table 1). The most abundant species at the site were Wren (*Troglodytes troglodytes*), Blackbird, (*Turdus merula*), Woodpigeon (*Columba palumbus*) and Chaffinch (*Fringilla coelebs*) all of which occurred in 100 % of the survey transects in all habitat types. Robin (*Erithacus rubecula*) and Goldcrest (*Regulus regulus*) were also common at the site, occurring in 90% of all transects. Dusk surveys revealed that Long-eared Owl (*Asio otus*) were present at the site, with a single individual recorded on ride R2, close to the centre of the site. In total, 17% of the bird species recorded at the site across all three habitats were migrant species. These were Blackcap (*Sylvia atricapilla*), Chiffchaff (*Phylloscopus collybita*), Willow Warbler (*Phylloscopus trochilus*) and Whitethroat (*Sylvia communis*). Just one individual Whitethroat was recorded, in a ride habitat.

The mean density of each species per habitat type is shown in Table 2, together with the densities of each species recorded during the 1996 survey. The highest overall density of birds was recorded in the edge habitat (16.5/ha), followed by the wooded habitat (13.6/ha) with the lowest density recorded in the ride habitat (9.6/ha).

Table 1: Maximum numbers of birds recorded on the 10 survey transects in Balrath Wood during the 2007 breeding season (R = ride habitat, W = wooded habitat, E = edge habitat).

Species	*Transect*									
	R1	*R2*	*R3*	*R4*	*W1*	*W2*	*W3*	*W4*	*E1*	*E2*
Blackbird	4	1	2	4	3	1	2	4	2	1
Blackcap	0	0	0	0	3	0	1	2	0	1
Blue Tit	0	0	2	1	0	0	2	0	1	1
Bullfinch	1	0	0	0	0	0	0	1	1	0
Chaffinch	1	1	2	1	3	2	3	2	2	2
Chiffchaff	1	1	1	1	1	2	1	0	0	0
Coal Tit	0	1	0	3	1	0	0	0	0	0
Dunnock	0	0	0	0	1	0	1	0	1	0
Goldcrest	0	1	1	1	2	1	1	1	2	1
Great Tit	0	1	0	0	0	0	2	0	0	0
Jackdaw	0	0	1	0	1	2	3	1	8	2
Long-eared Owl	0	1	0	0	0	0	0	0	0	0
Long-tailed Tit	0	0	0	0	0	0	0	1	0	0
Magpie	0	1	1	0	0	0	0	0	1	1
Pheasant	0	0	0	0	0	1	1	0	3	0
Robin	1	1	1	3	1	3	0	2	2	1
Rook	0	0	2	2	0	0	1	0	3	1
Song thrush	0	4	0	0	1	1	0	1	1	0
Whitethroat	0	1	0	0	0	0	0	0	0	0
Treecreeper	0	0	0	0	0	0	1	0	0	0
Willow Warbler	1	0	0	1	0	0	0	1	0	1
Woodpigeon	1	2	1	2	2	4	1	1	6	3
Wren	1	2	2	1	4	3	3	1	3	3

The highest density of birds recorded in any transect (22.6/ha) was also in an edge transect and the largest contribution to this density value was made by the sighting of 8 Jackdaws during one transect walk. It is important to note that the density at the second edge transect was less than half this value at 10.7/ha. The next highest density of birds (14.5/ha) was recorded in a ride transect. Maximum bird densities in all three habitat types were slightly lower than reported during the 1996 survey. The five most abundant species (birds/ha) in the three habitat types were similar with Wren, Chaffinch and Woodpigeon occurring in the top five at all sites (Table 3). A high proportion of corvid species (Jackdaw, *Corvus monedula* and Rook, *Corvus frugilegus*) occurred in the edge habitat, while Robin and Blackbird dominated the species assemblage in the ride habitat.

The Shannon Index revealed a similar diversity for the three habitats (H = 2.7, 2.7 and 2.5 in ride, wooded and edge habitats respectively). Diversity in Balrath Wood as a whole (including data from all three habitats) was 2.8. Avian Species Diversity in the wooded habitat, as estimated using Simpson's Reciprocal Index ($^1/_D$), was 12.2

Table 2: Mean maximum bird density (birds/ha) in the three habitats sampled (using maximum counts from the two survey dates) for each species in 2007, compared with data from Duffy et al. (1996).

Species	*Ride Habitat*		*Wooded Habitat*		*Edge Habitat*	
	2007	*1996*	*2007*	*1996*	*2007*	*1996*
Blackbird	1.62	1.27	1.62	0.83	0.92	1.30
Blackcap	0.00	1.11	0.97	0.00	0.31	0.00
Blue Tit	0.44	1.00	0.32	0.74	0.61	0.95
Bullfinch	0.15	0.00	0.16	0.32	0.31	0.00
Chaffinch	0.74	3.10	1.62	1.93	1.22	2.24
Chiffchaff	0.59	0.66	0.65	0.32	0.00	0
Coal Tit	0.59	0.53	0.16	1.24	0.00	0.96
Dunnock	0.00	1.88	0.32	1.19	0.31	2.23
Goldcrest	0.44	2.23	0.81	3.26	0.92	1.92
Great Tit	0.15	0.00	0.32	0.00	0.00	0.32
Jackdaw	0.15	0.00	1.13	0.00	3.06	0.00
Long-eared Owl	0.15	0.15	-		-	
Long-tailed Tit	0.00	0.00	0.16	0.64	0.00	0.00
Magpie	0.29	0.17	0.00	0.00	0.61	0.00
Pheasant	0.00	0.00	0.32	0.00	0.92	0.32
Robin	0.88	1.88	0.97	1.19	0.92	2.23
Rook	0.59	0.00	0.16	0.00	1.22	0.00
Song Thrush	0.59	1.58	0.49	1.15	0.31	0.33
Whitethroat	0.15	0.00	0.00	0.00	0.00	0.00
Treecreeper	0.00	0.00	0.16	0.00	0.00	0.00
Willow Warbler	0.29	0.14	0.16	0.00	0.31	0.33
Woodpigeon	0.88	2.02	1.29	1.56	2.75	2.90
Wren	0.88	3.31	1.78	1.52	1.83	2.91
Total	9.59	19.67	13.59	15.25	16.51	17.35

which was slightly higher than that of the ride and edge habitats (12.1 and 9.8 respectively). Species Diversity in Balrath Wood as a whole including transects from all habitats ($^1/_D$) was 13.4.

Table 3: Species rank in descending order of abundance for the three habitat types. Compared with data from Duffy et al. (1996).

Ride Habitat		*Wooded Habitat*		*Edge Habitat*	
2007	*1996*	*2007*	*1996*	*2007*	*1996*
Blackbird	Wren	Wren	Goldcrest	Jackdaw	Wren
Robin	Chaffinch	Blackbird	Chaffinch	Woodpigeon	Woodpigeon
Woodpigeon	Goldcrest	Chaffinch	Woodpigeon	Wren	Chaffinch
Wren	Woodpigeon	Woodpigeon	Wren	Chaffinch	Robin
Chaffinch	Robin	Jackdaw	Coal Tit	Rook	Goldcrest

Discussion

Plant species found on the ride margins at Balrath Wood included willow (*Salix* spp.), bramble (*Rubus fruticosus*) and rosebay willowherb (*Chamerion angustifolium*). The edges of the woodland itself lacked any transitional vegetation zones as the wood terminated abruptly where it abutted the surrounding agricultural land (improved grassland and tillage). The internal woodland was dominated by semi-mature or mature broadleaf trees, with almost continuous canopy cover and a dense understorey of young saplings, bramble and ivy. Therefore the canopy break created by the rides provided the only suitable habitat within the wood for sun-loving plants normally associated with forest edges. The periodic mowing operations carried out in the centre of the ride (Barron and Perrin 2007) promoted high numbers of plant species by controlling competition (Warren and Fuller 1993) in the margins of the rides, which are known to be important for deciduous trees and shrubs (Díaz 2006). The rides at Balrath Wood varied considerably in width from 5-22 m (Barron and Perrin 2007). Rides greater than 5 m are considered most valuable for birds (Warren and Fuller 1993), with those over 15 m supporting the greatest diversity (Smith et al. 2007). Wide rides also hold open grassland species for which other available habitats are in decline (Peterken and Francis 1999). In woods such as Balrath, which has only small areas of ephemeral open habitats, carefully designed and managed rides can help to enrich the bird life (Warren and Fuller 1993).

The composition of the avian community at Balrath Wood has changed little since the 1996 survey carried out by Duffy et al. (1997) and species richness remains much higher than in commercial plantations (O'Halloran et al. 1998, Smith et al. 2005) and is comparable with native woodlands (Batten 1976, Wilson 1977, Nairn and Farrelly 1991). None of the bird species recorded at this site were among those identified as species of conservation concern in Ireland (Newton et al. 1999, Lynas et al. 2007). Bird community structure was assessed using species richness (S), which was higher in the 2007 survey (23) than it was at the site during the 1996 survey (20). Species richness was highest (20) in the wooded habitat in 2007 and lowest (16) in the woodland edge habitat, while 18 species were recorded in the ride habitat. In 1996, species richness was similar in all three habitats (14 in rides and 13 in both wooded and edge habitats) (Duffy et al. 1997). The inclusion of the rides at Balrath Wood effectively increased the species richness at the site from 20 to 23 in 2007. This is typical of the positive association widely reported between rides and woodland bird communities (Mitchell et al. 2006), which is likely to be mediated through the provision of suitable habitat for nesting and feeding through increased structural diversity (Fuller 1995, Peterken and Francis 1999). The increased species richness of the wooded habitat itself is likely to be related to its maturation, and associated increases in structural diversity, making this area more attractive (Hobson and Bayne 2000, Díaz 2006) to a range of bird species since the 1996 survey.

The list of species detected differs only slightly between the two surveys, with the resident Sparrowhawk, *Accipiter nisus*, recorded in 1996, absent in 2007 and the resident Treecreeper, and migrant Whitethroat recorded in 2007 but not in 1996. Although these species may not be detected during surveys of short duration, the presence of Whitethroat, not recorded during the 1996 survey, in the ride habitat in 2007 is consistent with the development of shrub growth typical of managed rides, as this species breeds in open habitats with high levels of shrub cover (Mullarney et al. 1999, Smith et al. 2006). The presence of Treecreeper, which nests and forages in the bark of mature trees (Mullarney et al. 1999), probably reflects the more advanced growth stage of the wood in 2007 compared to 1996. This phenomenon is further demonstrated by the absence of Blackcaps, which were exclusively recorded in the ride habitat in 1996, from this habitat in 2007. This species typically breeds in shady woodland with dense undergrowth (Fuller 1995) and it is likely that the development of the understorey vegetation in Balrath through new planting (Barron and Perrin 2007) has resulted in a wider availability of undergrowth throughout the site, allowing Blackcaps to occupy territories away from the rides.

While Jackdaws, Rooks, Hooded Crows (*Corvus corone*) and Starlings (*Sturnus vulgaris*) overflew the study area in 1996 they did not appear to utilise the site itself at that time. Both Jackdaw and Rook were recorded roosting at the site during the 2007 survey. It may be that this apparent change in the use of Balrath Wood by these species is due to changes in the surrounding landscape rather than in the wood itself. These species typically use farmland and other intensively managed areas for feeding, and traditionally nest and roost in woodland (Waite 1984).

The study used a standard methodology that captures only those species seen or heard during the visits at the particular at the time of the surveys. Informal sightings of other less common bird species such as Buzzard (*Buteo buteo*), Grey Heron (*Ardea cinerea*) and Kingfisher (*Alcedo atthis*) have been reported at this site (John Simpson pers. comm.).

Mean bird densities differed between the three habitat types with the woodland edge habitat holding the highest density of birds and the ride habitat the lowest density (Table 2). This was not the case in 1996, when the ride habitat held higher densities of birds than the other habitat types (Duffy et al. 1997). The reason for this appears to be the presence of high numbers of roosting Jackdaws and Woodpigeons in 2007, two species which may favour the edge of woodlands due to ease of access to surrounding farmland (Waite 1984) and that were present in high numbers in the 2007 survey. Pheasants (*Phasianus colchicus*) were mainly recorded in the woodland edge habitat in both survey years, also possibly related to the proximity of farmland foraging habitat (Wilson et al. 1996).

The five most abundant species in the three habitat types were similar to general patterns observed in Irish woodlands (Coombes et al. 2006) and to those reported in 1996 (Table 3), with the notable inclusion of Jackdaw in the 2007 list. Goldcrest appeared in the top five list in all habitats in 1996 but not in 2007. This is possibly related to the relatively high numbers of Jackdaw at the site (which were not present in 1996) rather than an actual drop in Goldcrest abundance. Jackdaws were recorded in 90% of survey transects in 2007.

The ride habitat, while not holding the highest density of birds, did hold a high diversity of species ($^1/_D$ = 12.1) similar to that of the wood itself ($^1/_D$ = 12.2) and higher than the edge habitat ($^1/_D$ = 9.8). The inclusion of the ride and edge habitats in the woodland resulted in a total diversity at the site of $^1/_D$ = 13.4. This was also the case in 1996 where diversities of $^1/_D$ = 9.4, 8.5 and 9.0 were recorded in the ride, wooded and edge habitat respectively. The total diversity at the site estimated during the 1996 survey was $^1/_D$ = 9.6. These results provide further evidence for the hypothesis that the inclusion of rides as a management tool in forests is an effective means of increasing the diversity of birds associated with the woodland (Mitchell et al. 2006). The variety of early successional scrub species and availability of mature trees in this habitat attract a diverse range of species. The low species diversity in the woodland edge habitat observed during the 2007 survey may be related to the dominance of Jackdaws and Woodpigeons here which creates an uneven species distribution.

Management implications

The decline in woodland birds across Europe is related to the decrease in early successional and understorey vegetation (Warren and Fuller 1993, Fuller et al. 2005). The inclusion of rides within woodlands presents the opportunity to offset the effect of such habitat loss and this study demonstrates that the presence of the rides positively influenced the bird species diversity at Balrath Wood. These rides should be retained and managed to ensure that the scrub layer is maintained as the diversity in terms of cover and height of the shrub layer is particularly important for forest birds (Díaz 2006).

The maturation of trees in wooded habitats has been implicated in the addition of new species to woodland avifaunas (Fuller 1995), and appears to be responsible for the appearance of species (e.g. Treecreeper and Blackcap) that were not present in 1996. Any mature/semi-mature native trees in this habitat should be retained.

The woodland edge habitat supports a high density of birds, although a proportion of the species present exploit agricultural lands. The creation of a buffer zone of scrub and other early successional species between the woodland and the surrounding agricultural land would likely attract a higher diversity of species than the current abrupt boundary.

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The extent of recent peatland afforestation in Ireland

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Abstract

In 2004, the European Environmental Agency's (EEA) Spatial Analysis Group published findings from an analysis of CORINE data suggesting that 84% of the area afforested between 1990 and 2000 was on peat soils. The negative implications of these widely publicised statistics have been raised by environmentalists and policy makers alike. Our analysis shows that CORINE-based estimates of land use change are biased towards larger sized land parcels. Considering that more than 63% of land parcels afforested, in Ireland, since 1990 are less than 25 ha in size, the CORINE methodology tends to under represent the majority of afforested land parcels. In addition, comparison with high resolution Irish land cover and forest area geo data suggest that ca. 30% of the peatland area in the CORINE 2000 classification was misclassified. Work carried out by the Forest Service using the best available high-resolution data, estimated that the afforested area on peatlands is much lower than estimated by the EEA, representing 43.5% of total afforestation between 1990 and 2000. These results have been recently confirmed following the completion of the national forest inventory (NFI 2007a). This field-based assessment, which comprised 1,742 permanent sample plots, suggests that the percentage of peat afforestation between 1990 and 2000 ranged from 46 to 51% of the total afforested area.

Keywords

CORINE, peatland afforestation, national forest inventory

Introduction

Peatlands originally covered more than 17% or ca. 1,200,000 ha of the land surface of the Republic of Ireland. However, human use and modification over many decades, including private and commercial peat harvesting, afforestation and reclamation for agriculture following Ireland's entry to the European Community, have led to a significant loss of peatland cover.

In 2004, the European Environmental Agency's (EEA) Spatial Analysis Group published findings from an analysis of CORINE data suggesting that the 84% of the area afforested in Ireland, between 1990 and 2000, was on peat soils (EEA 2004). The publication of these findings in the national press raised public concern, and indeed criticism, about the extent of peatland afforestation and the loss of habitats.

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The area of peatland afforested will also have important consequences on the net national uptake or emission of greenhouse gasses by forests under Article 3.3 of the Kyoto agreement (see Black et al. in press).

In this paper we consider the validity of the EEA analysis in a national context. We have given special consideration to the limitations of the CORINE methodology for the purpose of land use change and forestry detection within the fragmented land use landscape that exists in Ireland. In addition, a comparison is made between the published EEA data and high resolution GIS data sources, and results from the recently completed national forest inventory (NFI 2007a, b).

Background

Description of CORINE

Coordination of Information on the Environment, CORINE, is an EU initiative established in 1985. The CORINE methodology for indicating Change in Land Cover (CLC) between 1990 and 2000 is complex (CEC 1993). Computer aided visual interpretation of satellite images (Büttner et al. 2004, Steenmans and Perdigao 2001) was applied in the process of updating the 1990 European Land Cover to 2000 (±1 year) and the Land Cover change detection for the interval of 1990–2000, using Landsat MSS and TM satellite images. The smallest unit identified in CLC 2000 is 25 ha, and the minimum width of a linear feature is 100 m. Changes detected in the CORINE CLC 1990-2000 were incorporated in CORINE 2000 only if the final CORINE 2000 polygon met the minimum mapping unit criterion of 25 ha. This means that a newly afforested area can only be detected by CORINE if it is larger than 25 ha. Clearly this is unlikely to accurately represent private afforestation since 1990, because the average size of newly established private forest parcels is 8 ha, and they are highly disperse and fragmented.

The CLC2000 nomenclature includes 44 land cover classes covering agriculture as well as urban and natural land use. The forest definition used by CORINE Land Cover (Bossard et al. 2000) is: "Areas occupied by forest and woodlands with a vegetation pattern composed of native or exotic coniferous and/or deciduous trees and which can be used for the production of timber or other forest products. The forest trees are under normal climatic conditions higher than 5 m with a canopy closure of 30% at least". Codes 311 representing deciduous forests, 312 for coniferous forests and 313 for mixed forests were used to interpret the change in forest area. An additional class, CLC324, was included in the analysis, based on the assumption that this would represent recently felled and afforested areas, which are less than 10 years old. However, CLC324 areas also include some semi-natural woodlands and scrub colonisation of cutaway peatland. This reclassification of land areas without ground truthing is one of our main concerns with the CLC 1990 to 2000 analysis.

High resolution Irish datasets

A number of data sources were used to derive land use change statistics to examine the extent of the Irish afforestation programme on peat soils. Two GIS overlay techniques were used to generate an afforested area-soils matrix between 1990 and 2000, namely point sampling and polygon intersection using Arc-GIS 9.1.

The afforestation grant and premiums dataset (iFORIS)

The afforestation grant and premiums scheme was introduced under European Commission Council Regulation 2080/92 to support afforestation of agricultural land as part of accompanying measures to CAP reform. The afforestation grant and premiums dataset captures all areas afforested following successful grant application. All afforestation areas recorded by the Forest Service are verified using a strict control and referrals process, which can include a post establishment site visit by a forestry inspector (Forest Service 2003). These datasets were primarily digitised using the 1:10650 and 1:2500 Ordnance Survey Ireland (OSi) raster maps. Post 2000 afforestation has been captured using 2000/2004 digital ortho-photography also produced by the OSi. The digitised grant and premiums afforestation database (iFORIS) represents 78% of the officially reported area for the period 1990 to 2000. These data sources are being updated for the new Forest Service Corporate system used to administer grant aided afforestation schemes (iFORIS).

Coillte afforestation dataset

This dataset was generated by Coillte, the Irish Forestry Board, and represents 100% geo data coverage for areas afforested over the reference period 1990 to 2000. This dataset was digitised using the OSi 1:10560 raster. The combined Coillte and iFORIS datasets represent a 96% spatial coverage of the area afforested between 1990 and 2000 (162,724 ha).

Irish Forest Soils (IFS) & land cover datasets

The soils and land cover datasets were derived from a number of map sources, remote sensed and ground-truthed data. These form part of a suite of maps provided to the Environmental Protection Agency (EPA) by the Spatial Analysis Group, Teagasc (Fealy et al. 2006).

A land cover map with a minimum resolution of 1 ha was derived using aerial photography and satellite imagery (Fealy et al. 2006). The land cover mapping exercise used the known occurrence of grassland types in Ireland in relation to soils. Thematic classes include grassland, bog and heath, rocky complexes, bare rock, forest (unenclosed) & scrub, urban land, coastal complexes, and water bodies (Fealy et al. 2006). The land cover dataset was derived primarily from remotely sensed data, including 1995 Landsat TM satellite imagery, 1995 black & white stereo aerial photography, and 2001 ETM satellite imagery.

The digital soil mapping project delivered soil and subsoil/parent material maps by extending information obtained from various surveys using a soil cover model (see Fealy et al. 2006). Over 40% of the dataset is a direct derivative of the National Soil Survey (Gardiner and Radford 1980) and has a minimum mapping unit of 1 ha. Subsequently, the FIPS-IFS project produced a first-approximation soil classification for those areas not previously surveyed by the National Soil Survey (NSS), using a methodology based on remote sensing and GIS. A modelling approach was then adopted to produce a projected map for Ireland using a modular system based on different soil/peat forming factors, such as sub-soils, parent material, vegetation and topography (see Fealy et al. 2006 and Loftus et al. 2002). These maps were then combined to create a predictive model of soil/peat occurrence, which is represented in GIS map form.

The OSi county boundaries and colour air photos

The OSi boundaries were extracted from the OSi Discovery Series, while the colour air photos were taken in 2000, at a scale of 1:40000. The latter was primarily used for visual checks of all other datasets.

The National Forest Inventory (NFI)

The Forest Service published results from the NFI in 2007. It was based on a randomised systematic grid sample design, at a grid density of 2 x 2 km, to provide the number of plots needed to estimate total standing volume with a precision of ±5%, at the 95% confidence level. The grid generated 17,423 intersections, each representing 400 ha. Land use was classified at each intersection, including afforested areas, using photo-interpretation of OSi aerial photographs, aided by supplementary information such as the Coillte and the iFORIS datasets. This resulted in the classification of 1,742 points as forest land. At each point permanent sample plots, representing 500 m^2, were set up. At each plot a wide range of growth, carbon stock, forest type, soil and other variables were assessed and electronically stored. Data collection began in November 2004 and was completed in November 2006. Quality control was implemented by carrying out an independent subsample of the plots, and by inbuilt checks in the data collection software.

A series of permanent plots were selected to represent the post-1990 afforested area using the iFORIS dataset, aerial photographs and ground measurements of tree age, and assessment of forest development phase (afforestation, first or second rotation).

The soil group classification used in the NFI was a modification of the great soil groups used in the National Soil Survey (Gardiner and Radford 1980), with the addition of sand, making 11 great soil groups: brown earth, gley, regosol, grey brown podzolic, rendzina, sand, brown podzolic, basin peat, lithosol, podzol and blanket peat. Soils had to have a peat depth greater than 30 cm in the drained state, and 45 cm in the undrained state. Basin peat consists of fen peat and raised bog and occurs almost entirely in low lying areas in the Midlands. Blanket peat occurs in high rainfall areas, down to sea level in the western half of the country, and at high elevations elsewhere. It is characterised by acid-loving plant species, such as *Sphagnum*, *Calluna*, *Tricophorum* and *Eriophorum*. Basin and blanket peats were further subdivided into cutaway peat and flushed or unflushed peats.

Analysis and comparison of land use change and soil matrices

Using the national high resolution datasets a number of analyses were carried out, independent of the CORINE analysis, to generate estimates of afforestation on peatland from 1990. The breakdown of the analysis is now described.

Comparison of land parcel resolution of different datasets

The frequency of post 1990 forest land parcel size, derived from the high resolution national forest geo datasets (Coillte and iFORIS), was compared with data derived from the national CLC 1990 and CLC 2000 to test the spatial accuracy of CORINE land use classification. For this analysis, the national forest estate geo data were processed using GIS to dissolve internal sub-compartment boundaries and adjoining forest compartment areas; so that the land parcel size could be compared to the CORINE data (CORINE and satellite data cannot distinguish internal boundaries within forest land parcels).

As the composite national forest estate dataset represented both a high resolution and spatially accurate representation of the estate, it was decided to intersect these with the CORINE 2000 dataset to test how spatially accurate CORINE was at mapping forests and other land uses.

Analysis of Forest Service and Teagasc soil datasets to generate independent estimates of afforestation of peatland

Forest Service datasets including forest, soils, OSi boundaries and ortho-photos were used to estimate afforestation of peatland over the 1990s reference period, to compare with the EEA study, and into 2006 to show more recent trends in relation to peatland afforestation.

The Teagasc Land Cover dataset intersected with CORINE data to compare peatland mapping

In this analysis the Teagasc (IFS) Land Cover polygons were intersected with the peatland polygons from CORINE 1990 and 2000 to compare peatland mapping.

The NFI dataset

Soils data from the NFI were initially analysed to estimate the distribution of soil types across the entire forest estate. To provide comparison with the EEA data, a subset of NFI data, representing land afforested between 1990 and 2000 was extracted based on mean stand age and planting year.

An additional analysis using a subsample of NFI and iFORIS data representing afforested areas from 1999 to 2005 was performed to demonstrate recent trends.

Results

CORINE land misclassification and resolution

Some 37% or 240,422 ha of the land area classified as forest by CORINE 2000 is misclassified when compared to the national forest geo data (Coillte and iFORIS data). This is a consequence of the conglomeration process within the CORINE methodology, which tends to underestimate smaller land cover parcels within a heterogeneous landscape. Therefore, pockets of peatland, grassland and other land cover areas can exist within a polygon which is dominated by forest. Likewise, pockets of forest within a landscape dominated by another land cover will be underestimated. The CORINE methodology assumes zero bias in the overall allocation of land use at the national level.

The CORINE digitising process may also result in overestimation, generalisation or amalgamation of land cover types. For example, when the residual parts of polygons are added to the neighbouring polygons during the CLC amalgamation process, the resulting shape and area changes are not the consequence of human impact or natural developments, but the result of amalgamation.

Significant discrepancies exist between CORINE and the Teagasc IFS-land cover data. Table 1 shows the results of the analysis of intersecting the Teagasc IFS-land cover dataset with the peatland classification from CORINE 2000. It is evident that the two datasets spatially coincided for 796,386 ha, representing a peatland area match of 69.5% for the dataset overlay (rows 1 to 6). However, 349,789 ha or 30.5% of what CORINE 2000 classified as peatland was classified as another land cover according to the IFS land cover dataset. Most of these IFS non-peatland land cover polygons, which intersected with CORINE peatland polygons were classified as grasslands (17.3%, Table 1, rows 7 and 8) and rocky complexes (6.7%).

Table 1: Intersection of CORINE 2000 peatland cover with the IFS land cover data.

IFS grid code	*IFS land cover classification*	*Area (ha)*	*%*
1	Bare soil	434	<0.1
2	Bog & heath	608,798	53.1
3	Bog	29,959	2.6
4	Cut bog	59,232	5.2
5	Cut & eroding bog	91,553	8.0
6	Bare peat & soil	6,410	0.6
IFS peatland cover intersected with CORINE peatland		796,386	69.5
7	Wet grassland	111,184	9.7
8	Dry grassland	87,264	7.6
9	Water	5,700	0.5
10	Unclassified	89	<0.1
11	Bare rock	6,569	0.6
12	Rocky complex	76,503	6.7
13	Mature forest	9,396	0.8
14	Forest & scrub	19,315	1.7
15	Built land	18,982	1.7
16	Sand	28	<0.1
17	Coastal complex	252	<0.1
18	Unclassified	14,507	1.3
	Other IFS land cover intersecting with CORINE peatland	349,789	30.5
	Total IFS/CORINE peatland intersected area	1,146,175	100.0

The CORINE misclassification issue seems to be related to two factors: dataset resolution and land use definition. The 25 ha minimum resolution of CORINE is too coarse to accurately delineate forest boundaries due to the fragmented nature and small size (average 5.8 ha, median 3.1 ha) of Irish forest compartments.

For a more valid comparison with CORINE, adjoining forest compartment boundaries were dissolved to arrive at larger areas. Following data processing (using the dissolving tool in Arc GIS) the average and median size of afforested areas were 18 and 14.3 ha, respectively. The frequency distribution of these land unit areas converted to forestry since 1990, based on high resolution datasets, shows that some 63% of the afforested dissolved boundary areas are less than 25 ha (80% of afforested area, Figure 1A). Thirty seven percent of afforested land parcels are larger than 25 ha, but only account for ca. 20% of total afforested area. Subsequent GIS analysis, based on an intersection of the afforestation land parcels > 25 ha and the IFS soils data, suggests that a high proportion of these large afforested areas are on peat soils.

Figure 1 also shows the frequency distribution of CORINE CLC forestry areas as a function of polygon size. The CORINE sample population histogram plot shows a distinct bimodal distribution of land use change area, with the split in the distribution occurring at 25 ha, the lower detection limit of CORINE.

The left hand side of the distribution represents isolated CORINE afforested land polygons between 5 ha and 25 ha (up to the arrow in Figure 1B). These polygons were all initially >25 ha, but were decreased in size due to the CORINE 1990/2000 intersection (i.e. the creation of smaller 'sliver polygons'). The right hand side of the distribution represents forests areas >25 ha, including smaller 'sliver polygons' now merged as one afforested land parcel.

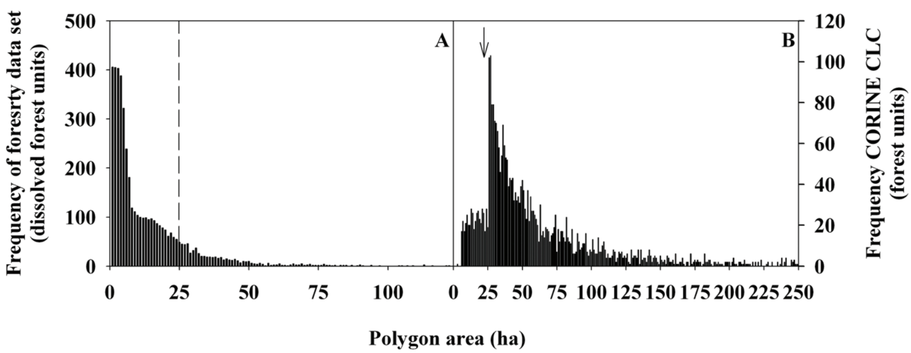

Figure 1: Frequency distributions of the forest land parcel size as derived from the national forest estate geo data (A) and CORINE 1990 and 2000 data (B). The dotted and broken lines in Figure 1A indicate the resolution of CLC 1990-2000. The arrow in Figure 1B indicates a distinct change in the detection frequency of the land use change (5 to 25 ha).

Comparison of different data sources

Both the NFI results and the analysis performed to intersect the IFS soils dataset with a composite national forest estate dataset show a considerably lower afforestation rate on peatlands, when compared to CORINE CLC analysis (Table 2). For the IFS soils and forest intersect, afforestation attributes for the 1990 and 2000 period, national forest estate datasets were generated and used in the intersection. From this available data, the total area of peat soils afforested was estimated to be 70,741 ha or 43.5% of the total area afforested in the reference period 1990 to 2000.

For the forest and IFS intersect analysis, blanket peat soils accounted for the largest proportion of peatlands planted with forests at 62.7%, followed by cutaway raised bog (32.3%), cutaway blanket peat (2.9%), intact raised peats (1.9%) and fen peat (insignificant).

Although the forest/IFS intersect area and officially reported afforested area is higher than the NFI estimated area (Table 2), this is due to the land use classification used in the NFI methodology, where open areas within forest boundaries are not counted as forest.

Table 2: A comparison of peatland area afforested (public and private) between 1990 and 2000 according to CORINE (EEA, 2004), the IFS soil/forest estate intersect and NFI datasets.

Dataset	*Peat area afforested ha*	*Estimated afforested area ha*	*%*
CORINE (EEA)	98,000a	116,667	83.9[a]
IFS soils/Forest	70,741	162,724	43.5
NFI[b]	72,979 (63,324 – 82,635)[c]	149,410 (136,320 – 162,500)[c]	48.8
Official total area 1990-2000		168,841	

[a] Taken from EEA (2004)

[b] The peat area afforested includes basin, blanket and cutaway peat. The estimated afforested area includes forest land only, open spaces such as ride lines and riparian zones are excluded. See NFI Methodology for definitions (NFI 2007b).

[c] NFI estimates exclude open areas within forest boundaries. Values in parenthesis show the confidence interval at $p \leq 0.05$.

Recent trends in peatland afforestation

Both the NFI and IFS-forest intersect estimates show a general decline in the afforestation of peatland from 1990 to 2006 (Figure 2A). The IFS-forest intersection estimates show a general downward trend in peatland afforestation, from 61.7% in 1990 to 32.9% in 2005. Similarly, the NFI data indicates a downward trend from 55% in 1990 to 43.1% in 2005. It should be noted that the total peatland area afforested since 1990 declined at a faster rate, when compared to proportional estimates, due to a decrease in the total area afforested in recent years. The spatial data estimates show that total peatland afforestation in 1990 was ca. 9,000 ha, compared to ca. 4,000 ha in 2005.

The proportional decline in peatland afforestation was consistent with a relative increase in afforestation on gley, grey brown podzolics and brown earths over the same period (Figure 2 B).

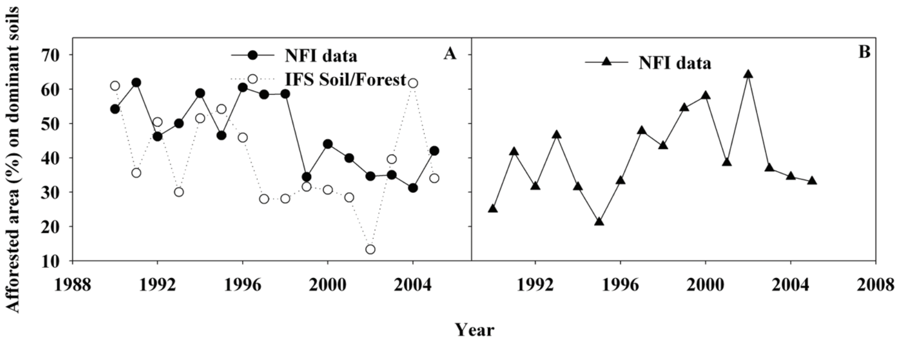

Figure 2: Afforestation of peatlands (circle symbols, A) and main mineral soil types (triangle symbols, B) from 1990 as determined the NFI and IFS soil/forest intersect estimates.

Statistics for the entire national forest estate

According to the NFI, 10% of the Irish landscape (697,840 ha) comprises forest and semi-natural woodlands. This includes open areas (72,100 ha) within forest boundaries, forest roads and ride lines. Forty-three percent of the total forest estate is located on peats. This includes plantations as well as semi-natural woodlands, such as the birch colonisation of cutaway peat. Gley soils are the other dominant soil group, occupying 26 % of the total forest estate (Table 3).

Table 3: Soil group composition of the national forest estate (from National Forest Inventory).

Soil group	*Area*	*Confidence interval (α=0.05)*		
		ha		*%*
basin peat	74,080	65,140	83,020	10.60
blanket peat	218,850	205,700	232,000	31.30
brown earth	58,880	49,900	67,870	8.40
brown podzolic	31,300	24,660	37,940	4.50
gley	181,280	167,740	194,830	26.00
grey brown podzolic	17,250	12,300	22,210	2.50
lithosol	16,410	11,520	21,290	2.40
podzol	74,120	64,680	83,560	10.60
regosol	6,430	3,300	9,570	0.90
rendzina	8,410	4,880	11,930	1.20
cutaway peat	8,840	5,190	12,480	1.30
sand	1,190	-	2,540	0.20
marl	400	-	1,200	0.06
limestone pavement	400	-	1,190	0.06
Total	697,840			100.00

[c] *Includes both forested areas and open areas which are integral to the forest (NFI 2007a).*

Discussion

Based on this comparative analysis, we have shown that the EEA CORINE-based estimation of afforestation of peatland was a large overestimate, when compared to independent high resolution geo data and ground-truthed NFI information. While there was good agreement between the NFI and IFS-forest dataset, it should be noted that these afforested estimates are based on afforestation and soil type statistics. In contrast, the CORINE afforestation estimate on peatlands is based on land cover classification statistics. However, the preliminary comparison of high resolution IFS land cover data and CORINE clearly show that there is a mismatch in land cover classification. Therefore, we suggest that the overestimation of the CORINE afforested area on peatlands between 1990 and 2000 in Ireland may be associated with:

1. statistical misrepresentation of Irish forest land parcels in CORINE (i.e. low resolution of CORINE) and
2. aggregation of classified categories, which may not reflect afforestation. This may be particularly relevant for CLC 234 (transitional woodland and scrub land), which may also include areas subjected to encroachment by hazel on the Burren, birch colonisation of cutaway midland peat and alder scrub on previously grazed upland.

CORINE classification and resolution problems have been highlighted in other comparative studies across northern Europe (Hazeu and de Wit 2004, Cruickshank and Tomlinson 1996). A study conducted in the Netherlands showed a 95% accuracy when CORINE 2000 areas were compared to orthophotography data on areas greater that 25 ha. However, when all areas, including land use parcels less than 25 ha, were compared, the accuracy decreased by 30% (Hazeu and de Wit 2004). A similar study conducted in Northern Ireland by Cruickshank and Tomlinson (1996), also highlights the resolution issue in relation to forest and woodland parcel size. More importantly, it was suggested that there was a bias towards Mediterranean land use in the CORINE classification, and there was a need for land classification subdivisions to avoid generalisations of peatland and pastures. These findings, together with the results presented here, suggest additional land classes for North-western Europe may be warrant inclusion in CORINE CLC. However, there is no indication that CORINE 2006 will include additional CLC nomenclature changes.

Temporal analysis of both the spatial geo data and NFI datasets suggests that there is a downward trend in peatland afforestation since 1990 (Figure 2). This not primarily related to a decrease in the afforestation rate since 1990, but rather a proportional increase (ca. 20%) in afforestation of mineral soils since 1990 (Figure 2B). These trends are likely to continue given the introduction of biodiversity enrichment incentives within afforestation grant and premium schemes, which favours the planting of broadleaved species on productive mineral soils, previously used for agriculture.

Finally, we suggest that afforestation, soil type and land-use change trend statistics should be taken from nationally derived high resolution data. The resolution and land class classification used for CORINE is clearly not representative of the

Irish landscape. The publication of these data has significantly overestimated the extent of peatland afforestation.

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Forest Perspectives

Commissioner Bailey's Foresight

Niall OCarroll

Abstract
Among the earliest voices, around 1890, to draw attention to the annihilative effects of the Land Acts on Irish woodlands, and to advocate their conservation and their extension by new plantings was that of a Land Commissioner. W.F. Bailey, traveller, *littérateur* and art connoisseur, became aware of the benefits that forestry could bring, and used his influence to publicise those benefits. He served on the 1907 Committee which led to the development of Irish state forestry.

Introduction

Specialist historians and biographers know where to go in search of the information they are looking for; in other cases information comes through sheer luck.

Re-reading Adrian Frazier's biography of George Moore (Frazier 2000) a passage prompted me to take down the little book of satirical verses, *Aids to the Immortality of Certain Persons in Ireland* by Susan Mitchell[1], the 1913 edition (bought for 2/-, i.e. two shillings), in Greene's Bookshop, Clare Street, Dublin, about 1960); a previous owner's name on the front flyleaf, W.F. Bailey, rang a bell: I went back to the biography.

George Moore (1852-1933), born at Moore Hall beside Lough Carra, Co Mayo, a successful novelist in London, had moved back to Ireland in 1901. His intention was to take part in the literary renaissance then in its initial stages. He hoped to regenerate Irish as a literary language as, he claimed, Dante had done for Italian. He left, disillusioned, in 1911.

Commissioner Bailey

It emerges that William F. Bailey was a Legal Commissioner in the Irish Land Commission. He had a lively interest in afforestation and in woodlands, particularly in their utilitarian functions. But before we consider that let us explore his other interests. George Moore, in his *Hail and Farewell* (1976), an account of his time in Ireland from 1901 to 1911, first published in three volumes from 1911 to 1914, describes Bailey thus: "I had gained his friendship in the last year of my sojourn in Ireland, and I found his alert and witty mind so pleasant that I had begun to think it a pity I had let him go by unknown for so many years. Bailey knows a good picture and buys one occasionally, he reads books and has practised literature and will

[1] Born 1866 in Carrick-on-Shannon, Co Leitrim. Assistant to George William Russell (Æ) at *The Irish Homestead*, journal of the Irish Agricultural Organisation Society, died 1926 (Pyle 1998).

probably practise it again; some day he will write his memoirs. And better still, he practises life, going away every year for long travel, to return to Ireland, his mind enriched…If I closed this book without mention of him it would seem that I had forgotten the many hours we spent together." In February 1911 Bailey held a dinner party to mark Moore's departure from Ireland, where "… he assembled all my friends: AE [George William Russell, promoter of the co-operative movement, pen-name Æ], Ernest Longworth [Dublin barrister; helped Moore to avoid potential libels in the composition of *Hail and Farewell*], Philip Hanson, John Healy [Editor of *The Irish Times*], John Eglinton [librarian, the National Library], the graceful and witty Dena Tyrrell, and Susan Mitchell, who sang songs about the friends I was leaving behind me".

Susan Mitchell (1918) in her own biography of George Moore, in a passage listing the literary persons than active in Dublin concludes "… one cannot pass from this company without mentioning Mr. Commissioner Bailey, clever, discriminating, at whose hospitable house anything that painted, sang, composed, or acted was sure of a welcome."

Regrettable as it might seem, it appears that Bailey did not write memoirs, but he was active and highly visible in the arts scene in Dublin. He was a trustee of the Abbey Theatre and Governor of the National Gallery. The poet W.B. Yeats developed an interest in the ruined tower house at Ballylee, near Gort, Co Galway, and moved to buy it. In the autumn of 1916 he was in the process of negotiating with the Congested Districts Board which then owned the building. Yeats's biographer R.F. Foster (2003) describes him writing to the 'ubiquitous' W.F. Bailey, who passed the letter to Henry (later Sir Henry) Doran, Chief Land Inspector at the Congested Districts Board. Foster's use of the term 'ubiquitous' in this context indicates Bailey's prominence at that time. Doran[2] was by then a permanent (or paid) member of the Board (Micks 1925).

Life, career and character

Surprisingly, Bailey does not feature in the *Dictionary of National Biography*, a British publication (perhaps the reported manner of his death, as indicated in the final section, may have led to this omission), but he does appear in *Who Was Who 1916-1928* (1967). He was born in Castletown Conyers, near Ballingarry, Co Limerick, on 9 February 1857, educated at Trinity College, Dublin, called to the Bar in 1881 and appointed to the Land Commission in 1887. He presented eleven papers to the Statistical and Social Enquiry Society of Ireland[3], including those on forestry which we will come to presently. He also edited the poems of Thomas Gray, and Coleridge's Ancient Mariner. His recreations are recorded as golf, cycling, motoring, photography and travel.

2 Doran, a civil engineer, gave detailed evidence about the planting of Knockboy to the 1907 Departmental committee on Irish Forestry (OCarroll 2004).

3 It is noteworthy that the same society was the publisher of an important paper by H.J. Gray (1963), where it was publicly revealed for the first time that government policy to exclude agricultural land from afforestation was implemented by setting a low maximum price that could be paid by the Forest Service for plantable land.

Irish Land Commission

For readers of more recent vintages it might be useful to briefly describe the Irish Land Commission. It was set up in 1881 with a dual purpose: to fix fair rents for tenant farmers and to buy estates or untenanted land for division among the existing tenants or other landless farmers. The Commission could advance a large proportion of the purchase price to the new tenants at a low interest rate, to be repaid over long periods, which varied over time from 35 years to 66 years. Transfer of land from landlord to tenant was by means of a two-stage sale process: landlord to Land Commission, then Land Commission to tenant; it was not a free gift. The tenants' annuities, were initially passed on to the UK government (which had advanced the money to buy the land), but from 1932 were retained by the Irish government, leading to the 6-year Economic War with Britain. One or more of the Commissioners had the status of a judge of the High Court. In all some 88% of the land area of the Republic of Ireland passed through the Land Commission, which was finally dissolved by an Act of 1992 (O'Shiel and O'Brien 1954, Connolly 1998).

Personal character

George Moore describes Bailey as living "in Earlsfort Terrace." A footnote to a mention of a "conversation at Bailey's" dated to September 16, 1909 in W.B. Yeats's *Memoirs* reads "William F. Bailey (1857-1917), Irish Land Commissioner, traveller, and *bon viveur*. His flat at 3 Earlsfort Terrace, Dublin, was a meeting-place for artists and politicians." (Yeats 1972). In the National Archives of Ireland internet version of the returns for the 1911 census for Dublin (NAI internet), that premises is recorded as occupied by two females, initially described as 'Servants', but the first of these descriptions is struck through and the word 'Head' inserted. One may hypothesise that Bailey was enjoying his hobby of travelling on census night.

Forestry matters

Publications

As already mentioned Bailey presented two papers dealing with forestry to the Statistical and Social Enquiry Society of Ireland. (He was elected president of the Society in 1902.) They were: *Forestry in Ireland* (1889) and *The Woods, Forests, Turf-bogs and Foreshores of Ireland. Opportunity for, and advisability of, establishing Government management and protection* (1890).

<u>Paper of 1889</u>

In the 1889 paper Bailey regrets the effect on woodlands of the transfer of holdings from landowner to tenant under the Land Purchase Acts. "It is pitiable in many cases to see the occupier, as soon as he gets a conveyance executed to himself, proceed to cut down and sell any trees that may be on his holding … In view of the probable further extension of the Land Purchase Acts, it is worth consideration whether the legislature should not introduce provisions which would prevent purchasers from acting in a manner undoubtedly detrimental to the country at large." He contrasts the apathy of the British, (and, at that time, also Irish, legislature), in this area with "other civilised countries", and adds "Most probably the time is not far distant when the people will be driven to planting trees for fuel purposes." It is not suggested that Bailey foresaw the rise and subsequent probable decline of oil as a universal source of heat and energy, but it is possible now that his prediction may be about to come true for reasons not remotely on the horizon in the 1890s. Bailey was conscious of a decline in the supply of turbary in Ireland and, as he assumed, the prohibitive cost of importing supplies of coal from England. He goes on to record the continuing decline in Irish woodland area from 152,000 ha in 1841 to 133,000 ha in 1881 (from 1.78 to 1.55% of the land area).

In his survey of the position in other jurisdictions he draws attention to the fact that in the Austrian Empire "… the [forest] proprietor cannot exercise a single act of ownership except under the control and with the approval of the forest inspector." Troup (1938) refers to the Austrian Forest Act of 1852 (presumably the legislation in force at the time of Bailey's visit) under which there may be no diversion of forest land to any other purpose without authority. An FAO survey (1988) of forest policies in Europe found that one of the objectives of forest policy in Austria was "Promotion of conversion of *productive* agricultural areas into forest (e.g. *for the production of firewood*)" (emphases added). It is also specified that "clearings of more than 2 ha. may only be carried out in exceptional cases." In an analysis of the results of the FAO survey just referred to, Hummel and Hilmi (1989) state that "… some countries place particular emphasis on maintaining the extent of the existing forest area by stipulating that any necessary forest clearance (e.g. for road construction) must be compensated by the afforestation of an equivalent area in the vicinity."

Bailey concluded that "Provisions should be introduced into future acts prohibiting the cutting of trees without the permission of the Land Commission, or whatever government department may be entrusted with the duty of supervision…Special legislation should be devised for the encouragement of planting."

<u>Paper of 1890</u>

In his second forestry-related paper entitled *Woods, Forests Turf-bogs and Foreshores of Ireland* (1890), following on from his 1889 paper already described, Bailey cites examples of large areas of woodland that have been cleared following implementation of the Land Purchase Acts.

He suggests that the legislation currently being prepared for introduction to Parliament should include a clause whereby all woodland areas potentially useful to the local district or community should be excluded from each farm sold under the Acts, and should be vested in the Land Commission. The Commission should then have power to manage them as thought best. The Commission should also have power to reserve any land of any estate to be disposed of to tenants, which is considered best suited to be afforested. He goes further and suggests that the Commission should have power to acquire land in various parts of Ireland with the purpose of having them planted.

Among the persons trying to promote forestry in Ireland he acknowledges a Mr Dermot O'Connor Donelan, J.P., of Tuam, C. Galway. He quotes Mr Donelan: "It is often surprising, in districts as bare of trees as the Sahara, the number of hills and townlands, called after woods, which have long since disappeared. All along the coast from Ballina to Galway, these constantly recurring names prove that, at no very remote period, a great part of that district was covered with timber", a point which has been often repeated by proponents of forestry. The present writer has no further knowledge of the said Mr Donelan.

In this paper Bailey discusses other wood-based industries then developing. These included paper-making, and downstream products such as "barrels, railway carriage wheels, gas-pipes, chimney-pots, carpets, artificial leather, and the thousand-and-one articles made from papier-mâché." He continues: "Celluloid made from paper-pulp is already proving an efficient substitute for ivory. It can be manufactured into cuffs and collars, backs of brushes, umbrella handles, and billiard balls, and makes drumheads better than parchment, as it is not affected by damp.

"The chemical products of timber are also very important. Among them we may mention charcoal for gunpowder and filtering, wood-tar, and extracts for tanning, and pyroligneous acids from which are formed creosote and acetic acid."

While not all of the avenues listed have proved fertile in the longer term, their mention shows that Bailey had done his homework very thoroughly.

He concludes: "The demand for telegraph poles, railway sleepers, pit props, etc., is constantly increasing. These articles are mainly supplied from pine forests, which would undoubtedly flourish in Ireland."

1907 Committee, and conclusion

As a result, presumably, of his demonstrated interest in forestry, W.F. Bailey was appointed to be a member of the 1907 Departmental Committee to enquire into forestry in Ireland, which reported in 1908! (Departmental Committee on Irish Forestry 1908). That report led directly to the beginning of state forestry in Ireland. William Bailey was appointed a Privy Councillor[4] in 1909. He died on 16 April 1917. In the first, privately printed, edition of *A Story-Teller's Holiday* (1918) George Moore states that Bailey "died a few months ago of a gun-shot wound", while in the commercial edition (1928) the words "of a gun-shot wound" are omitted. In both editions the passage continues "… and already Dublin society has forgotten him. His gift was atmosphere. He brought an atmosphere of happiness into the room; a precious gift truly for the conduct of life, but one so easily appreciated that it is forgotten as easily as the passage of a pleasant breeze coming and going in and out of a garden." The unsigned obituary notice in *The Irish Times* (Anon.1917) simply states "The death of Mr. Commissioner Bailey occurred on Monday at his residence, Earlsfort terrace, Dublin". He appears not to have married.

It seems that William Frederick Bailey may have been the earliest authoritative voice to articulate the need for positive moves to protect and increase the area of woodland in Ireland, primarily with utilitarian purposes in mind. Some of his suggestions were taken up by the Department of Agriculture and Technical

[4] Most of the powers of the Privy Council had transferred to the Chief Secretary so that the appointment was more honorific than functional.

Instruction in the years following 1908, but more substantial implementation had to await the Forestry Act, 1928, passed into law by the independent Dáil of the Irish Free State.

We may conclude that William Bailey was one of that class of nineteenth century prominent persons whose principal objective was the enhancement of the public good, rather than self-aggrandizement or self-enrichment.

It is my personal regret is that I did not observe and investigate the autograph signature on my copy of Susan Mitchell's book before I started work on my *Forestry in Ireland – A Concise History.*

Acknowledgements

I wish to acknowledge the help of staff at the Mayo County Library, Castlebar. TARA, Trinity's Access to Research Archive, made Bailey's papers available through the internet.

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Trees, Woods and Literature – 32

Planting Trees
Our last connection with the mythic.
My mother remembers the day as a girl
she jumped across a little spruce
that now overtops the sandstone house
where still she lives; her face delights
at the thought of her years translated
into wood so tall, into so mighty
a peer of the birds and the wind.

Too, the old farmer still stout of step
treads through the orchard he has outlasted
but for some hollow-trunked much-lopped
apples and Bartlett pears. The dogwood
planted to mark my birth flowers each April,
a soundless explosion. We tell its story
time after time: the drizzling day,
the fragile sapling that had to be staked.

At the back of our acre here, my wife and I,
freshly moved in, freshly together,
transplanted two hemlocks that guarded our door
gloomily, green gnomes a meter high.
One died, gray as sagebrush next spring.
The other lives on and some day will dominate
this view no longer mine, its great
lazy feathery hemlock limbs down-drooping,
its tent-shaped caverns resinous and deep.
Then may I return, an old man, a trespasser,
and remember and marvel to see
our small deed, that hurried day,
so amplified, like a story through layers of air
told over and over, spreading.

John Hoyer Updike was an American novelist, poet, short story writer and critic. He was born in 1932 in the small town of Shillington, in eastern Pennsylvania. When he was 13 years old the family moved to his mother's birthplace, the Hoyer farm in nearby Plowville. After completing his secondary education at Shillington High

School, he received a scholarship to Harvard, where he studied English, graduating in 1954.

As an undergraduate he edited the Harvard *Lampoon*, as well as contributing a string of articles and cartoons in his own right. His artistic talents drew him towards a career in graphic arts, and on graduation he attended the Ruskin School of Drawing and Fine Art at Oxford University for a year. While at Oxford, Updike met E.B. White and his wife Katharine, editors at *The New Yorker*, who encouraged him to take up a writing position at the magazine. He wrote for *The New Yorker* for two years, leaving to concentrate on his novels and other writing. He settled in Massachusetts, where he lived at various locations for the remainder of his life. He died in early 2009.

Updike is best known for the four Rabbit novels, two of which, *Rabbit is Rich* and *Rabbit at Rest*, received the Pulitzer Prize. Apart from the four novels, his overall output was prolific – almost thirty novels in all, as well as short story collections, ten books of poetry, and a huge corpus of criticism, articles and other pieces.

Although Updike's primary medium was the novel, he was also an accomplished poet. In fact, his first book, *The Carpentered Hen*, published in 1958, was a collection of verse.

Planting Trees is an exploration of family myths, and how the planting and longevity of trees marks and keeps them alive. Tree planting to mark events works best with individual trees. One recalls the controversy surrounding the Millennium Forest, planted in 2000, when every household received a certificate to say it had its own "special tree" in the forest. Naturally, some went in search of their special tree, but they found it hard to find (*Irish Times, Letters to Editor*, 22 April 2003, and passim). The silvicultural reality is, of course, that all planted trees do not survive, and those that do compete vigorously with one another, with some being shaded-out by early juvenile stage.

The poem also has a deeper meaning: nothing stays the same and all things pass. Each stanza marks a moment in time, from the childhood of Updike's mother, Linda Grace Hoyer, to the poet's birth, before concluding with his marriage and thoughts on his mortality. Each verse recalls a particular day, and the tree associated with the day and person – trees in growing and remaining (for a time) provide the "connection to mythic".

In the opening verse his mother recalls the day "she jumped across a little spruce", the metre conveying the movement of the child. The tree "now overtops the sandstone house". The house is the family home at Plowville, where Updike spent his teenage years.

The second verse opens with the "old farmer still stout of step", which may be a reference to Updike's maternal grandfather, John Hoyer, who was the original owner of the farm at Plowville, and who lived with the Updike family. His grandfather, on a rainy day, set "the dogwood planted to mark my birth". Updike said in later life that he "learned quite early [the dogwood] was exactly my age, was, in a sense, me." This statement, and the fact that he was a sickly child, marks "the fragile sapling" as Updike himself.

The allegorical connection of trees with people continues into the final verse, where Updike recalls the day he and his new wife transplanted two hemlocks, when they were "freshly moved in, freshly together"… "One died, gray as sagebrush next spring", but another survived, "lazy feathery hemlock limbs down-drooping/its tent-shaped caverns resinous and deep". Updike was grey of hair, his wife fair of limb.

Like many another, Updike was not averse to reusing a good metaphor or motif, albeit with some changes to meaning and context. Hemlock is a good example; where, over a long number of years, he used the tree's architecture as a mood/scene setter. In *Rabbit Run* (published in 1960, and wherein begins the angst-ridden odyssey of Harry 'Rabbit' Angstrom), a scene develops among the rhododendrons, which were "Planted all along the edges of the towering droop-limbed hemlocks that sheltered the place…" Thirty two years later, in 1992, in the novel *Seek My Face*, Updike resurrects and adds to the image: "She had loved living there when so small, but after her parents moved to Ardmore visits back felt strange, the huge droopy-limbed hemlock having grown sinister…" In one of his final pieces, a short story *The Full Glass*, published in *The New Yorker* in 2008, the image surfaces again: "With a sort of birdy animation he would faithfully lead me to the spring, down a path of boards slippery with moss from being in the perpetual damp shade of the droopy limbs of a great hemlock there. In my memory, beyond the shadows of the hemlock the spring was always in a ray of sunlight. Spidery water striders walked on its surface, and the dimples around their feet threw interlocking golden-brown rings onto the sandy bottom."

Updike was originally from Pennsylvania (Penn's woods), where eastern hemlock, *Tsuga canadensis* - is the state tree. Its crushed foliage is supposed to have a similar smell to the poisonous perennial hemlock (*Conium* spp), hence the tree's generic name. The range is from Quebec to Nova Scotia (*canadensis*), and south along the Appalachians, as far as northern Georgia and Alabama.

Eastern hemlock is under severe threat from the hemlock woolly adelgid (*Adelges tsugae*), a sap-sucking insect accidentally introduced to the US from Asia in 1924. The adelgid has now spread across the southern parts of the species range, but its northward expansion is much slower, possibly due to the colder climate. Most of the hemlocks in the southern Appalachian Mountains have seen infestations of the insect within the last five to seven years, with many "thousands of hectares dying out within the last two to three years". Asian species of *Tsuga* are resistant to the pest, more than likely a reflection of coevolution, while western hemlock (*Tsuga heterophylla*) is moderately resistant.

Tsuga canadensis is rarely planted in Ireland; it does not grow well here. The late Tom Clear, Professor of Forestry at UCD, to illustrate the importance of proper species selection, was fond of telling the story of visiting an estate to offer advice to the owner who was puzzled by the slow growth of his hemlock (he had christened it "bush hemlock"). It turned out the owner had planted eastern hemlock, mistaking it for the western species.

Western hemlock is a productive species under Irish conditions, but it has never achieved major prominence; it has been largely overshadowed by Sitka spruce, which has similar site requirements. There are number of fine productive stands, however, notably at Avondale: "Douglas fir, coast redwood, Lawson cypress, western hemlock and western red cedar have all done well…" (Carey, M. 2004. Avondale - a national forest resource. *Irish Forestry* 61(2): 20-37).

(Selection and note by *Lia coille*)

Society of Irish Foresters Study Tour to Norway 9-15 September 2007

On Sunday, 9 September, 40 members of the Society flew to TorpSandefjord Airport, 23 km north of Oslo, to begin the 64th Annual Study Tour. The party was welcomed at the airport by tour guide Tore Molteberg, and taken by bus to overnight accommodation at Hotel Budor, near Elverum.

Forests cover 119,000 sq km or 37% of the land surface of Norway. Productive forests comprise a smaller area, 72,000 sq km, about ten times the area of forests in Ireland. About 79% of the productive forest is privately owned, by some 125,000 forest owners. The annual roundwood harvest in 2006 was 12.2 million cubic metres. The forest resource is important to the country's economy as a source of raw material for the sawmilling, pulp and paper industries.

Monday - 10 September

The tour began with a visit to the Norwegian Forest Museum at Elverum, situated 145 km north east of Oslo. Norway has been an important exporter of timber since the beginning of the 15th century. The country's long forest history is portrayed in multi media presentations and well-preserved artefacts. Images show the development of forests since the Ice Age and the significant role played by the county's coniferous forests in the global ecological balance.

Norway's hunting and trapping traditions also feature, showing the equipment and techniques used by generations of hunters. In addition, an aquarium contains trout and char from mountain lakes, grayling from deep river pools and perch from forest ponds and lowland lakes.

The museum plays an important educational role in encouraging interest in forestry and wildlife among children, among an increasingly urbanised population. Displays encourage discovery through playing. Accommodation is provided in log cabins in a demonstration forest attached to the museum.

Educational programmes are designed for different age groups and levels of forestry/outdoor knowledge. Instruction and supervision is provided by museum staff and volunteers. Programmes are supported by a technical library comprising 25,000 volumes, as well as 200 periodicals related to the items featured at the museum.

Next stop was the Forestry Extension Institute at Biri, 162 km north of Oslo. We were welcomed by the Director, Dr Jon Pettersen, who outlined the institute's role in developing Norway's forest industry. The institute was founded in 1958 by the Norwegian Forestry Society and is a partnership of 38 member organisations, drawn from forest organisations and scientific institutions. The main objective is to provide continuous education in forestry and related areas by organising conferences and training courses, publishing educational material and funding research. On-site training is supplemented by an extensive, internet-based distance education programme.

Groups targeted by the institute are professional foresters, forest owners, forest workers/contractors, school teachers, pupils and the general public. Courses offered include silviculture, forest operations, forest economics and management, wildlife management and forest ecology. These vary from one to three days and attract in excess of 3,000 participants each year.

Financing is by way of grants from Norway's Ministry of Food and Agriculture, course fees, sale of educational material and funding received for research projects.

In 1977, the Forestry Extension Institute commenced a national programme of continuing education and extension courses entitled "Activity in Forests". The programme's objectives are to reduce the number of accidents/injuries, improve silvicultural practices and encourage better management of forest holdings. Its target groups are forest owners and forest workers/contractors. Course instructors are mainly foresters or skilled forest workers and farmers with some education in forest management and economics. Two important criteria for selecting instructors are forestry experience and a record of community involvement. All instructors are certified by the institute and must hold a diploma, which is awarded if the instructor successfully completes the institute's courses on forestry subjects and field use of educational equipment. There are 60 instructors throughout the country. Between 1977 and 2006, more than 19,400 courses were held, attended by 104,000 participants.

In Norway there is little tradition of co-operation between the formal education system and the forestry extension service. However, "Activity in Forestry" represents a successful bridging of this gap in educational collaboration. The overriding objective is to achieve a consistently high standard of forestry education and practice throughout the country.

Tuesday - 11 September

The party was welcomed to the nursery at Biri in Oppland by Dr Sjur Haanshus, President of the Oppland Forestry Society. Biri district is an important forest area which has an annual timber harvest of 1.2 million cubic metres; there is potential to increase this significantly as the annual increment is in excess of 2.4 million cubic metres.

The nursery manager, Mr Svein Krishansen, led the group on a tour of the nursery. Annual plant production is 5.5 million Norway spruce and 0.15 million Scots pine plants. The reason for the small production of Scots pine is that stands are mostly regenerated naturally. Most of the seed used is sourced from seed orchards, which results in a 10-15% improvement in growth over seed collected from the forest. It is expected that the next generation of seed orchards will provide a 20-30% improvement in growth. Seed from ten different provenances is used.

Seed is sown in a mixture of soil and vermiculite with a pH of 7.0. Germination rates of 96% are achieved regularly. Spruce seedlings are produced on a 2-year cycle, pine on a 1-year cycle. Fertiliser is applied through the irrigation system; levels are adjusted depending on foliar nutrient levels. Plants are treated with lambda cyhalothrin in the nursery to protect against pine weevil attack after outplanting.

Plant production in tunnels at Biri nursery.

Packing Norway spruce plants for dispatch at Biri nursery.

Almost all (97%) plants are containerised

More than 90% of spruce is artificially regenerated. Manual planting, carried out on contract, accounts for at least 97% of the annual planting programme. Only 2-3% of planting is machine based. By early to mid June, once the risk of frost is over, seedlings are moved out of the glasshouses. Snow cover, which persists from mid November to early April, protects 1-year-old transplants from frost damage by snow cover. In winter, glasshouses are heated by wood pellet boilers, supplemented by oil. In an effort to maximise the use of glasshouses, some 6 million tulips are grown during the winter. Overall, the greatest difficulty is forecasting demand – a problem familiar to nursery managers everywhere.

Wednesday – 12 September

From Biri the party travelled to Lillehammer, 180 km north of Oslo. We visited the Museum of Traditional Norse Architecture and the ski-jump used during the 1994 Winter Olympics.

Lillehammer district has a forest area of 27,500 ha, which produces an annual cut of 70,000 cubic metres, mainly Norway spruce sawlog and pulpwood, with some birch firewood. There are 545 forest owners in the district, with an average forest area of 50 ha.

Our first forest stop was a farm forest at an elevation of 600 m (in this part of Norway the tree line is at 900 m). The property is 103 ha, with four separate blocks producing 260 cubic metres/annum. To reach the site we travelled 22 km by forest road, through the properties of 60 separate forest owners.

Stands of naturally-regenerated Norway spruce aged 105–120 years, with a standing volume of 180 cubic metres/ha were being harvested by processor. Total harvesting costs were €14/cubic metre, while the expected log price was €50/cubic metre, at roadside. Prices had risen in the period before the visit, mainly due to curtailment of supplies from Russia, following the imposition of taxes on roundwood exports. Felled timber must be removed from the site within 14 days to avoid bark beetle damage. The processor contractor harvests 36,000 cubic metres/annum, working the machines in two shifts. Cable logging is seldom used nowadays.

On clearfell sites, at least ten deadwood/ha trees must be retained. Some high stumps are also left as platforms for hunting owls. Stumps are treated with urea on thinning sites but not on clearfells. The site was to be reforested with Norway spruce at a stocking of 1600/ha, at a cost of €880. Elk damage is a major problem in the locality - pine is rarely planted as it particularly vulnerable.

Our fourth stop was at the 45 ha farm of Erik Verdun, which comprised two stands of Norway spruce, planted on former farmland. One was 54-years-old, with a maximum mean annual increment of 8 cubic metres/ha. It carried 230 cubic metres/ha, and was approaching maximum mean annual volume increment. The other stand was 69-years-old, with the same productivity, and a standing volume of 300 cubic metres/ha. It had been thinned in 1975.

There was an ancient elk trap on the site. Such archaeological features must be included in forest management plans. A felling licence is not required but the forest owner must have a management plan.

Annual rainfall is 660 mm - it is seldom dry enough for forest fires to be a problem.

Thursday – 13 September

Sogn og Fjordane (Land of the Fjords) is a huge, sparsely populated district, 18,634 sq km in extent, with a forest area of 270,000 ha. Species composition is 13% Norway spruce, 33% Scots pine and 54% broadleaves (mainly birch, willow and aspen). Annual increment is 0.9 million cubic metres - 50% spruce, 28% pine and 22% broadleaves. Potential annual harvest is 400,000 cubic metres but the annual cut is only 53,000 cubic metres, due to lack of adequate forest roads and the difficulty of getting trained forest workers in this sparsely populated part of the country.

The greatest challenge is to manage the huge increase in the volume of spruce coming on stream. By 2015, the potential annual harvest will be 430,000 cubic metres – more than 10 times what is being cut at present.

Next was a visit to the Tree Breeding Centre at Aroy, an important seed orchard and gene bank for Norway spruce. Here we were met by Ms Merete Larsman, a professional forester, forest owner and geneticist. She outlined the development of the Norway spruce breeding programme since the early 1920s.

Middle European provenances are most suited to the district. In the main, Russian and Alpine provenances of Norway spruce, grafted onto native stock, have the highest seed production.

In selecting seed stands, 138 separate Norway spruce blocks were assessed, from which 47 were selected as suitable.

Afforestation levels in the district have dropped significantly – from six million plants in 1965 down to 0.2 million in 2007. Species composition of recent afforestation is 35% Norway spruce, 35% Scots pine and 30% broadleaves. State subsidies are available for afforestation. Eco-tourism is now an important contributor to the economy of the district, and there is intense debate on the best way to develop multi-use forestry in the area.

At the next stop we met Mr Arnt Hovland, the owner of the nearby salmon fishery and hatchery at the Aroy river. This 2 km stretch of fishing was bought by the great, great, great grandfather of the owner in 1746. The hatchery dates from 1936. Sea lice pose a serious threat to fish farming so smolts are fed an anti sea lice supplement, which is proving to be very effective.

The fishing season lasts from 1 June to 31 August. The largest fish ever caught was a 31 kg salmon in 1895. In recent times, a 25 kg salmon was landed in July 2006. Fishing does not come cheaply; the price for a full season's fishing for four rods is €52,600. Any fish caught belongs to the fisherman.

Most fishermen are Norwegian, but in recent years there have been an increasing number of British and Russian anglers. Since 1991, the local hydro electric power station has funded approximately 20% of the smolts released each year. Currently, the water level in the river is being lowered by the three hydro electric power stations up-stream, with the result that only 47 salmon were caught in 2006, whereas the normal annual catch is close to 100.

We departed the fish farm and headed for Amblegard where we were met by the forest owner, Mr Gjert Heiberg, who is also the local District Forest Officer. The forest at Amblegard is 2,550 ha in area, and is located on the western edge of Sognafjord. As it receives the full benefit of the Gulf Stream, the climate is quiet mild. Apples, pears, plums and cherries can be grown commercially. The soil is generally shallow. Annual precipitation is 740 mm.

The forest at Amblegard was bought by an ancestor of the present owner in 1687. The timber dwelling house, still in use today, was built in 1690 – the year of the Battle of the Boyne.

Over the intervening 300 years, the forest has been harvested regularly. The more accessible areas, along the valley floor and lower slopes, comprise one third of the productive area and are harvested each year, whereas the less accessible, higher slopes are harvested only when timber prices are high. The high elevation forest blocks became accessible in the past 35 years only, as a result of an extensive road building programme. Forest road building began in 1938, but it was 1971 before a significant programme began. Today there are 39 km of truck roads.

Prior to 1930, all pine forests were naturally regenerated. Between 1930 and 1950 artificial regeneration (often combined with burning of the lop and top) was introduced. After 1950 there was a gradual move towards artificial regeneration using 2-year-old transplants. This change arose, partly from a scarcity of good seed, but also concerns were surfacing regarding the loss of nutrients following burning. Planting after burning gave a quick start to the young pine transplants but the initial boost was often followed by a long period of growth stagnation, which allowed heather to become established. Windthrow and snow break, following heavy snowfall, are the main causes of forest damage. Insect or fungal attack are not major problems.

The main sources of revenue are timber sales; rent from the letting of five holiday houses (from May to October); shooting lettings – usually six red deer stags, valued at €65 apiece, are shot each year; and the sale of organic fruit and vegetables grown on the farm. The main land types in the forest are:

Group at Mr Gjert Heiberg's forest in the Sogn og Fjordane district.

Land type	*ha*	*%*
Productive forest land	1,280	50.1
Bogland (within the productive forest area)	80	3.1
Waste land (within the productive forest area)	400	15.7
Pine forest (above the commercial timberline)	230	9.1
Birch forest (above the commercial timberline)	40	1.6
Unplanted mountain land and lakes	500	19.6
Farmland	20	0.8
Total	**2,550**	**100**

We were treated to a lunch of homemade Hunters soup (a thick broth made from venison and vegetables), washed down with locally brewed beer and homemade apple juice.

After lunch, the group visited the following areas:

- A 65-year-old stand of naturally-regenerated Scots pine, which had been thinned twice and is programmed to be clearfelled when 95-100 years old.
- Artificially regenerated Scots pine, planted in 1956 following burning of the lop and top. It has never been thinned and is now greatly overstocked. It will be thinned next year and will be thinned once more, probably in 2020, before being clearfelled in 2035.
- A stand of Douglas fir, planted in 1965 using 4-year-old plants. It has been thinned once and 30% of the stems were pruned to a height of 3 m. The thinnings were sold to the local sawmill. The final crop will supply transmission poles. Generally, there is little planting of Douglas fir in Norway as there is a strong environmental lobby which is opposed to the planting of exotic tree species.
- A stand of grand fir, planted in 1946 and thinned twice. This species is 10 times more productive than Scots pine but there is very little demand for the timber which has to be sold for pulp.
- A stand of European larch (Scottish origin) which was planted in 1946 at 3 x 3 m spacing and later underplanted with Norway spruce. It has been thinned twice but has not been pruned. The timber is used around the farm for fencing posts, gates, light construction work and repairs.
- A stand of Scots pine, with a mean maximum volume increment of 6-8 cubic metres/ha, which was planted in 1948 using 4-year-old plants. In 1986, it was designated as a Health Stand and is assessed each year to monitor the health of the forest. The main assessment criteria are the density of the crop (stems per ha), the number of cones produced per annum and the colour of the cones.
- A small clearfell site. The felled crop was 120-year-old Scots pine, mean maximum volume of 6-8 cubic metres/ha, which produced 450 cubic metres/ha when clearfelled in 2006. The site will be reforested in spring 2008 using Norway spruce tubed seedlings. No mechanical site preparation will be necessary.
- The final stop was a magnificent stand of 114-year-old Scots pine which is programmed to be clearfelled in 2021, when it will be 120 year old.

Thinning of Scots pine in the Sogn og Fjordane district.

Friday – 14 September

The group enjoyed a very pleasant drive through the Hallingdal Valley with its spectacular scenery and extensive forests. We joined our guide, Mr Tore Molteberg, for lunch in the picturesque holiday village of Gol, which is located at the eastern end of the valley.

Following a brief tour of Gol we set off for the Forest Park at Ringerike to see the animals of Norway's forests at close quarters – bear, elk, wolf, reindeer and arctic fox. Our guide gave us detailed information of their history, habitats, life-cycle and the threats to wild populations posed by more intensive forest management practices.

Recorders, chairman and accommodation

Date	***Recorder***	***Chairman***	***Accommodation***
9 September	-	-	Hotel Budor, Elverum
10 September	Frank Nugent	Michael O'Brien	Forestry Research Institute, Biri
11 September	Bob Dagg	Liam O'Flanagan	Fossberg Hotel, Lom
12 September	Kevin Collins	Ken Ellis	Eikum Hotel, Hasfeld
13 September	Brigid Flynn	John Connelly	Stalheim Hotel, Voss
14 September	Paddy O'Kelly	Kevin Hutchinson	Klaekken Hotel, Honefoss
15 September	-	-	Return to Dublin

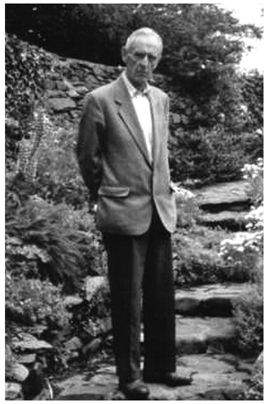
Participants

Denis Beirne, PJ Bruton, Frances Burke, Kevin Collins, John Conneff, John Connelly, Jim Crowley, Bob Dagg, Ken Ellis, Jerry Fleming, Brigid Flynn, Tony Gallinagh, Sean Galvin, Eugene Griffin, Christy Hanley, George Hipwell, Liam Howe, Jim Hurley, Kevin Hutchinson, Kevin Kenny, Tony Mannion, Ted McCarthy, Pat McCloskey, Kevin McDonald, Tom McDonald, Jim McHugh, PJ McElroy, PJ Morrissey, Liam Murphy, Jim Neilan, Frank Nugent, Dermot O'Brien, Michael O' Brien, Pat O'Callaghan, Liam O'Flanagan, Derry O'Hegarty, Paddy O'Kelly, Tim O'Regan, Denis O'Sullivan, Trevor Wilson.

8: Group photograph at circa 2,000 m.

Obituaries

Dermot Mangan
1914 - 2006



Dermot Mangan, born in Dublin in June, 1914, was the youngest of a family of six. His parents were an important influence on his life and from them he inherited a lifelong interest in literature, politics and culture. His father Henry, who was employed by Dublin Corporation, wrote under the pseudonym 'Henry Conell' and published a number of books including The Sieges of Derry and Limerick in 1901 and a compilation of the works of Alice Milligan, poet and well-known figure of the Gaelic revival movement. Both his parents knew Eamon De Valera, the future President of Ireland and his wife Sinead. In fact, Dermot's uncle, Peter De Loughry, was the locksmith who made the key used by De Valera to effect his dramatic escape from Lincoln Jail.

Dermot sat the State forestry entrance examination in 1934. He was subsequently called for an interview, chaired by Dr M. L. Anderson, who was then Acting Director of Forestry in the Department of Lands. He obviously impressed Anderson and duly entered Emo Forestry Training School in 1934.

The training regime at Emo was harsh but he recalled it with humour. He spoke with affection about his fellow students Tadgh Begley, Billy Breslin, Myles Cosgrave, P.V. Delaney, Jimmy Donoghue, Oscar Grant, Peadar Healy, Seamus McMenamin, Michael O'Connell, Bill Shanahan, Pat Turley and Paddy Verling.

In 1937, shortly after qualifying from Emo, Dermot won a Department of Lands' scholarship to study Forestry in UCD. He graduated with a Batchelor of Agricultural Science (Forestry) in 1941 and subsequently served in a number of forests around the country including Clonmel, Co Tipperary; Adare, Co Limerick and Blessington, Co Wicklow.

He was extremely interested in developments taking place in rural Ireland at the time and saw many opportunities for Irish forests to supply the burgeoning rural electrification scheme. At this time, the Electricity Supply Board was purchasing large numbers of transmission poles and needed somebody with the necessary technical expertise to act as its Timber and Forestry Advisor. Dermot fitted the bill and, in 1946, he began a career with the ESB which lasted until his retirement in 1979.

He was a very enthusiastic forester and his visits to forests throughout Ireland, now as the ESB's transmission pole inspector, were always interesting, positive and encouraging. He was a diligent promoter of Irish timber and encouraged his fellow inspectors and the many foresters he encountered to maximise the use of native timber, now available from the maturing forests of Douglas fir, Scots pine, European and Japanese larch.

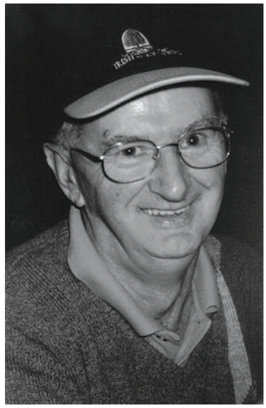
Dermot took no pleasure in rejecting an occasional pole if it failed to reach the strict size and form specifications of the ESB. But these were the exceptions rather than the rule and he enjoyed an excellent working and social relationship with Forest Service foresters, many of whom were former colleagues. They recall him as a diligent worker who served the ESB with great pride and loyalty. At the end of a day's work he was excellent company and a marvellous raconteur.

Dermot never forgot his forestry roots and was a lifelong member of the Society of Irish Foresters. He served on its Council in a number of roles, including President in 1958/1959, and was awarded honorary membership in 1996. He was a great supporter of the Society's Annual Study Tour and held the record for unbroken attendance of the first 37 tours - from the inaugural event in 1943 to his final tour in his retirement year in 1979.

His wife, Catherine, predeceased him and he is survived by his sons Fergal and Barry and daughters Tina, Niamh and Daire.

Donal Magner

Joe Treacy
1939-2006



It was on the morning of 15 September that we learnt of the untimely death of our friend and former colleague Joe Treacy, while on the Society of Irish Foresters' annual study tour in Galicia, northern Spain. That Joe died immersed in what he loved will, in time, be a source of consolation to those that were shocked and saddened by his sudden death. Joe was a larger than life character, full of fun and always on the move and is sadly missed by many of his former colleagues and throughout the wider forestry community.

Joe was born in 1939 in Scarriff in his beloved Banner County which he followed with considerable pride in their hurling glory days of the 1990s. He was educated in St. Flannan's College, Ennis and started his forestry career on entering UCD forestry school in October 1957. After graduation in 1963 Joe went into the timber business and worked for both Morgan McMahons and Brooks Thomas, where he gained his considerable interest in, and knowledge of, timber. In 1968 Joe entered into two very important partnerships which were to influence the rest of his life. First, and most importantly, he married Pat in March, and in October joined the then Forestry Division of the Department of Lands, taking up his first posting as a Forester in Glenmalure, Co Wicklow. Later he moved to the Assistant District Inspector post in Wicklow. He was promoted to the position of Utilization Inspector in 1976 where he used his considerable knowledge of timber and the timber business to great effect. In 1989 on the formation of Coillte, Joe became Marketing Manager for the Eastern Region a position he held until he changed careers in 1993.

Never happy to sit still, Joe pursued further professional qualification and in 1994 he became a member of the Marketing Institute of Ireland, a qualification he used to great effect in one of his new areas of interest, notably Wicklow Tourism. Joe maintained his interest in forestry, running a small consultancy business and was a regular on the Society annual study tour. He had a particular interest in Christmas trees which he grew and sold in his adopted home of Greystones. He wrote the *Christmas Tree Growers Companion* for the Irish Christmas Tree Growers Association, a much valued contribution to the then fledgling industry.

Always in motion Joe had many other interests outside of forestry. Gardening was probably his number one interest/relaxation but he also followed politics closely, almost as closely as the stock market, hurling and cards, a combination which often led to some heated exchanges with friends and colleagues. But Joe never held a grudge and was always there to help friends and colleagues in need – often unnoticed by everyone but the recipient. He was generous to a fault.

Joe valued his Christian faith and was a regular churchgoer and supported his parish and community in many unsung ways – every year he supplied the Christmas trees to his local parish church. But above all Joe was a great family man and a loving partner to Pat and father and real friend to his daughters Fiona, Trudy, Emma and Christine. In recent years, the girls added to his joy with grandchildren.

To Pat and his family we extend our sincerest sympathies.

And there's a barrel that I didn't fill
Beside it, and there may be two or three
Apples I didn't pick upon some bough.
But I am done with apple picking now.
Essence of winter sleep is on the night,
The scent of apples: I am drowsing off.

After Apple Picking by Robert Frost

May he rest in Peace.

Bill Murphy

Mick McCarthy
1914 – 2009

Mick McCarthy, one of Ireland's best known foresters, passed away peacefully on 24 April after a long and fulfilled life. Mick was born in January 1914, the youngest of a family of seven. Brought up on the family farm at Ballycullane, near Rathmore, Co Kerry, he attended the local national school. After spending a year in Clonakilty Agricultural College (1935-36) Mick successfully sat the forestry entrance examination to Avondale Forestry School. This course offered both classroom and practical work under the tutelage of Alisdair Grant, a Scottish forester, who was an excellent lecturer according to Mick. His older brother Tim also qualified as a forester from Avondale Forestry School.

After qualifying, he was assigned as a forester to Ballinglen, Co Wicklow – a busy forest where up to 100 workers were employed during peak periods. Here he met his wife Brigid O'Neill, a native of Annacurra. Shortly after they married he was transferred to Banteer Forest, Co Cork and from there to Pettigo Forest, Co Donegal. Just when Mick, Brigid and their young family were adapting to life in Pettigo, they were transferred to Multyfarnham, Co Westmeath where they had to set up house all over again, this time in a remote area far from shops and other amenities. But he recalled that there were positive aspects to this transfer. The McCarthy's new home was on two acres of land where Mick put his farming background to good use. Here he grew potatoes and other vegetables, kept a cow and fattened a few pigs. Not only was the McCarthy household self sufficient in food but Mick was also able to supplement his income by selling the surplus produce of his carefully tended garden.

Although he had now worked with the Department of Lands as a forester for almost ten years, he was still classified as a 'non-established' Civil Servant. This meant that, in addition to his being subject to transfers at short notice, his post was neither permanent nor pensionable. He recalled purchasing his first car, a Baby Ford, for £97 from the proceeds of the sale of a few pigs in 1947 after his bank manager turned him down for a loan because his position wasn't permanent. Like other foresters, he lobbied to change this ruling and foresters eventually secured 'established' status in 1954.

Multyfarnham was followed by a transfer to Ravensdale Forest, Co Louth in the early 1950s. Without doubt, the transfer system that operated at the time was harsh especially for Brigid and their children. However, Mick maintained that it provided him with valuable practical experience as there was little information on silviculture, which was specific to Irish conditions, available at the time. Species selection was simple but shifted dramatically over the years. European species, mainly Scots pine and Norway spruce, which were popular during his early years in forestry, were replaced by Sitka spruce and lodgepole pine from the 1950s onwards. Ravensdale forest provided him with opportunities to experiment with a wide range of species.

Mick was appointed Senior Forester at Shelton Forest near Arklow, Co Wicklow, in 1959 and he remained on the east coast for the rest of his career. Shelton had an important forest nursery at the time. Here he developed his nursery skills and management techniques. This aptitude was quickly recognised and he was promoted to the rank of Inspector in the Nurseries Division of the Forest Service, Dublin.

An excellent forester, he adapted quickly to life in Nurseries Division. The Forest Service was now collecting more home produced seed from the fine forests established earlier in the century and, although reliance on imported seed continued, for Mick there was a great sense of achievement in setting up Irish provenances. He had an encyclopaedic knowledge of the entire nursery stock and could speak with complete familiarity about the quantity and quality of stock in each nursery. Mick McCarthy, and the late Joe Deasy, made up a formidable team in Nurseries Division and, with limited resources; they developed a very efficient sector which provided good quality plants for the developing forest industry.

When Mick McCarthy received honorary membership of the Society of Irish Foresters on his 95th birthday in January 2009, it was a well-deserved recognition of his role as a forester, nursery inspector and founder member of the Society of Irish Foresters. It is difficult to believe that when he attended the inaugural meeting of the Society in 1942, he already had four years of experience as a forester in a career that spanned 43 years of loyal service.

Mick's philosophy – which he always practised – was to treat forest workers fairly and with compassion. From his days in Ballinglen, he greatly admired the forest workers who worked six days a week and made their way by bicycle or on foot, often in harsh weather, to bleak bogs and inhospitable mountains where much of the early afforestation took place. For the many foresters he encountered, his was a calming and encouraging voice and it is for this mixture of dedication to his work and kindness of heart that he will be best remembered.

Mick, whose wife Brigid predeceased him, is survived by his daughters Maura and Carmel and sons Diarmuid, Seoirse, Michael and Cathal. Seoirse followed his father's footsteps into a career into forestry.

Donal Magner