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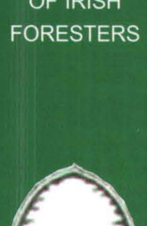

Vol. 62 No. 1&2, 2005

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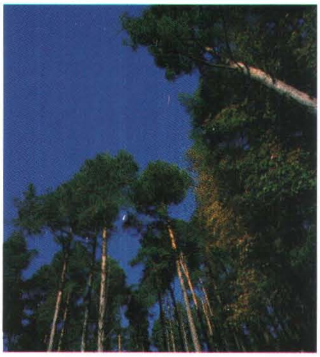

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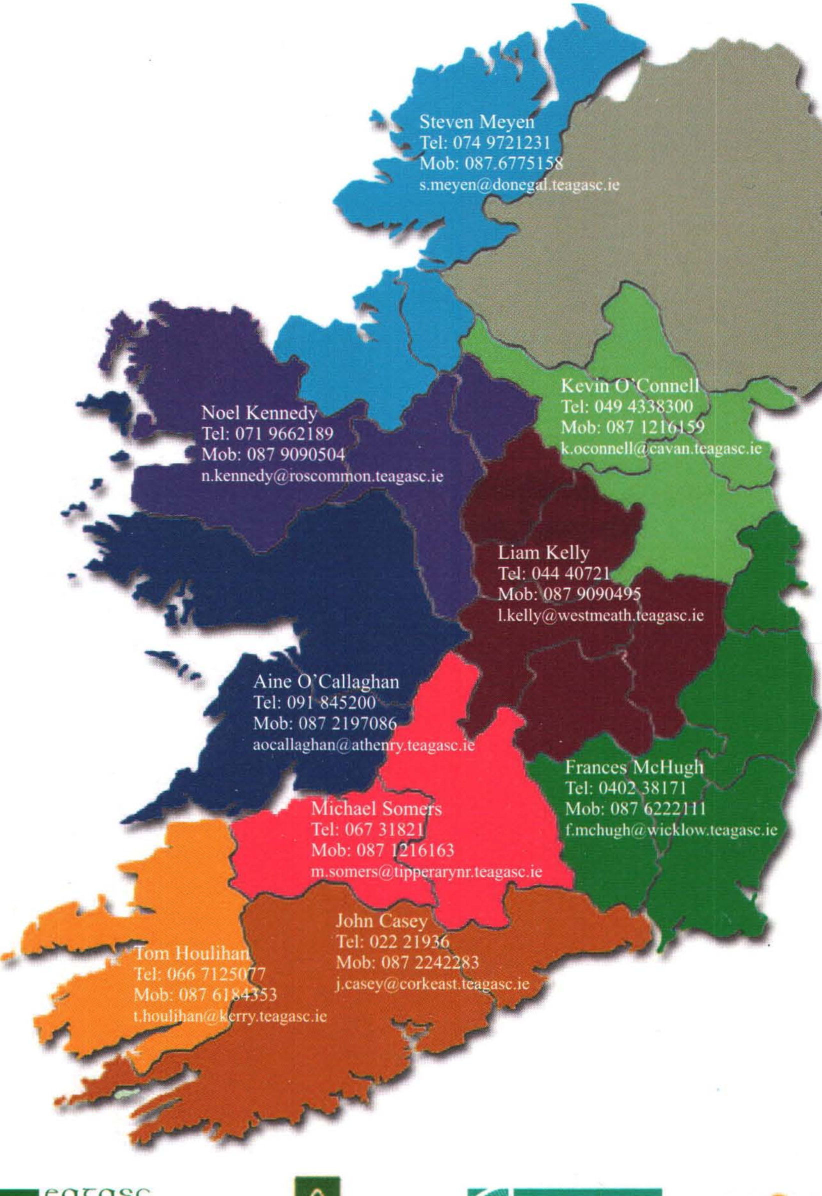

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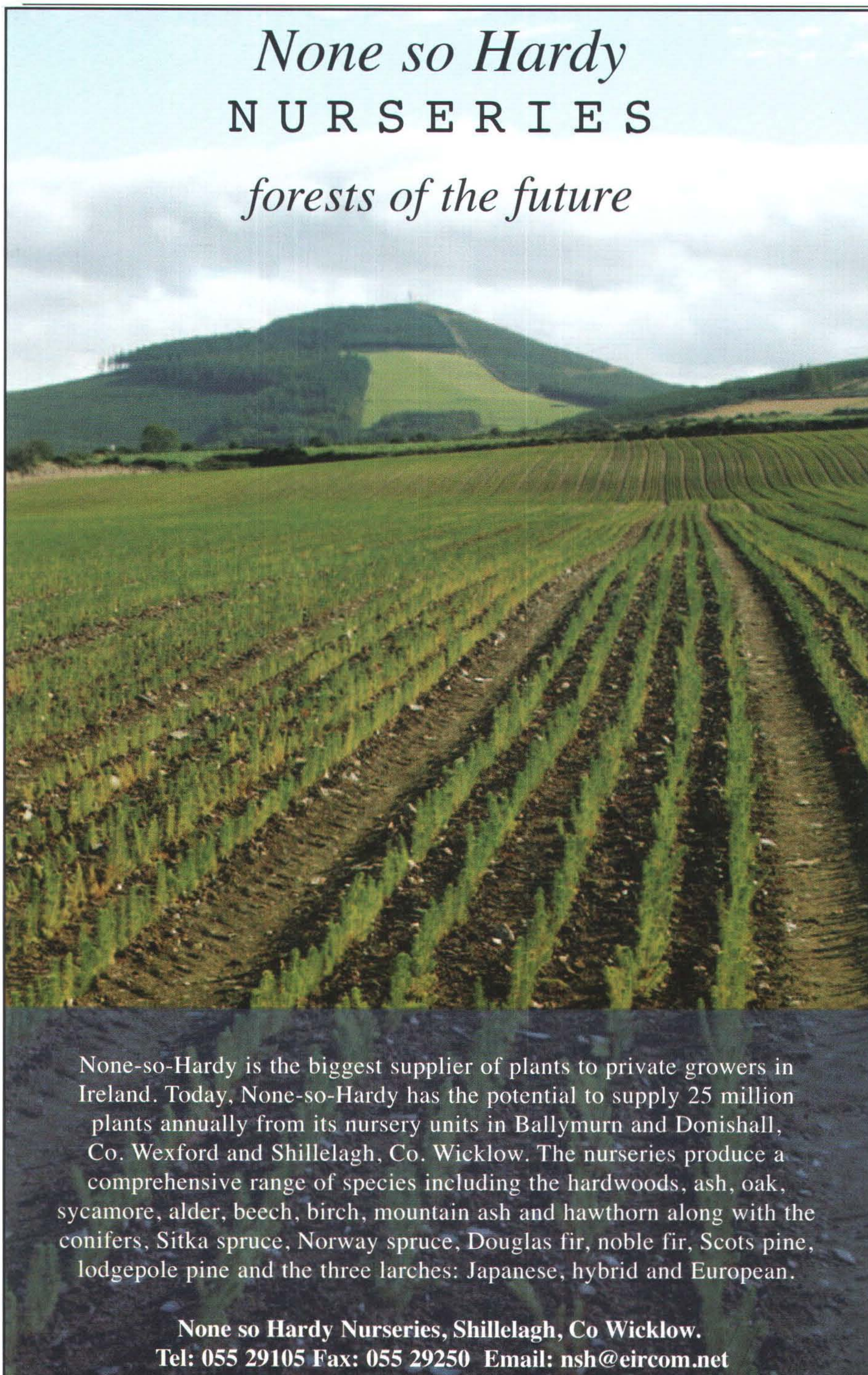
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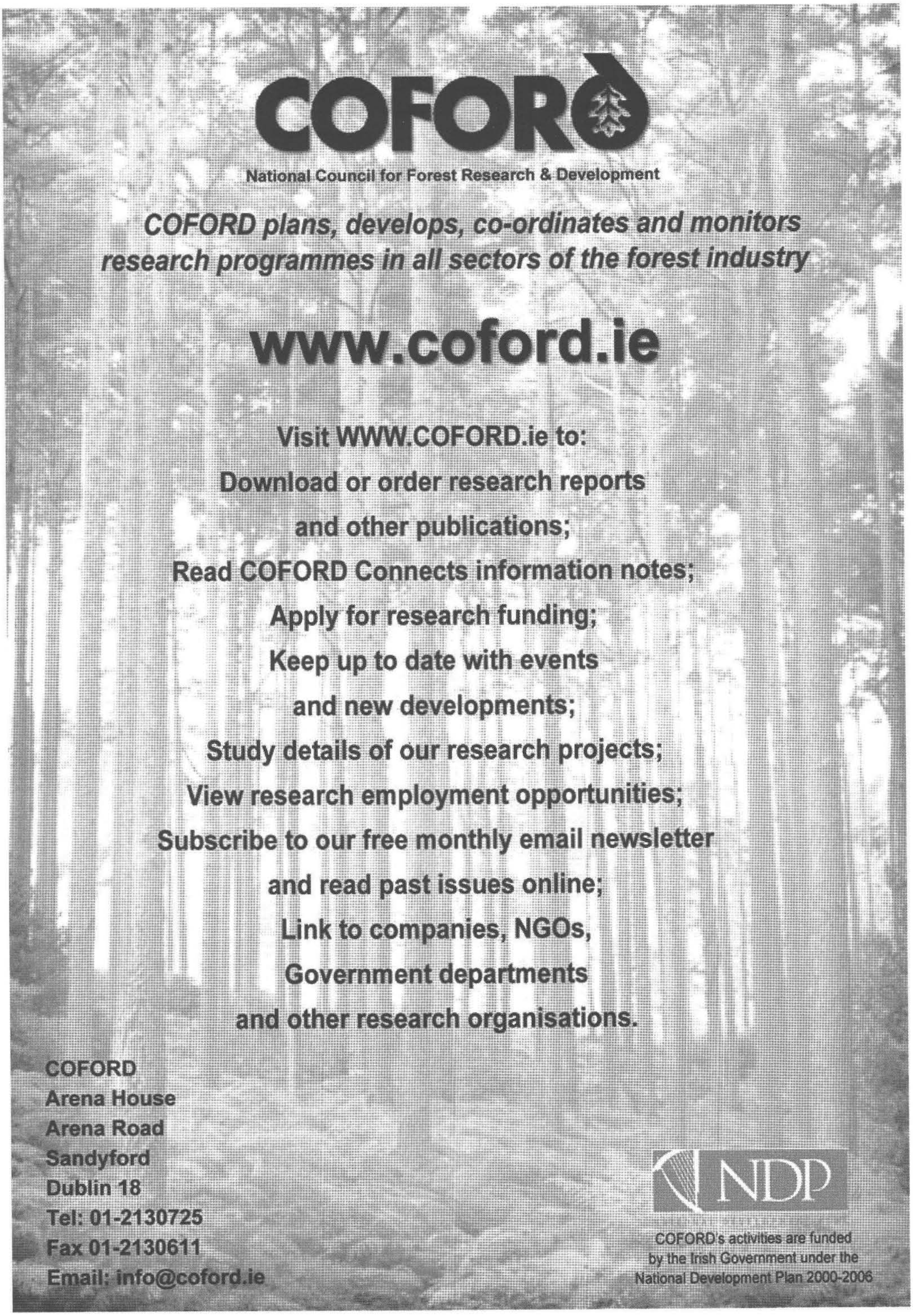
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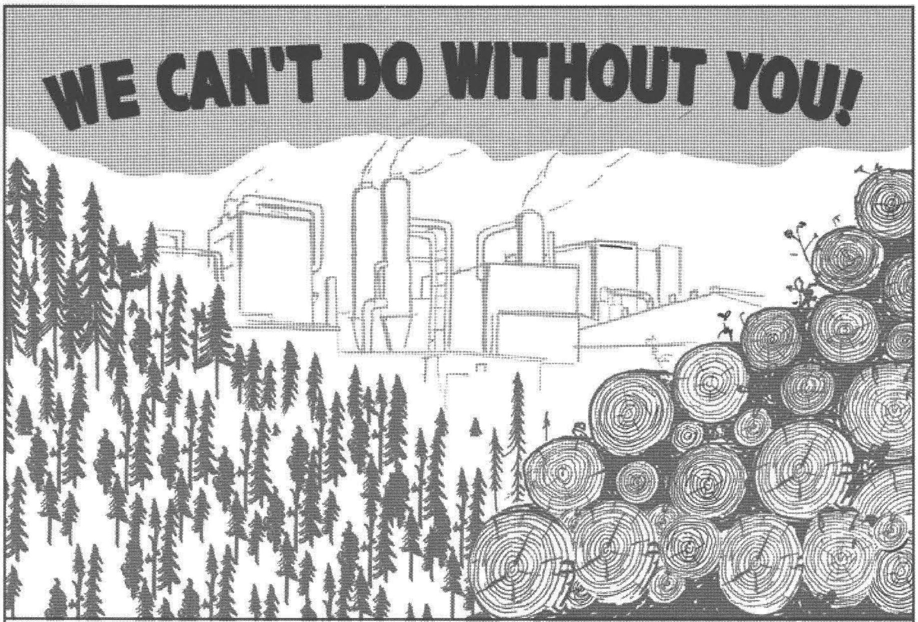
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Cover: Strawberry tree - *Arbutus unedo* - one of relatively few tree species native to Ireland - see Trees, Wood and Literature this issue (photo by Mike Hartwell).

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

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- Representing the interests of over 700 members, predominantly professional foresters, but including, through its associate and student membership, a wide cross-section of people involved, or with an interest in, the forest and timber industry.
- Providing an appropriate range of services to its members, e.g. field days, study tours, workshops, lectures and symposia. The Society also publishes *Irish Forestry*, the sole technical publication on forestry in Ireland, a quarterly newsletter *The Irish Forester*, policy position statements and other books of both historical and technical interest. An expansion of services is proposed, e.g. group indemnity insurance scheme.
- Supporting its members by ongoing representation and dialogue at National Government and EU level on forestry issues.
- Promoting professional standards in forestry and the regulation of the forestry profession, by implementation of its Code of Ethics and Professional Conduct.
- Ensuring that the practice of forestry is carried out by appropriately qualified and recognised professionals. To this end SIF is involved with forestry education in Ireland and has a Continuous Professional Development (CDP) Programme in position.
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3. Correct spelling, grammar and punctuation are expected. Nomenclature, symbols and abbreviations should follow established conventions, with the metric system used throughout. Dimensions should follow units with one full space between them, for example 10 kg.
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EDITORIAL

Rural Ireland and afforestation in the twenty-first century

Recent months have seen a number of reports on the status and future of Irish agriculture. Among them is *Foresight Perspectives*. Along with the other reports, it is saying essentially the same thing: agriculture in Ireland, as a contributor to rural development and the overall economy, is in serious decline. The report provides a suite of policies of how to address rural development in the face of declining of declining agriculture, among them an increased role for environmental services and knowledge-based land use – roles the forestry is well placed to play a significant role in delivering.

The picture painted by *Rural Ireland 2025* is of a greatly reduced number of full-time farmers, just 10,000 by 2025 - a number that was hotly contested when the report was issued at the end of 2005, but which many commentators agreed was a realistic estimate. Currently, there are about 130,000 farms in Ireland. Many are already being run on part-time basis – a substantial number, somewhere in the region of 15,000, are part of the afforestation scheme. Many more have joined the Rural Environment Protection Scheme (REPS). All face an uncertain future: farm subsides, whether direct payments – such as the single farm premium, or those under the accompanying measures to CAP reform - such as the forestry scheme and REPS, are by no means assured post 2012.

Two sentences on page 41 of *Rural Ireland 2025*, under a heading *Elimination of agricultural subsidies*, sum up a lot of thinking on the future of subsidy regimes, and send out a stark message: *The low levels of market-based income in farming have been concealed by farm subsidies. These will be much reduced in scale in future reforms of the CAP and under WTO rules, because of their unsustainability without clear and measurable public good benefits.* The message is clear: post 2012, farm subsidies are under very serious threat.

Post 2012, therefore, land-owners' minds will be far more concentrated on ways to compensate for reduced direct payments, and, if they are around, afforestation subsidies, will be more attractive. In the period up to 2012, as Jasmina Behan and Kieran McQuinn point out in their paper in this issue, there is likely to be an overall reduction in afforestation. Their analysis was, however, undertaken before the draft EC Rural Development Regulation (post 2006) was available.

Therein lies a significant opportunity for the forestry sector: getting due recognition for the environmental benefit of tree planting in the post 2006 EC rural development package, and specifically in REPS. If this is achieved, levels of woodland establishment on farms will almost certainly increase above the levels envisaged by Behan and McQuinn. And investment in tree planting, unlike some of the more ephemeral aspects of REPS, will have continuing benefits for the environment, provided of course that tree cover is maintained.

Apart from devising ways of aligning forestry more closely with REPS there are good arguments, from a rural development perspective, for the state to now reinvigorate public and private non-farming investment in the afforestation programme. Over time one could envisage a twin-track approach of commercial and non-commercial forestry to provide for economic development, environmental benefits and societal demands. The current, one-size-fits-all approach of trying to deliver both public goods and economic roundwood from small plantations scattered over a wide area, must be questioned. An alternative approach by the state, of encouraging farmers to provide environmental goods and services through tree planting and native woodland establishment, while at the same time encouraging commercial afforestation at a larger scale, makes more sense from both the rural development and national perspectives.

Assessment of genetic variation in black poplar in Ireland using microsatellites

Kevin Keary[a], Stuart A'Hara[b], Helen Whitaker[c] and Joan Cottrell[b]

Abstract

Ireland represents the most northwesterly limit of the distribution range of black poplar (*Populus nigra* L). The objective of this study was to increase the understanding of genetic variation in the species in Ireland by using a species-specific marker and seven microsatellite markers to determine i) the accuracy with which morphological methods can distinguish between black poplar and the introduced hybrid poplar, *P. x euramericana* and ii) the degree of clonal reproduction which has occurred in the past. In addition, hairiness of the leaf petiole was assessed to determine whether the Irish black poplar trees sampled were members of the subspecies *betulifolia*.

A total of 117 black poplar trees were sampled in spring 2003 by taking distal sections of twigs, preferably with healthy flowering buds, from the crowns and standing them in water in the lab until bud burst. Samples were taken from trees believed to be black poplar from counties Dublin, Kildare, Offaly, Tipperary and Galway. The species-specific molecular marker indicated that almost a third of the sampled trees were *P. x euramericana* which had been misidentified as *P. nigra.* There was considerable clonal duplication such that only nine genotypes were present in the 80 *P. nigra* samples that were DNA tested. These results indicate that considerable vegetative propagation had occurred in the past. The majority of the black poplar belonged to the sub-species *betulifolia*.

Keywords: *Populus nigra, Populus* x *euramericana,* black poplar, species-specific genetic marker.

Introduction

Black poplar (*Populus nigra* L.) is not grown as a commercial species in Ireland; interest in its occurrence is due to its endangered status, both in Ireland and elsewhere in Europe.

The species's natural range extends from the Iberian Peninsula, across southern, southeastern, central and eastern Europe, as far as western Siberia. It also occurs in North Africa, Asia Minor and the Caucasus (Zsuffa 1974, Bialobok 1973). Its occurrence in Ireland represents the northwestern limit of its natural range, although its status remains uncertain. It was not considered native by Colgan and Scully (1889), while Elwes and Henry (1913) were also doubtful of its native status. In contrast, Hobson (1991) believed the tree to be native, on the basis of its close association with river valleys and flood plains and its local abundance in areas such

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as Kildare and Lough Derg. Many Irish botanists believe it was introduced to Ireland by Anglo-Irish settlers. (Smyth (1997) explains that as a result of a series of parliamentary acts between 1698 and 1791, many tree species, including poplar, were planted. However there is no information available on the species of poplar used.) Black poplar, in common with other members of the genus, roots readily from cuttings, which have been used for centuries to propagate the species.

Black poplar has been recorded in four botanical surveys in Ireland during the past fifteen years. The first of these, conducted by the Botanical Society of the British Isles (BSBI), concentrated on black poplar in England and Wales (Milne-Redhead 1990), but a small number of records were included from Ireland, with two from Co Kildare and one from Co Cork. Later, a survey of southern and central Ireland, carried out by Hobson (1991), located 210 trees. Hobson later extended his work (1993), so that a total of 373 trees covering a wide age range were eventually recorded. High levels of occurrence were recorded along the river Shannon, and in the headwaters of the Liffey and Barrow rivers (both located in the east of Ireland). The most recent survey was conducted in 2000 by the first author of this paper. It formed the basis for the sampling described here.

It is difficult on the basis of morphology to distinguish black poplar from its hybrid *P. x euramericana* (crosses with North American poplar species, usually *P. deltoides*). Hence, there are concerns that the surveys may have overestimated the number of black poplar by erroneously including *P. x euramericana*. However, the development of a DNA based species specific-marker by Heinze (1997), based on primers developed by Bradshaw et al. (1994), has provided a molecular method for separating *P. x euramericana* from *P. nigra*, and this has been followed in this study. The species specific marker (win3) amplifies a single band of about 265 base pairs (bp) for *P. deltoides* and one or two bands or a smear of about 165-210 bp for *P. nigra*. The *P. x euramericana* hybrid produces a banding pattern which is a combination of the two parental species (Heinze 1997).

P. nigra comprises two sub-species: *nigra* (or *typica*) and *betulifolia*. Both subsp. *nigra* and *P. x euramericana* have non-hairy petioles, whereas subsp. *betulifolia* is characterised by the presence of hairs on the petioles of young leaves. Also, *betulifolia* has burrs that grow on the trunks and lower branches of mature trees (Bialobok 1973, Elwes and Henry 1913). These do not occur in subspecies *nigra*. Furthermore, *betulifolia* has a largely western distribution; almost all black poplar which were examined from *ex-situ* genebanks of trees growing in England and Wales had the hairy petioles characteristic of this subspecies (Cottrell et al. 2002). There has been no equivalent morphological assessment of putative Irish black poplar, so it is not known to which sub-species they belong. However, the fact that Hobson (1993) observed that fifty per cent of the Irish trees do not possess stem burrs suggests that they are either subsp. *nigra*, or that they have been misidentified as *P. x euramericana*.

Molecular tools have, however, recently become available which enable the clonal identity of individual trees to be determined. Microsatellites, or simple sequence repeats are highly variable regions of DNA which provide effective markers for the clonal identification of poplar material (Storme et al. 2004). This technique was applied to black poplar from *ex-situ* clone banks containing samples from England and Wales; only 16 genotypes were detected in the 66 trees that were analysed (Storme et al. 2004). There has therefore been a great deal of vegetative propagation of this material in the past.

This paper documents genetic variation found in Irish black poplar populations in counties Dublin, Kildare, Offaly, Tipperary and Galway. This was done by surveying the geographical distribution of the species, examining whether putative trees belonged to the species, using the species-specific DNA marker (win3), examining petiole hairiness to determine if trees belonged to the subspecies *betulifolia* and using microsatellite markers to establish the number of unique genotypes present in the populations.

Materials and methods

Survey and collection of cuttings

A survey of *P. nigra* in Ireland carried out by the principal author in the summer of 2000 verified the findings of earlier surveys of Hobson (1991, 1993). This most recent survey was restricted to Dublin, Kildare, Offaly, Tipperary and Galway. The survey used Hobson's directions to locate the trees. Additional putative black poplar found en-route were surveyed, recorded and included in the study. The grid reference location of each tree was recorded using a Trimble ProXRS Global Positioning System. This consists of an Easting and a Northing, measured in meters and logged to 5 decimal places. In addition, tree height, diameter at breast height, sex, general health condition, silvicultural/management activities and general landscape character were recorded for most of the trees visited. The geographic and attribute data for each tree were exported to Arc View 3.1, and maps of the distribution of the species were generated. In all 117 trees were recorded.

Just prior to bud burst, dormant twigs, 15-25 cm long, were collected from each tree and were placed in sealed plastic bags and dispatched to the Forest Research laboratory, at Roslin, near Edinburgh, for molecular analysis. On arrival, twigs were removed from the bags and stood in water. Buds on 105 samples eventually flushed sufficiently for a single leaf disc (0.8 cm diameter) to be taken from the twig. The leaf discs were placed in plastic microtubes and stored at –80°C. Petioles of the youngest expanding leaves were examined and their hairiness recorded. If flowers were present the sex was noted. On very tall trees it was only possible to sample epicormic twigs; these did not flower, and therefore their sex could not be determined.

DNA extraction

DNA was extracted from young leaves using QIAGEN plant DNeasy™ mini kits according to the manufacturer's instructions. The Polymerase Chain Reaction (PCR) and electrophoresis conditions for the species-specific marker were the same as those described by Heinze (1997). The seven microsatellites reported by Storme et al.

(2004) were used to provide a multilocus genotype for the 105 trees which provided leaf samples. The microsatellite locus known as PMGC014 was developed in *P. trichocarpa* and is listed in the Poplar Modular Genetics Co-operative (PMGC) database (http://www.poplar2.cfr.washington.edu/pmgc). The other six microsatellite loci were developed in *P. nigra* by van der Schoot et al. (2000) and Smulders et al. (2001). Details of the primer pair used for the species specific marker and the seven

Table 1. *Primers used and the species in which they were developed, primer sequences and the PCR conditions.*

a) Species specific marker (Heinze 1997 and Bradshaw et al. 1994)

Primer	***Species in which primer was developed***	***Forward Primer 5'>3'***	***Reverse Primer 5'>3'***	***Cycle***	***Annealing temperature °C***
Win3	*P. deltoides and P. trichocarpa*	*CCCGAAGTGTCCAGAGC*	*CCCACTCAAATAGTCTAC*	*See Heinze (1997)*	*55*

b) Microsatellite markers used for clonal identification

Primer	***Species in which primer was developed***	***Forward Primer 5'>3'***	***Reverse Primer 5'>3'***	***Cycle***	***Annealing temperature °C***
PMGC014	*P. trichocarpa*	*TTCAGAATGTGCATGATGG*	*GTGATGATCTCACCGTTTG*	*NP*	*50*
PMS09	*P. nigra*	*CTGCTTGCTACCGTGGAACA*	*AAGCAATTTGGGTCTGAGTATCTG*	*LP*	*60*
PMS12	*P. nigra*	*TTTTTCGTATTCTTATCTATCC*	*CACTACTCTGACAAAACCATC*	*NP*	*50*
PMS14	*P. nigra*	*CAGCCGCAGCCACTGAGAAATC*	*GCCTGCTGAGAAGACTGCCTTGAC*	*LP*	*60*
PMS16	*P. nigra*	*CTCGTACTATTTCCGATGATGACC*	*AGATTATTAGGTGGGCCAAGGACT*	*LP*	*55*
PMS18	*P. nigra*	*CTTCACATAGGACATAGCAGCATC*	*CACCAGAGTCATCACCAGTTATTG*	*LP*	*60*
PMS20	*P. nigra*	*GTGCGCACATCTATGACTATCG*	*ATCTTGTAATTCTCCGGGGCATCT*	*NP*	*60*

primer pairs that were used to provide a multilocus genotype for each tree in the collection are presented in Table 1 (a and b respectively).

The PCR reaction for the microsatellites was as follows: 5 μl template DNA, 2 μl x 10 PCR buffer (GibcoBRL), 2 μl of both 200 μM primers, 0.8 μl dNTP Mix (Perkin-Elmer, 10 mM), 0.4 U Taq polymerase (Gibco BRL) made up to a final volume of 20 μl using water. Amplification was carried out in a PE 9700 thermal cycler using either a short reaction time cycle (NP) or a long reaction time cycle (LP). The NP programme had an initial denaturing step of 3 minutes at 94°C, followed by 30 cycles of: 5 seconds at 94°C, 15 seconds at the annealing temperature and 60 seconds at 72°C, followed by a final elongation step of 10 minutes at 72°C. LP programmes had an initial denaturing step of 3 minutes at 94°C, then 30 cycles of; 45 seconds at 94°C, 45 seconds at the annealing temperature and 105 seconds at 72°C, followed by a final elongation step of 10 minutes at 72°C. The annealing temperature used for each microsatellite locus is listed in Table 1.

PCR products for the microsatellite analysis were denatured and resolved on 6% denaturing polyacrylamide gels using a Licor DNA sequencer. Gels were scored with the aid of standard ladders.

Results

Hybrid status

Results were obtained using the species-specific marker for the 105 samples from which DNA was extracted. Twenty five samples produced the banding pattern typical of *P. x euramericana*. All the sampled trees from the townland of Pallas proved to be *P. x euramericana* with the exception of Pallas West.

In the remaining 80 samples the banding pattern was typical of *P. nigra,* 76 produced a single band and four samples (Birr Caravan, Birr Boyds, Abbey West and Ardchroney layby) produced a double band. Both these banding patterns have been described by Heinze (1997) and are typical of *P. nigra*. The reason for this double banding pattern is not understood as the fragments have not been sequenced.

Petiole hairiness

All the samples classified as *P. x euramericana* on the basis of the species specific marker, had young leaves with non-hairy petioles with the single exception of Looscaun Church North (Appendix Table 1). In five of the *P. x euramericana* samples it was not possible to assess petiole hairiness because the buds did not open sufficiently. Of the 80 trees classified as *P. nigra* on the basis of the species specific marker, 65 had hairy petioles and only four samples had no hairs on the petioles of young leaves (Ballinderry 5/4, Sawnagh Mid 6, Birr Boyds and Ardchroney layby). The leaves produced by the first two of these did not expand fully and it was difficult to be entirely certain that no hairs were present. In eleven of the *P. nigra* samples it was not possible to assess petiole hairiness.

Sex

The eleven *P. x euramericana* samples that flowered were males; the remaining 14 did not flower. Of the 41 *P. nigra* which flowered, 36 were males and only five were females. The remaining 39 *P. nigra* samples could not be sexed because they did not flower.

Microsatellites

Number of alleles per locus

In the *P. nigra* samples locus PMS14 was the most diverse, with five alleles. There were four alleles in the following four microsatellite loci: PGMC14, PMS09, PMS18 and PMS20. Locus PMS16 had three alleles and locus PMS12 had two alleles. The average number of alleles per locus was 3.7.

Number of genotypes

According to the multilocus genotype based on the seven microsatellite loci there were three distinct clones in the 25 *P. x euramericana* trees. Of these, clone 1H was only represented by a single tree; eight trees belonged to clone 2H. The remaining 16 *P. x euramericana* trees were all members of clone 3H.

The 80 *P. nigra* samples consisted of nine distinct clones. Three clones were particularly common and over 85% of the *P. nigra* trees that were tested belonged to one of these. The *P. nigra* clone 6 was the most common and was represented by 37 of the 80 samples. Eleven trees of this clone came from the Ballinderry 15 group and all eight of the trees from the Blackrock group were members of clone 6. Although there was a tendency for several trees from a single location to be of the same clone there was usually some clonal variation present at most sites. For example, the twelve trees from the Ballinderry 15 group consisted of two genotypes. None of the clones in Ballinderry 15 were unique to that location. The three trees from the Ballinderry 5 location consisted of two clones, one of which was unique to that location and one which was also present in the Ballinderry 15 site. When the two Ballinderry sites were taken as one, the clonal composition was as follows, clone 3 (3 trees), clone 4 (1 tree), clone 6 (11 trees). In contrast, the eight trees at Blackrock, which is about 150 km to the east, consisted of only a single clone; clone 6. Some locations, such as Aughameelick, and Shannon Park consisted of both *P. x euramericana* and *P. nigra* trees.

Only two *P. nigra* female clones were detected, clone 2 consisted of a single female representative from Abbey West and clone 8 which was represented by female trees from Terryglass South, Drumcooley East 4, Drumcooley East 5 and Aughameelick Mid South. Clone 8 consisted of another eight trees which, although they were not sexed, were likely, on the basis of their common genotype, to be female. Three of these unsexed trees representing clone 8 resided at Aughameelick, four at Drumcooley, and one at Kilcormack. The Terryglass female grew in the same vicinity as *P. nigra* male clone 3. The Aughameelick female grew near a male (clone 3H). The Drumcooley female grew in the same region as a *P. x euramericana* male

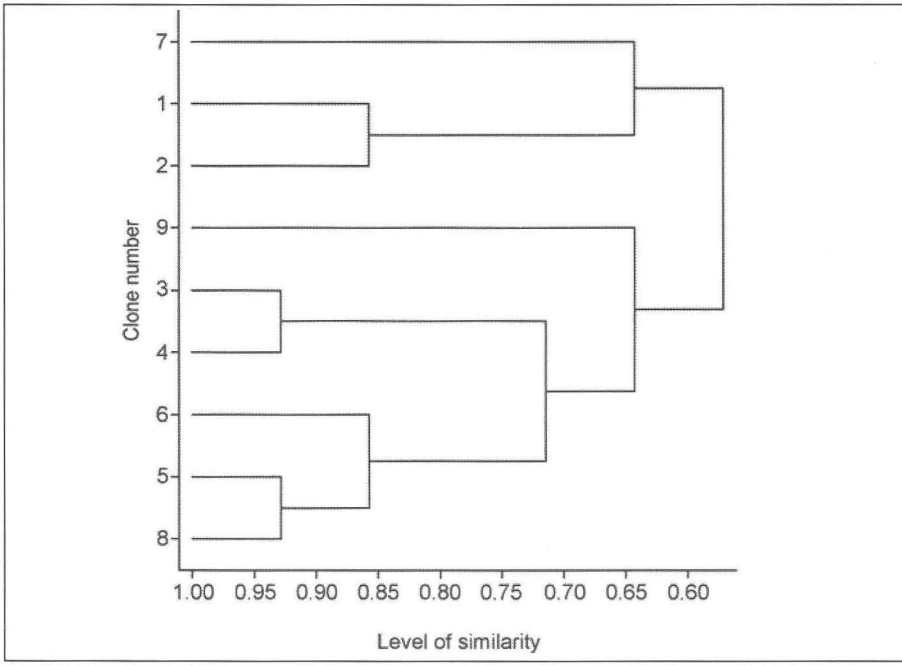

Figure 1. *Dendrogram illustrating the similarity of the clones based on microsatellite analysis.*

(clone 3H) and the only recorded sample of *P. nigra* clone 5 of undetermined sex.

The four *P. nigra* trees which produced the unique double banded pattern with the species specific marker also had rare alleles at several microsatellite loci. These samples were the sole representatives of clones 1, 2 and 7. The two of these which flushed had hairless petioles, which indicates that although they are *P. nigra*, they do not belong to sub-species *betulifolia*. The similarity dendrogram, calculated using the program Popgene (http://www.ualberta.ca/~fyeh/), demonstrates that the microsatellite fingerprints of these three genotypes are very different from those of the other *P. nigra* clones investigated in this study (Figure 1).

Geographic distribution

Using Hobson's early surveys, together with the more recent survey carried out in connection with this work, the number of trees that are now positively identified as *P. nigra* with a heretofore unprecedented level of confidence is 85 in the counties of Dublin, Kildare, Offaly, Tipperary and part of Galway. The geographical distribution of the individuals from which DNA was extracted and subsequently positively identified as *P. nigra* is shown in Figure 2.

By using Hobson's unpublished records of *P. nigra* it is apparent that approximately 40 trees cannot now be located. The disappearance of these trees may have resulted in a loss of genetic diversity. The status of approximately 200 trees

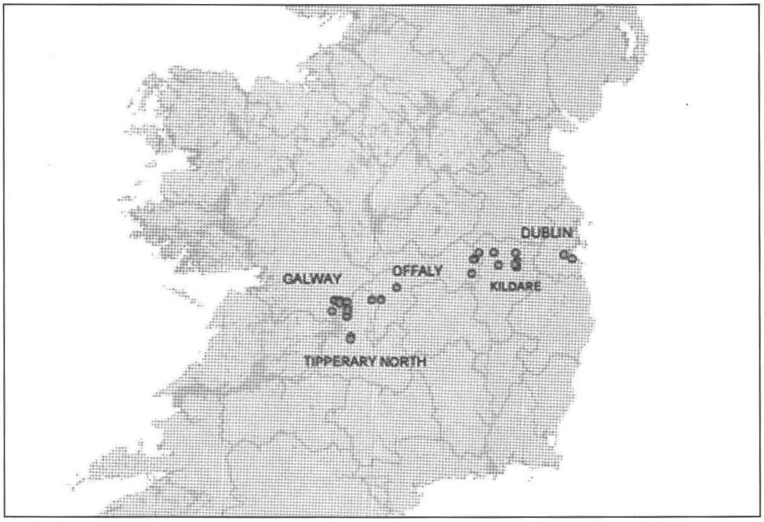

Figure 2. Distribution of individuals positively identified as P. nigra.

surveyed by Hobson in the counties Leitrim, Limerick, and the remainder in Galway, Clare, Cork and Wexford is not known.

The distribution of the three most prevalent genotypes (clones 3, 6 and 8), is wide (Appendix Table 1). For example, clone number 3 is present in northwest Co Kildare as Timahoe-Carbury, but it also occurs at Ardchroney Garden in North Tipperary. The distance between these trees is about 95 km. The distance between the trees in Blackrock (all clone 6) and the majority of the Ballinderry 15 group of trees (also clone 6) is approximately 140 km. Most members of clone 8 are located around east Co Offaly. However one individual; Terryglass South 1 is present in north Co Tipperary, which is at least 77 km from its nearest counterpart in Co Offaly.

Discussion

There was a high level of misidentification in the current study, with almost a quarter of the trees being *P. x euramericana* and not *P. nigra* as originally thought. This is due to the difficulties associated with distinguishing *Populus* species based on morphological traits and crown structure. This identification problem has led to the rarity of *P. nigra* being underestimated (Milne-Redhead 1990).

The development of the species specific marker by Heinze (1997) is valuable because it offers a tool that allows first generation *P. x euramericana* to be securely distinguished from *P. nigra* trees. The fact that the majority of the *P. nigra* trees in our sample had young leaves with hairy petioles compared with the *P. x euramericana* which were mostly non-hairy is also a useful morphological character with which to distinguish *P. nigra* trees in Ireland. The presence of hairs on the petioles confirms that, like the English and Welsh black poplar, the majority of the Irish trees in the sample belong to the subspecies *betulifolia*. This subspecies develops burrs on the trunk, and Hobson's (1993) observation that such trees only comprise 45% of the Irish population is a further indication that there may, in the past, have been cases where *P. x euramericana* (without burrs) were misidentified as *P. nigra*. This, accompanied by the fact that a large number of the trees surveyed by Hobson are no longer present today, indicates that black poplar is even rarer than it was thought to be in Ireland.

The Irish sample also resembles the English and Welsh trees in that male trees are more common than females. In a sample from England and Wales, the males outnumbered the females by a ratio of nearly 4 to 1 (Cottrell et al. 2002). This compares with a ratio of 9:1 in the sample from Ireland. This may be the result of active selection against females because they produce unsightly seed fluff which is undesirable in amenity areas (Tabbush 1996).

Many of the clones in the Irish sample were represented several times. This was also the case in the English and Welsh sample. On average, each *P. nigra* clone was represented by 9 trees in the Irish sample. This means that the number of clones in Ireland is even lower than had been anticipated. If Hobson (1993) located the majority of black poplar in Ireland then the 373 trees found in his survey are likely to represent less than 41 clones. If misidentified *P. x euramericana* trees are also taken into account this number could be even lower. Clones were not repeated to the same extent as the sample from England and Wales, where each clone occurred five times in the total sample (Cottrell et al. 2002, Storme et al. 2004). This suggests that the English and Welsh population may have experienced less human interference than in the Irish case. Also, the trees sampled in England and Wales had a wider geographic distribution and this may be a reason why there was less clonal duplication in this than the Irish sampling. There was a tendency for several of the trees growing in close proximity in Ireland to belong to the same clone, although there was usually some diversity at a given site. The opportunity for sexual reproduction however, is low because of the small number of female trees. The fact that some of the females grow in close proximity to *P. x euramericana* trees is of some concern, although Tabbener and Cottrell (2003) found no evidence of interspecific crossing between *P. nigra* and *P. x euramericana* in their study of seedling paternity. Other studies (Fossati et al. 2003, van den Broeck et al. 2002, and van den Broeck et al. 2004) confirm that interspecific crossing is confined to situations where there are only *P. x euramericana* males within pollinating distance of *P. nigra* females. The absence of suitable sites for seed germination in Ireland also means that they are unlikely to become established so that any interspecific crossing events are unlikely to have any lasting effect.

These results do not allow the question of the native status of *P. nigra* in Ireland to be addressed. However, the fact that three clones were very different from the other six clones in terms of their microsatellite fingerprints suggests that there may have been at least some importation of material from abroad. These three clones (Clones 1, 2 and 7) were also different in that they did not have hairy petioles in those samples where the leaves were present, and they produced the double rather than the single banded pattern with the species specific marker. An analysis based on the maternally inherited chloroplast DNA markers (Cottrell et al. 2005) might provide more insight into the geographic origin of these clones.

It is reasonable to presume, based on the distribution of the different clones throughout the countryside that the population of *P. nigra* in Ireland has been very heavily influenced by human activity, i.e. the propagation and establishment of cuttings from existing trees. Nevertheless, the abundance of the species around south east Co Galway merits further molecular investigation and survey work. There is a need to complete the geographic and molecular survey of the trees in the remaining counties so that an informed conservation policy can be developed for the species in Ireland.

Acknowledgements

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Appendix Table 1. *Tree name and location, sex and the hairiness of the young expanding leaves of the sample. Trees are classified as P. x euramericana or P. nigra on the basis of the species specific marker and as a clone number (based on the multilocus genotype produced by the seven microsatellite loci.*

Tree name and Watsonian Vice-County	Sex	Petiole hairs a: absent p: present	Heinze marker	Clone number	Tree name and Watsonian Vice county	Sex	Petiole hairs a: absent p: present	Heinze marker	Clone number
Birr Caravan, Offaly			P. nigra (double band)	1	Looscaum Church middle, SE. Galway	m	p	P. nigra	6
Ardchroney layby, N. Tipperary		a	P. nigra (double band)	1	Looscaum Church South, SE. Galway	m	p	P. nigra	6
Abbey West, SE. Galway	f		P. nigra (double band)	2	Millisent House, Kildare	m	p	P. nigra	6
Ardchroney Garden, N. Tipperary	m	p	P. nigra	3	Millisent Quarry, Kildare	m	p	P. nigra	6
Ballinderry 15/1, N. Tipperary		p	P. nigra	3	Millisent Track, Kildare	m	p	P. nigra	6
Ballinderry 5/2,N. Tipperary		p	P. nigra	3	Sawnagh House, SE. Galway	m	p	P. nigra	6
Ballinderry 5/4, N. Tipperary		a	P. nigra	3	Shannon Park 1, SE. Galway	m		P. nigra	6
Baltracey X, Kildare		p	P. nigra	3	Shannon Park 2, SE. Galway		p	P. nigra	6
Riverstown 1, N. Tipperary	m		P. nigra	3	Shannon Park 4, SE. Galway		p	P. nigra	6
Riverstown 2, N. Tipperary	m		P. nigra	3	Shannon Park 5, SE. Galway		p	P. nigra	6
Sawnagh mid 1, SE .Galway	m	p	P. nigra	3	Shannon Park North, SE. Galway		p	P. nigra	6
Sawnagh mid 2, SE Galway	m	p	P. nigra	3	Stoney Island, SE. Galway	m		P. nigra	6
Sawnagh mid 3, SE. Galway	m	p	P. nigra	3	Loughanroe West, SE. Galway			P. nigra	6
Sawnagh mid 4, SE. Galway	m	p	P. nigra	3	Birr Boyds, Offaly		a	P. nigra-(double band)	7
Sawnagh mid 5, SE. Galway	m		P. nigra	3	Terryglass South, 1 N. Tipperary	f	p	P. nigra	8
Sawnagh mid 6, SE. Galway	m	a	P. nigra	3	Kilcormack, E. Offaly		p	P. nigra	8
Sawnagh mid 7, SE. Galway	m	p	P. nigra	3	Drumcooley East 5, Offaly	f	p	P. nigra	8
Terryglass North 1, N. Tipperary	m	p	P. nigra	3	Drumcooley East 2, Offaly		p	P. nigra	8
Terryglass North 2, N. Tipperary	m	p	P. nigra	3	Drumcooley East 1, Offaly		p	P. nigra	8
Terryglass North 3, N. Tipperary		p	P. nigra	3	Drumcooley West, Offaly		p	P. nigra	8
Terryglass North 4, N. Tipperary	m	p	P. nigra	3	Drumcooley East 4, Offaly	f	p	P. nigra	8
Terryglass North 5, N. Tipperary	m	p	P. nigra	3	Agameelick South, Offaly		p	P. nigra	8
Terryglass South 2, N. Tipperary	m	p	P. nigra	3	Agameelick North, Offaly		p	P. nigra	8
Timahoe-Carbury, Kildare		p	P. nigra	3	Agameelick mid, South Offaly	f	p	P. nigra	8
Edenderry East 1, Kildare	m	p	P. nigra	3	Agameelick mid, North Offaly		p	P. nigra	8
Edenderry East 2, Kildare	m	p	P. nigra	3	Drumcooley East 3, Offaly		p	P. nigra	8
Pallas West, SE. Galway	m	p	P. nigra	3	Mount Pleasant, Dublin		p	P. nigra	9

Ballinderry 5/3, N. Tipperary	m	p	P. nigra	4
Drumcooley far East South, Offaly		p	P. nigra	5
Allenwood Canal, Kildare		p	P. nigra	6
Ballinderry 15/10, N. Tipperary		p	P. nigra	6
Ballinderry 15/11, N. Tipperary		p	P. nigra	6
Ballinderry 15/14, N. Tipperary		p	P. nigra	6
Ballinderry 15/2, N. Tipperary		p	P. nigra	6
Ballinderry 15/3, N. Tipperary			P. nigra	6
Ballinderry 15/5, N. Tipperary		p	P. nigra	6
Ballinderry 15/4, N. Tipperary		p	P. nigra	6
Ballinderry 15/6, N. Tipperary		p	P. nigra	6
Ballinderry 15/7, N. Tipperary	m	p	P. nigra	6
Ballinderry 15/8, N. Tipperary		p	P. nigra	6
Ballynderry15/13, N. Tipperary			P. nigra	6
Blackrock 1, Dublin		p	P. nigra	6
Blackrock 2, Dublin	m	p	P. nigra	6
Blackrock 3, Dublin			P. nigra	6
Blackrock 4, Dublin		p	P. nigra	6
Blackrock 5, Dublin	m	p	P. nigra	6
Blackrock 6, Dublin	m	p	P. nigra	6
Blackrock 7, Dublin	m	p	P. nigra	6
Blackrock 8, Dublin		p	P. nigra	6
Claggernagh East North, SE. Galway	m	p	P. nigra	6
Claggernagh West1, SE. Galway	m	p	P. nigra	6
Claggernagh West 2, SE. Galway	m	p	P. nigra	6
Clane Dublin Road, Kildare	m	p	P. nigra	6
Castle Park South, Dublin		a	P. x euramericana	1H
Looscaum Church North, SE. Galway	m	p	P. x euramericana	2H
Pallas South 1, SE. Galway	m		P. x euramericana	2H
Pallas South 2, SE. Galway		a	P. x euramericana	2H
Pallas South 3, SE .Galway	m	a	P. x euramericana	2H
Sawnagh South East, SE. Galway		a	P. x euramericana	2H
Sawnagh South West, SE. Galway		a	P. x euramericana	2H
Shannon Park 3, SE. Galway	m		P. x euramericana	2H
Kylemore West, SE. Galway			P. x euramericana	2H
Aughameelick South East, Offaly	m	a	P. x euramericana	3H
Booth Road, Dublin		a	P. x euramericana	3H
Carrigahorrig 1, N. Tipperary		a	P. x euramericana	3H
Carrigahorrig 3, N. Tipperary		a	P. x euramericana	3H
Carrigahorrig 5, N. Tipperary		a	P. x euramericana	3H
Castle Park North, W. Dublin		a	P. x euramericana	3H
Drumcooley far East North, Offaly	m		P. x euramericana	3H
Fair English River, Kildare		a	P. x euramericana	3H
Pallas Hill, SE. Galway		a	P. x euramericana	3H
Pallas South 4, SE. Galway	m	a	P. x euramericana	3H
Pallas South 5, SE. Galway	m	a	P. x euramericana	3H
Pallas South 6, SE. Galway	m	a	P. x euramericana	3H
Pallas South 7, SE. Galway	m	a	P. x euramericana	3H
Riverstown 3, N. Tipperary	m		P. x euramericana	3H
Riverstown 4, N. Tipperary		a	P. x euramericana	3H
Monastery Gate Copse, Dublin		a	P. x euramericana	3H

Washington, Oregon or Queen Charlotte Islands? Which is the best provenance of Sitka spruce (*Picea sitchensis*) for Ireland?

David Thompson[a], Michael Lally[b] and Alistair Pfeifer[c]

Abstract
Perceived reductions in both productivity and timber quality in faster growing Washington and Oregon Sitka spruce seed sources have led to the widespread use of Queen Charlotte Islands (QCI) sources in Irish forestry. The belief is that the more northerly sources provide slower and more consistent growth, superior wood qualities, increased stability and protection against frost damage. However, none of these assertions is supported by results from over 40 years of provenance testing in Sitka spruce in Ireland. The widely held belief that QCI origins are less prone to late spring frost damage is not supported by field trial results. The use of Washington origins will result in at least a one Yield Class (2 m^{-3} ha^{-1} $year^{-1}$) increase in wood production over QCI origins without any significant increase in frost risk. Therefore, the continued planting of large amounts of QCI origins in Ireland is not justified. For commercial plantations of Sitka spruce in Ireland, Washington and Oregon sources are the recommended sources.

Keywords: Sitka spruce, *Picea sitchensis,* provenance, origin, seed sources, frost damage, wood quality.

Introduction
Current opinions on the best provenance or seed origin of Sitka spruce (*Picea sitchensis*) for use in Ireland are not based on the results of formal provenance trials, but rather on the perceived risks associated with using more southerly provenances. These concerns are that more southerly sources:

1. grow too rapidly,
2. produce poor quality wood,
3. have an increased incidence of lammas growth,
4. suffer from poor stability,
5. are at increased risk of frost damage, and
6. show rapid initial growth rates which decline over the rotation.

Another important consideration is that the Forestry Commission in Britain has in the past recommended QCI sources.

Because QCI is always readily available and Washington less common, QCI has been planted on poorer, more exposed sites than Washington, and as a result it has developed an undeserved reputation of being more robust than Washington.

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The objective of this paper is to summarise over 40 years of provenance research in Ireland with Sitka spruce and to demonstrate that none of these concerns is sufficient to justify the current planting of large amounts of QCI material.

Background

Sitka spruce was first recorded by the Scottish botanist Archibald Menzies in the Puget Sound area, near Seattle (in Washington State), in 1792. About 1831 the first seeds were imported to Europe by another Scottish botanist, David Douglas. Most of the original seed was planted in arboreta and gardens throughout Britain and Ireland. Some of the first Sitka spruce planted in Ireland was in about 1843, at Curraghmore, Co Waterford (Fitzpatrick 1966). The performance of Sitka spruce in gardens and arboreta attracted interest as a potential commercial timber species and the first experimental planting in Ireland was in Avondale in 1905; commercial planting began in the 1920s (Fitzpatrick 1966).

The suitability of the species on a wide range of sites and soil types in this country has led to it becoming the most widely utilised species in Ireland (Joyce and OCarroll 2002). Currently, it accounts for about 57% of the national forest estate, comprising 60% of the Coillte, and 50% of the private forest estates, respectively.

Sitka spruce is native to a long, narrow coastal strip that adjoins the Pacific Ocean, from south-central Alaska (61°N) to northern California (39°N), a distance of about 3,000 km. Initial commercial imports of seed to Britain and Ireland were mainly from Oregon and Washington, but later imports, especially to the UK, were predominantly from the Queen Charlotte Islands, located off the coast of British Columbia, Canada (Fletcher 1990). This was mainly because of the similarity of latitude, climate and ecological conditions between Scotland and the Queen Charlotte Islands. Unfortunately, this practice completely ignored the influence of the Gulf Stream on the climate of the British Isles, which, as will be shown later, plays a considerable role in determining the most suitable seed origins, especially for Ireland.

During the period 1922 to 1990 approximately 85% of the Sitka spruce planted in Britain was of QCI origin (Fletcher 1990), while in Ireland during the period 1930 to 1970 the origins planted in State forestry were 45% QCI, 36% Washington, 14% home-collected and 5% unknown (Pfeifer 1983).

One reason why so much QCI has been planted is the fact that it is easier to grow in the nursery than either Washington or Oregon sources, because it tends to stop growing earlier in the autumn. As a result, it is less susceptible to early autumn frost damage, which can be a problem in nurseries, but not in young plantations (see discussion later on frost susceptibility). For this reason QCI plants are generally readily available in most years.

Because both QCI and Washington material had performed well under most conditions, and because there were no obvious differences between provenances, very little attention was paid to the effect of seed origin (Fletcher 1990). In fact, no detailed study of the effect of seed origin was undertaken until 1960, when a series of trials testing 10 provenances (from Alaska to mid-Oregon) was organised by the

Forestry Commission in Britain, with one replicate being established in Ireland near Killarney. After 10 growing seasons the more southerly Washington and Oregon provenances showed superior growth rate, compared with QCI sources (O'Driscoll 1977).

In 1970, under the auspices of the IUFRO (International Union of Forest Research Organisations), an international provenance experiment in Sitka spruce was established which consisted of seed from 67 different locations, from the entire natural range of the species. This allowed for a more detailed examination of the influence of provenance than was previously possible. This trial was established in 1975 on 9 sites, covering most of the typical Sitka spruce planting sites in the country (Pfeifer 1993).

An internal Forest and Wildlife Service report, based on the results of the 1960 Killarney (after 24 growing seasons) and the 1975 IUFRO trials (after 9 growing seasons), highlighted the benefits of planting Washington and Oregon over QCI origins (Pfeifer 1983). It concluded: "Provenance trials have shown that growth differences between the QCI and Washington coast origins are in the region of 12 to 14% over all sites sampled in the trials. Therefore even if seed from managed QCI seed stands were available, its growth potential would still fall short of an imported Washington provenance. If we continue to collect seed from home collected stands of QCI origin, then we will perpetuate the planting of a less productive provenance."

As a result of the report, a Forest and Wildlife Service committee was formed in 1984 to discuss the question further. It decided that an overall national planting policy of 50:50 QCI: Washington would be the most prudent action. This decision was based on arguments that:

1. more southerly provenances "...might give rise to problems of too rapid growth, poor wood quality, lammas growth, stability and dangers of autumn frost damage".
2. the IUFRO provenance experiment was too young to make any firm recommendations;
3. early growth rates of the more southerly provenances might not be maintained throughout the lifespan of the crop;
4. the Forestry Commission at that time recommended QCI for use in the United Kingdom.

In the 20 years since the original decision, the 50:50 QCI:Washington national policy has been remarkably upheld. In 1993 the Sitka spruce planting programme in Coillte consisted of 56% QCI, 36% Washington and 8% Oregon origins. However, a survey carried out of 1997/1998 private sector planting showed that 79% of the plants were QCI 20%, Washington and 1% Oregon origin.

The purpose of this paper is to question the widespread use of QCI origins in light of more recent data (Pfeifer 1993, Thompson and Pfeifer 1995) and to argue that to optimise the productivity of Sitka spruce in this country it is time to increase the planting of Washington and Oregon origins and reduce the use of QCI origins.

Results from research trials, field investigations and observation of Sitka spruce origins, and change to Forestry Commission policy

As stated, since the 1984 decision to adopt a 50:50 QCI:Washington policy, new research relevant to the selection of Sitka spruce origins has become available. In addition, there has been a change to Forestry Commission policy. The material presented below follows the sequence of the four issues that were the basis for the 1984 decision.

Growth pattern, commercial wood yield and economic return from Sitka spruce origins

1960 Forestry Commission Sitka spruce trial at Killarney

This trial consisting of 10 commercially collected seed lots and one seed lot from Denmark was organised by the Forestry Commission in 1960. It was replicated at 14 sites across Great Britain, together with one at Tomies Wood, close to Killarney in Co Kerry. The Killarney site was selected as frost-free, fertile and sheltered, to

***Table 1**. Growth of 11 Sitka spruce provenances at Killarney up to 37 growing seasons.*

	Number of growing seasons									
	0	*3*	*6*	*9*	*14*	*32*	*37*	*14*	*32*	*37*
Provenance and location code[1]	*Mean height (m)*							*Diameter breast height (cm)*		
Cordova (AK)	*0.12*	*0.49*	*1.32*	*2.14*	*6.07*	*18.7*	*22.1*	*10.0*	*19.0*	*26.7*
Sitka (AK)	*0.18*	*0.57*	*1.44*	*2.15*	*5.97*	*19.1*	*22.2*	*9.5*	*22.2*	*24.6*
Terrace (BC)	*0.20*	*0.62*	*1.54*	*2.46*	*6.69*	*19.9*	*23.1*	*11.2*	*25.8*	*30.3*
Skidegate (QCI)	*0.23*	*0.75*	*.83*	*3.05*	*7.98*	*20.1*	*22.9*	*11.7*	*24.6*	*28.8*
San Juan (VI)	*0.24*	*0.74*	*1.93*	*3.32*	*8.01*	*16.6*	*23.5*	*11.5*	*24.6*	*32.5*
Sooke (VI)	*0.27*	*0.92*	*2.30*	*4.14*	*9.19*	*22.1*	*25.3*	*11.8*	*25.1*	*32.4*
Forks (WA)	*0.25*	*0.90*	*2.19*	*4.14*	*9.13*	*20.7*	*23.2*	*12.2*	*24.5*	*32.3*
Hoquiam (WA)	*0.23*	*0.81*	*2.15*	*3.94*	*9.06*	*20.5*	*22.7*	*12.3*	*25.1*	*32.8*
Jewell (OR)	*0.23*	*0.76*	*1.97*	*3.50*	*8.94*	*21.2*	*24.3*	*12.1*	*26.3*	*32.8*
North Bend (OR)	*0.23*	*0.92*	*1.97*	*3.32*	*8.27*	*21.7*	*24.9*	*11.4*	*26.6*	*33.3*
Jutland (DK)	*0.17*	*0.98*	*2.53*	*4.61*	*10.3*	*20.0*	*27.5*	*13.5*	*27.2*	*34.1*

[1] Location codes: (AK) Alaska, (BC) British Columbia, (QCI) Queen Charlotte Islands, (VI) Vancouver Island, (WA) Washington, (OR) Oregon and (DK) Denmark.

provide an optimal site for the different provenances, in comparison with some of the harsher sites planted in the UK. Results from the Killarney trial are presented in Table 1.

The results show a trend of increased height and diameter growth when moving from north (Alaska) to south (Oregon). The most productive provenances are the more southerly, especially Vancouver Island (Sooke), Washington (Forks) and Oregon (Jewell and North Bend). It is also interesting to note that the material from Jutland, which originated from a Washington seed source, was the top performer. Selection in the nursery and in plantations in Denmark may have contributed to its increased adaptedness to European climatic conditions.

The results also demonstrate that the initial fast growth rate of the more southerly sources does not decline with age (up to 37 growing seasons), which was one of the original concerns about their proposed more widespread use.

One criticism made of the results from the Killarney trial was that they represented only one site, which was specifically selected for the absence of frost. These criticisms were taken into account when the IUFRO trial was established. Nevertheless, Killarney provided a first look at the performance of different seed sources of Sitka spruce, which, at the time of writing, is still quite impressive.

1975 IUFRO Sitka spruce provenance trials

In 1975 a series of nine Sitka spruce provenance trials, representing 67 different seed origins or provenances was established in Ireland (Pfeifer 1993). Sites were specifically selected to represent typical sites were Sitka would be grown. These have been measured after 9 (Pfeifer 1993) and 19 growing seasons (Thompson and Pfeifer 1995). Site descriptions of the five are presented in Table 2.

Results of growth assessments in the five trials at the end of 22 growing seasons are presented in Table 3.

These results show the same trend as the Killarney trial, with increased volume production in the Washington and Oregon origins compared to QCI. It is also important to note that this trend was consistent over all five trials, which were located on a wide range of site types and different climatic conditions across the country.

Table 2. *Site descriptions of Sitka spruce IUFRO provenance trials.*

Trial	*Elevation*	*Rainfall*	*Soil type*	*Date of last spring frost*
	m	*mm yr^{-1}*		
Killygordon, Co Donegal	*185*	*1600-2000*	*peaty gley*	*May 1*
Belturbet, Co Cavan	*90*	*1000-1200*	*gley*	*May 1*
Rossmore, Co Waterford	*240*	*1000-1200*	*gley*	*May 15*
Comeragh, Co Waterford	*90*	*1000-1200*	*gley*	*April 15*
Kenmare, Co Kerry	*25*	*1600-2000*	*brown earth*	*March 15*

Table 3. Relationship between seed origin, height and volume growth in Sitka spruce IUFRO provenance trials after 22 growing seasons.

Origin	*Site*				
	Killygordon	*Belturbet*	*Rossmore*	*Comeragh*	*Kenmare*
	Mean height (yield class) M ($m^3\ ha^{-1}\ yr^{-1}$)				
QCI	*12.0 (18)*	*15.0 (22)*	*13.0 (20)*	*14.5 (22)*	*15.0 (22)*
N. WA	*12.5 (20)*	*15.5 (24)*	*13.5 (20)*	*16.0 (24)*	*17.0 (24+)*
S. WA	*12.5 (20)*	*16.5 (24)*	*14.5 (22)*	*18.5 (24+)*	*17.5 (24+)*
N. OR	*12.0 (18)*	*16.0 (24)*	*14.5 (22)*	*not tested*	*18.0 (24+)*
S. OR	*12.5 (20)*	*not tested*	*14.5 (22)*	*17.5 (24+)*	*17.0 (24+)*

***Table 4**. Average growth, associated volume assortments and standing value of five Sitka spruce IUFRO provenance trials.*

Origin	*Mean top height*	*Mean DBH*	*Yield Class*	*Standing volume*	*LSL/SSL[1]/pulp*	*1996 standing value*
	m	*cm*	*$m^3\ ha^{-1}\ yr^{-1}$*	*$m^3\ ha^{-1}$*		*£ ha^{-1}*
QCI	*13.9*	*19.1*	*22*	*315.7*	*27/44/29*	*6246*
N. WA	*14.9*	*20.7*	*24*	*389.6*	*38/40/22*	*8843*
S. WA	*15.9*	*21.4*	*24+*	*430.0*	*40/41/19*	*10180*
N. OR	*15.1*	*20.6*	*24*	*399.6*	*37/43/20*	*9110*
S. OR	*15.4*	*20.9*	*24*	*434.4*	*33/45/22*	*9456*

[1]LSL large sawlog, SSL small sawlog

Further assessments of standing volume were made and the percentage of large sawlog, small sawlog and pulp was estimated for each trial. The standing value (1996 prices) of the crop (after 22 growing seasons) was then calculated (Table 4).

Differences in the value of the standing crop (Table 4) were mainly due to differences in the percentage of large sawlog; total standing volume had a smaller influence (the greatest volume production was in the southern Oregon material). The high value of the southern Washington stands was due to their having the highest percentage of standing volume (40%), in the most valuable large sawlog category.

Although it might be expected that QCI material was the best suited to Irish conditions, due to its latitude of origin (53°N) and similar climatic conditions to here, the results of both the Killarney and the IUFRO provenance trials did not support this hypothesis. The reason is more than likely due to the warming effect of the Gulf Stream on the Irish climate. The result is a climate that is more similar to southern Washington and northern Oregon, a shift of about 7 degrees south (to about 46°N). Provenance trial results from other Pacific Northwest conifer species such as Douglas fir (*Pseudotsuga menziesii*) show a very similar pattern. Thus, using latitude alone to select provenances is not always as reliable a predictor of success as might be expected.

Wood quality

Fast growth results in increased volumes, but usually at the expense of wood quality. The main criterion used to determine wood quality is density, mainly because it is relatively easy to measure, and because it is closely correlated with strength properties.

The effect of provenance on wood density in Irish stands was reported by Murphy and Pfeifer (1991). Their study showed that wood density decreased slightly as seed sources moved from north (Alaska) to south (Oregon) and growth rate increased (Table 5). However, the decrease in density between QCI and Washington was only 5%. Whether this would result in a significant decrease in wood strength has not been established. Perhaps a more important observation in their study was that site conditions and management regime resulted in a greater variation in wood density than the influence of provenance (Murphy and Pfeifer 1991).

Wood density is only one of several factors involved in determining wood strength. It is particularly relevant in clearwood, but branching and knots have a greater influence on timber strength. Measurements of the size and number of branches in different Sitka spruce provenances (Murphy and Pfeifer 1991) have shown that southern provenances have both fewer and smaller diameter, branches than northern provenances per unit length of stem (Table 6). This occurs because the faster growth of the southern provenances results in branch whorls that are further

***Table 5**. The relationship between north-south origin and wood density of Sitka spruce.*

Origin	***Mean wood density*** ***g cc^{-1}***
Alaska	*0.425*
British Columbia	*0.415*
QCI	*0.401*
Vancouver Island	*0.387*
Washington	*0.382*
Oregon	*0.397*

Table 6. The relationship between north-south origin and branching in Sitka spruce.

Origin	*Mean branch/stem diameter ratio*	*Mean number of branches/stem internode length*
Alaska	*0.22*	*0.27*
British Columbia	*0.21*	*0.25*
QCI	*0.19*	*0.21*
Vancouver Island	*0.19*	*0.21*
Washington	*0.19*	*0.20*
Oregon	*0.19*	*0.17*

apart along the stem, and earlier canopy closure which suppresses the diameter growth of lower branches.

These results show that for southern origins the size and number of branches decreases, with a corresponding decrease in knot size and frequency. This is likely to offset any reductions in strength properties due to a slightly lower wood density.

Treacy et al. (2000) examined wood density, microfibril angle, modulus of elasticity and modulus of rupture in Sitka spruce (QCI, Washington, Oregon and California origins) from a single experimental location in Ireland. They found the QCI material had the highest wood density, but also observed very large differences from tree to tree. The Washington material had the highest modulus of rupture, which indicates higher strength properties in this source. There were no significant differences ($p \leq 0.5$) in either the modulus of elasticity or microfibril angle between the four sources tested. These results also indicate that wood strength properties in the more southerly Washington and Oregon sources are comparable to QCI material.

Lee et al. (1999) compared both forest production and sawmill conversion of material from a 44-year-old Sitka spruce provenance trial in north Wales that included QCI and several Washington sources. The Washington sources produced higher sawlog volume, a larger proportion of 5 m length logs, no decrease in the proportion of sawn timber that satisfied the SC3 standard, and only a slight reduction in the proportion of SC4 construction timber, as compared to the QCI material. The report concluded that "Selection of either of these two origins (Washington-Hoh River or Columbia River) should give an increase in value to the forest manager relative to unimproved QCI material without any loss in overall strength for the construction timber market".

All these studies indicate that concerns that a significant decrease in timber strength will result from more widespread use of southern Sitka spruce origins are unjustified.

Leader breakage

It is logical to expect that leader breakage will be greater in faster growing origins where leaders may not be fully lignified before winter storms occur. However, observations in field trials and plantations do not support this because:

1. most leader breakage occurs during summer months (mainly July), before leaders of both fast or slow growing origins have begun to lignify,
2. leader breakage has not been found to be correlated with specific origins, but depends more on the site and degree of exposure.

Fears about increased incidence of leader breakage in Washington and Oregon sources are therefore not supported by field observations.

Lammas growth

Lammas growth is a second flush that occurs in late summer, after main shoot extension has finished. There is evidence to suggest that it is higher in southern or more vigorous provenances, but this does not seem to have had any significant effect on the frost hardiness or stem form of these origins.

Therefore concerns about a significantly increased incidence of lammas growth in Washington and Oregon sources are not justified.

Stability

Increased shoot growth could result in reduced root growth and thus reduce the stability of faster growing Washington and Oregon sources. However, there is no evidence to suggest that there is such a relationship. Studies on root:shoot ratios of different sources of Sitka spruce have not shown significant differences between sources (Cannell and Willett 1976). Stability of Sitka spruce is determined more by soil type, elevation, slope, site preparation and thinning regime than by seed source (Ni Dhubháin et al. 2001).

Concerns about reduced stability in Sitka spruce origins from Washington and Oregon compared to those from QCI are not valid.

Frost susceptibility

One of the largest fears of increasing the use of Washington and Oregon origins is that they are at a greater risk of frost damage than QCI. This may indeed be true in the nursery bed, where, as prolonged shoot growth is encouraged. QCI origins will tend to suffer less autumn frost damage because they become dormant earlier (late September to early October) than Washington or Oregon sources (late October to early November). However, once trees are established on the planting site, autumn frost causes little damage to Sitka spruce in Ireland. In fact Cannell et al. (1985) showed that early autumn frost was less frequent (once in every 8 to 10 years) than late spring frost (once every 3 to 5 years) in Scottish upland plantations.

Therefore, late spring frosts present much more of a threat. During the first 4 to 5 years after planting, once the air temperature falls below –5°C, newly flushed shoots can be damaged, leading to retarded growth, forking and, in severe cases, mortality. Damage typically occurs to shoots from ground level up to about 2 m,

Table 7. *Date of bud break by origin in the Killarney Sitka spruce provenance trial, over a period of two years.*

Origin and location code[1]	***1971 Bud break***	***1971 Days since first bud break (April 26)***	***1972 Bud break***	***1972 Days since first bud break (May 2)***
Cordova (AK)	*May 4*	*8*	*May 9*	*7*
Sitka (AK)	*May 2*	*6*	*May 7*	*5*
Terrace (BC)	*April 26*	*0*	*May 2*	*0*
Skidgate (QCI)	*April 26*	*0*	*May 2*	*0*
San Juan (VI)	*April 28*	*2*	*May 3*	*1*
Sooke (VI)	*April 29*	*3*	*May 2*	*0*
Forks (WA)	*May 3*	*7*	*May 8*	*6*
Hoquiam (WA)	*May 3*	*7*	*May 6*	*4*
Jewell (OR)	*May 1*	*5*	*May 5*	*3*
North Bend (OR)	*May 5*	*9*	*May 11*	*9*

[1] Location codes as Table 1.

Table 8. *Date of bud break at the end of the first growing season (1975) of 3-year-old plants in the IUFRO Sitka spruce provenance trial, averaged over three sites (Aughrim, Belturbet and Kenmare).*

Origin and location code[1]	***Bud break***	***Days since first bud break (May 9)***
Duck Creek (AK)	*May 14*	*5*
Ward Lake (AK)	*May 16*	*7*
Usk Ferry (BC)	*May 14*	*5*
Inverness (BC)	*May 13*	*4*
Link Road (QCI)	*May 13*	*4*
Holberg (VI)	*May 12*	*3*
Big Qualicum (VI)	*May12*	*3*
Forks (WA)	*May 13*	*4*
Hoquiam (WA)	*May 13*	*4*
Necanicum (OR)	*May 9*	*0*

[1] Location codes as Table 1.

although in frost pockets damage can occur above 2 m. As soon as trees have grown out of the danger zone they are usually free of frost damage, and because Washington origins grow faster, they generally outgrow frost risk earlier than slower growing origins.

In species such as Douglas fir and Norway spruce, which cover a wide range of diverse environments in their native range, it is possible to select seed sources that have large differences (up to 30 to 60 days) in the date of bud break, which can provide protection against late spring frost damage. However, because Sitka spruce is native to a long, low-lying, narrow strip along the Pacific coast, differences between origins in the date of bud break are not very large (Lines and Mitchell 1965, Kraus and Lines 1976). This is illustrated by flushing assessments carried out in the 1960 Killarney provenance trial (Table 7), and in a sample of provenances from the 1975 IUFRO trial (Table 8).

Although there were differences in both the date of bud break and the order in which the origins flushed from year to year and from trial to trial, this may be partly explained by year-to-year weather differences (different dates that origins became dormant, different origin chilling requirements, temperatures during the winter and how early spring arrived) that affect bud break. In addition, the Killarney results were from trees that had been in the field for 12 or 13 growing seasons, while the IUFRO trees had been in the field only one growing season. Nevertheless, the overall trends in both sets of results were similar: the most northerly origins (Alaska) flushed latest. However, these origins are too slow-growing to have a role in commercial forestry (Table 1), and only those from QCI and southwards are realistic options.

In both trials the date of bud break varied little between QCI, Washington or Oregon origins (2 to 9 days in the Killarney trial and 4 to 5 days in the IUFRO material). When the 2 to 9 day difference in bud break between origins of Sitka spruce is compared to the 30 to 60 day difference that occurs between origins of Norway spruce, it is clear that the use of different provenances of Sitka spruce to reduce the occurrence of late spring frost damage is not an effective option.

Thus, the commonly held belief that QCI origins provide protection against late spring frost is not supported by the facts.

In the absence of the option to use different Sitka spruce origins to protect against late spring frost damage, it becomes necessary to identify sites with a greater likelihood of late spring frost damage. Some attempt at this has been made in Scotland (Cannell, 1984). In Ireland some approximate frost likelihood maps have been produced which attempt to identify the average date of the last spring frost in different parts of the country (Figure 1). Despite their lack of precision they show that the likelihood of a late spring frost after 15 May is quite low.

Exposure tolerance

Because QCI material originates from exposed islands off the coast of British Columbia, it has developed the reputation of providing greater protection against exposure than other origins. In a study in Denmark on an exposed North Sea site, Alaskan Sitka was the most tolerant of exposure and there was little if any difference

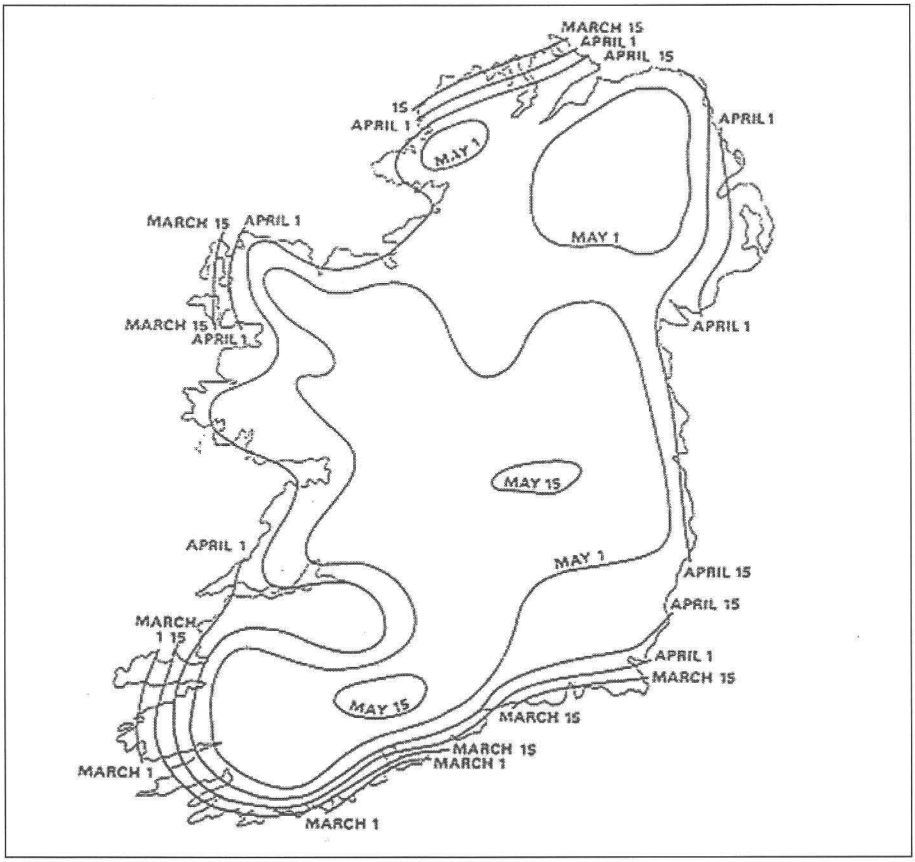

Figure 1*. Average last date of spring frost in Ireland (Collins and Cummins 1996).*

between QCI and Washington in their ability to tolerate exposure (Nielsen 2005). Thus, the belief that QCI provides greater tolerance to exposure is not supported by the facts.

Cold hardiness

Laboratory freezing tests have shown that both Washington and QCI material ultimately reach about the same degree of cold hardiness, although because QCI sources become dormant earlier than Washington, QCI material will reach a greater degree of cold hardiness earlier than Washington (O'Reilly 2005). However, this time difference between provenances is unlikely to provide any significant protection against early severe cold temperatures.

Forestry Commission policy

The original recommendation of the Forestry Commission to plant only QCI material on all sites has since been modified to include the use of Washington and Oregon material on low elevation sites in Wales, Cornwall and southern England (Lines and Samuel 1993), where climatic conditions are more similar to Ireland than to Scotland. More recently, an Ecological Site Classification system has been developed in the UK (Pyatt et al. 2001) to identify specific climatic zones, soil nutrient regimes and soil moisture regimes matched to a range of species. Specific origins of Sitka (Alaska, QCI, Washington and Oregon) have been recommended for sites with certain accumulated temperatures (degree days above +5°C) based on the accumulated temperatures experienced by these origins in the natural species range. For locations with an accumulated temperature (AT) of less than 1,400, QCI should be planted; for sites with an AT greater than 1,800 Oregon should be planted and for sites with an AT of more than 1,400 but less than 1,800 Washington should be planted. Applying these AT limits to Ireland (Figure 2) it is clear that Oregon should be planted in a coastal strip from the southeast, along the south coast to the southern

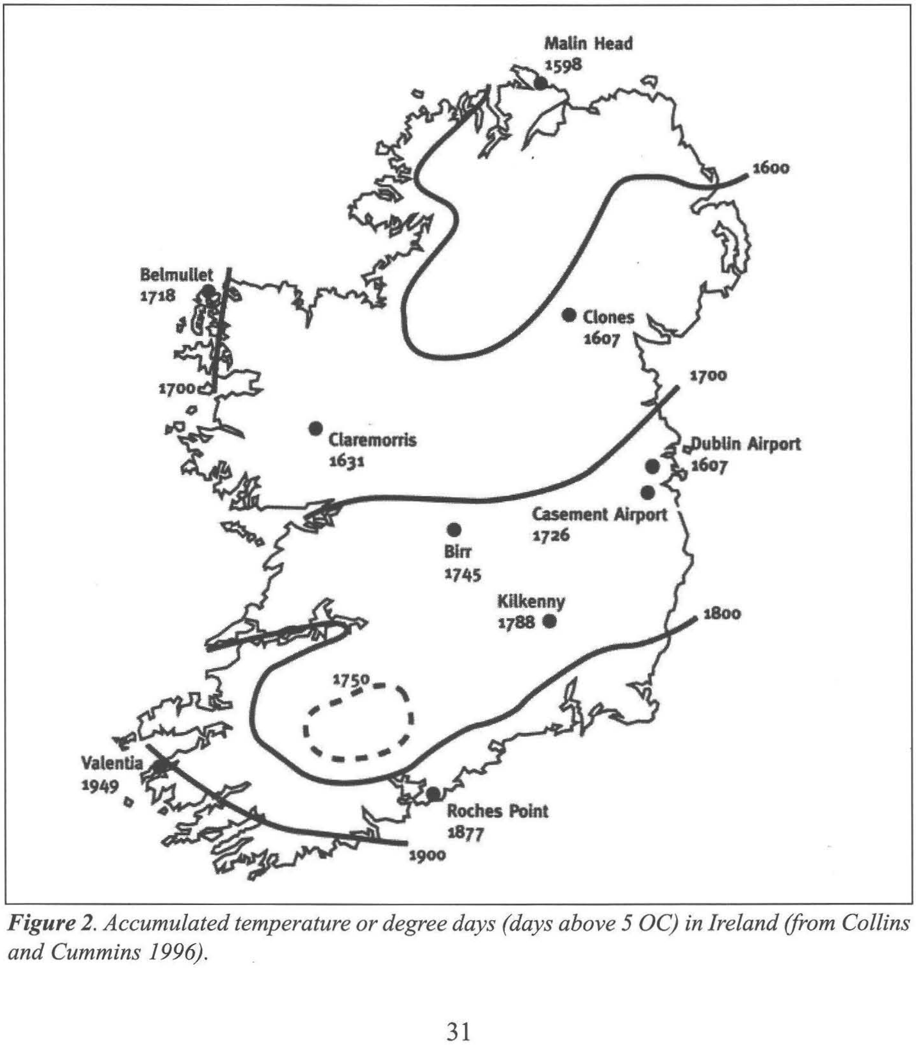

Figure 2. Accumulated temperature or degree days (days above 5 OC) in Ireland (from Collins and Cummins 1996).

shore of the Shannon Estuary (south of the 1,800 degree day line in Figure 2). Following the premise that QCI should be planted in areas with less than 1,400 AT, it would appear that there is no need to plant QCI anywhere in Ireland. Thus, Washington can safely be planted on all Sitka sites in Ireland not planted with Oregon.

Conclusions

The original arguments against the increased use of Washington and Oregon origins of Sitka spruce included concerns about too rapid growth, poor wood quality, lammas growth, stability, autumn frost damage, initial rapid growth that would not be maintained and the Forestry Commission recommendation to use QCI origins. As has been demonstrated in this paper, none of these arguments stand up to scrutiny and provide no compelling reason why QCI should be used to the extent it is. The conclusion is that Washington and Oregon origins of Sitka spruce should be planted for commercial purposes in this country.

The belief that QCI provides protection against late spring frost or that it can tolerate poorer or more exposed sites than Washington has no basis in fact. It is an unjustified fear of failure with Washington or Oregon sources that is perhaps the main reason for the widespread planting QCI.

However, the reduction in the planting of QCI will be a gradual process as stocks in nurseries gradually reflect the change in planting patterns. It will not happen overnight.

By planting more Washington and Oregon origins the productivity of the forest estate will be increased. For example, the current average Sitka spruce yield class of 16 in Coillte forests could be increased to almost 18, if more Washington and Oregon material were planted.

The 1984 decision to plant nationally plant a 50:50 ratio of QCI and Washington/Oregon sources was a safe, conservative approach, especially with only early provenance performance information available at that time, but now, in light of additional evidence, it is time for growers to change to Washington/Oregon origins. Thus, based on the arguments put forward above, there is no reason why so much QCI material should be planted in this country. Currently, Coillte planting comprises 64% Washington/Oregon: 36% QCI origins, but it is moving towards an 85% Washington/Oregon to a 15% QCI target. The QCI percentage could fall even lower in time. However, the continued planting of very large amounts QCI by the private sector - up to 80% - continues. This is based more on a false sense of security than on the results of scientific experiments. The widespread use of QCI origins results in at least a full Yield Class (2 m^3 ha^{-1} yr^{-1}) loss in roundwood production, with little or no benefit.

Sitka spruce provenance recommendations

Oregon provenance should be planted along the south coast (south of the 1,800 AT line in Figure 2). Elsewhere, Washington provenance should be planted where Sitka spruce is the chosen species.

QCI provenance - as discussed in this paper there are no good reasons to plant QCI in Ireland. In areas where QCI has been planted in the past, Washington will grow and produce a more productive crop. Even in areas of midland bog, because QCI provides no protection against late spring frost, Washington will survive, be more productive and will outgrow the risk of frost damage faster than QCI.

Acknowledgements
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Birch seedlings can be grown to plantable size in one year using cloches in the nursery

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Abstract

Seedbed covers were evaluated to determine if they could be used in the nursery to grow birch (*Betula pubescens* Ehrh.) seedlings to plantable size in one growing season. The effects of four different seedbed covers (a spun-bonded polyester fabric cloche, a non-perforated cloche, a perforated clear polythene cloche, and a 'floating' polythene mulch) on seed germination of birch after sowing in March, April and June and on subsequent seedling growth were investigated. Seedbed cover type had no consistent effect on germination, suggesting that all provided favourable conditions for germination. Bed cover type also had no significant effect on seedling density at the end of the growing season, suggesting that plant survival was not influenced by cloche type. However, up to 53% of the seedlings reached target size dimensions (>40 cm tall and 4 mm diameter) under the perforated cloche, compared with a maximum of 35% under the fleece cloche, suggesting that the use of the perforated cloche might be economically viable in the nursery. Germination was better for seeds sown in March than on other dates and seedling density was highest in these beds at the end of the season. Seedlings derived from seeds sown in June and under the mulch grew poorly. Sowing date and seedbed density had no significant effect on seedling morphological quality.

Keywords: Germination, seed dormancy, seedling density, morphology, plant quality.

Introduction

The current Irish target is for broadleaves to account for 30% of new plantings. In Ireland, birch (*Betula* spp.) forms an important part of this planting programme. Common birch (*Betula pubescens* Ehrh) accounts for about 85% (data on file, Coillte) of the birch planted, with the remainder being silver birch (*Betula pendula* Roth). It takes two years to produce birch planting stock (> 40 cm tall and 4 mm diameter) in Irish nurseries, whereas equivalent sized stock can be produced within one year in continental European nurseries. In fact under Irish conditions, birch seedlings are usually only about 10 cm tall (range 6-12 cm) at the end of the first growing season (data on file).

Seed pre-treatments, sowing date, nutrient regime and other nursery cultural practices can be modified to maximise germination and growth of seedlings in the nursery, but it is more difficult to influence environmental factors such as temperature, CO_2 concentrations and humidity levels. Broadleaf species appear to be particularly sensitive to environmental factors (Mason 1994). Research carried out in

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Britain has revealed that 'floating' mulches and cloches (which increase temperature and humidity but reduce exposure) can be used to improve seedbed microclimate, and thus improve growth and yields in the nursery bed (Thompson and Biggin 1980, Thompson 1982, Stevenson and Thompson 1985). Floating mulches are lengths of polythene or fabric that are laid flat on the surface of the bed, whereas cloches are similar materials raised off the bed, usually supported by wire hoops (similar to bird netting) (Mason 1994).

Results of studies conducted on several conifer species showed that germination, growth and seedling survival is favoured by using cloches (Thompson and Biggin 1980, Thompson 1982, Stevenson and Thompson 1985), but little information is available for broadleaves. Cloches improve the microenvironment for growth. Air temperatures up to 20°C above ambient have been recorded inside clear polythene cloches, but increases of 8-16°C are more usual (Thompson and Biggin 1980, Mason 1994). Minimum temperatures are usually only about 1-2°C above ambient levels. CO_2 produced by soil organisms and plants accumulates under cloches (Shadbolt et al. 1962), which may also stimulate seedling growth (Rey and Jarvis 1998, Kellomäki and Wang 2001). Because moisture is retained within the cloche system, downward leaching of nutrients is reduced when non-perforated cloches are used (Thompson and Biggin 1980), but is unclear how effective perforated covers and floating mulches are in doing this.

The main aim of this study was to evaluate the effects of three different cloche types and a floating mulch on the germination and growth of common birch seedlings after sowing in March, April and June (delayed from May) in the nursery.

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 6.5, having an organic matter of ca. 5%, and sand, silt and clay fractions of 66, 19, and 15%, respectively. The soil was sterilised in August 2001 using Metham Sodium (a.i. sodium N-methyl dithiocarbamate) at 800 l/ha and the beds were formed three weeks later. The seeds from a single lot (seed zone details: BC-IELAOI-A19, Templetouhy Co Laois) were chilled in excess water for 3-6 weeks. After seed pre-treatment there were about 558,000 germinable seeds kg^{-1}. The sowing rate was about 680 bed m kg^{-1} to achieve a target seedling density of about 175 plants m^{-2}. The seeds were covered with 3-5 mm of lime free grit (1 m^3 100 m^{-2}) just after sowing. The seeds were sown on 25th March, 13th April and 5th June 2002. The last sowing date was later than scheduled (mid May) due to adverse weather conditions.

Seed germination and seedling density at end of season

Treatments and experimental design

The experiment was laid down as a randomised split-plot design. The trial contained nine nursery beds, each about 200 m long. Three randomly chosen beds (main plots) were sown in March, April and June. Soon after sowing, four different bed covers (subplots) were erected/ laid over the seedbeds; including a spun bonded polyester fabric (F), a non-perforated (N), a perforated (P) clear polythene type cloches and a photodegradable polythene floating mulch. Each subplot was 20 m long. Therefore, there were a total of three main plots (sow dates), each containing nine split subplots (seedbed covers). The non-perforated cloche (British Polythene Industries) was 65 µm thick; the perforated polythene cloche (Sotrafa, Spain) was 35 µm and had 10 mm diameter perforations, with 200 perforations per m^2; the fleece gauge was 17 g m^{-2} (Agryl P17, Agriweb, France). The mulch was a 6-µm thick photodegradable maize plastic (IP Europe, France). No other information is available for these covers.

Observations

The number of germinating seeds was recorded at two sampling points (each 0.0625 m^2) in each subplot at 4-7 day intervals soon after germination commenced. These points were located near the centre of each subplot, approximately equidistant from each other. Total germination per subplot and mean germination time (MGT) was calculated from these data. Mean germination time was calculated as the mean number of days since sowing for seeds to germinate in each subplot (Jones and Gosling 1994).

The number of seedlings in two sampling points (each 0.50 m^2) in each subplot was recorded at the autumn 2002. These points were located at random in the centre of each subplot.

Data analyses

The effects of sow date and bed cover type on parameter responses were analysed according to a split-plot factorial design. The germination counts were transformed to log values to standardise variation. Treatment means were compared using least significant difference tests.

End-of-season morphology

In general, the growth of seedlings derived from seeds sown in June and under the floating mulch was very poor, so seedlings from these plots were excluded from this part of the experiment; temperature data also are not presented for this cover type.

Treatments and experimental design

The cloches were removed at different times for practical reasons. The N cloche was removed early in the season (25 June) as the soil tended to get too dry under it. In the other two treatments, the cloches were removed when the leading shoots began to touch the surface of the cloche, which was about two weeks later for the F cloche (8 July) and another month later for the P cloche (8 August).

Sampling, observations and measurements

Seedlings were lifted from each subplot in February 2003 to examine the effects of treatments on morphological quality. About 150 seedlings were lifted from each subplot, 50 from each of three randomly chosen positions located in the centre of each subplot. Each batch of 50 plants was bundled separately. The plants were then dispatched to UCD and held at 2-4°C until the time of processing. The diameter and height of 10 plants sampled at random from each bundle was measured, after which the roots of the plants were washed, excised at the root collar and then placed in an oven at 105°C for 24 h. The weights of the shoot and root of each plant were measured after drying. The shoot to root dry weight ratio, and the proportion of 'target' seedlings (>40 cm tall and 4 mm diameter) per subplot were calculated from these data.

Analyses

The effects of treatments were analysed according to a split-plot factorial design to test for the effects of sow date and cloche type. Proportion data were transformed to arcsine square root values before analysis. Treatment means were compared using least significant difference tests.

Temperature data

Temperatures were recorded at the bed surface at only one location under each cover type from early April onward, and at the same location thereafter until October after the covers had been removed. Temperatures were recorded (TinyTag®, Gemini Data Loggers, Monotherm Ltd., Dublin) at approximately 5-minute intervals, but less frequent readings were recorded on some dates. Unfortunately, the data are not available for all periods due to instrument malfunction. Mean, maximum and minimum temperatures were determined from these data.

Results

Seed germination

Sowing date significantly (both $p<0.0001$) influenced total germination (Table 1), but bed cover type or its interaction with sow date had no significant effect. There were 1,380 germinants per m^2 in the plots sown in March, significantly ($p<0.0001$) more than the 635 and 1,095 for those sown April and June, respectively. Both sowing date ($p<0.0001$) and seedbed cover ($p<0.05$) significantly influenced speed of germination. Seeds sown in June germinated after only 43 days compared with 61

Table 1. *Mean germination, mean germination time – MGT (days since sowing and mean date) and mean number of seedlings that survived until the autumn in 2002. Values in parentheses are standard errors.*

Sow date	***Germination***	***MGT***		***Number of seedlings***
	number m^{-2}	***Days***	***Date***	***m^{-2}***
March	*1,380 (218.4)*	*88 (0.72)*	*21 June*	*166 (15.5)*
April	*635 (77.0)*	*61 (0.77)*	*13 June*	*88 (10.6)*
June	*1,095 (79.1)*	*43 (0.53)*	*18 July*	*95 (8.5)*

and 88 days for those sown on earlier dates. The corresponding mean dates of germination are 21 June, 13 June and 18 July for seeds sown in March, April and June, respectively. On average, seeds germinated a little more quickly under the N and P cloches and the mulch (about 63 days) than under the F cloche (66 days).

There were significantly ($p<0.05$) more seedlings in the autumn in beds sown in March (166 seedlings per m^2) compared with beds sown later (88 and 95 for the March- and June-sown beds, respectively) (Table 1). Bed cover or its interaction with sow date had no significant effect on these values.

End-of-season morphology

Morphological attributes

The effect of sow date or its interaction with cloche was not significant for any morphological parameter except height/ diameter ratio or sturdiness ($p<0.05$). Nevertheless, the means are presented for each sow date and cloche type (Figure 1). Cloche type significantly affected height, shoot dry weight and the proportion of plants that reached target size. Cloche type had no significant on the other parameters.

Seedlings grown under the N and P cloches were significantly ($p<0.05$) taller than those grown under the F cloche, although differences were not entirely consistent with sow date. For the March sow date, the mean heights were 41, 40 and 34 cm for seedlings grown under the N, P and F cloches, respectively. The equivalent values for the April sow date were 34, 38 and 34 cm. Similar differences were evident for the dry weight measurements. Sturdiness (low values indicate more sturdy plants) or height/diameter ratio was influenced by cloche type for seedlings derived from seeds sown in March, but not for those sown in April, especially for seedlings grown under the N cloche. Seedlings that were grown under the N cloche derived from seeds sown in March were less sturdy (10.4) than those from the other treatment (7.5-9.5) plots.

Cloche type had the most dramatic effect on the proportion of plants that reached target size dimensions (>40 cm tall and 4 mm diameter) (Figure 1). Significantly ($p<0.05$) fewer seedlings reached target dimensions under the F cloche than under the N and P cloches. For the March sow date, 16, 44 and 53% of the plants reached target size under the N, P and F cloches, respectively. The equivalent values for the April sow date were 35, 38 and 46%.

Effects on temperature

Temperatures were warmest under the non-perforated cloches and coolest under the fleece cloche when compared with the uncovered bed. For example, the mean temperature during late June was 22.3°C under the N cloche, 19.8°C under the P cloche and 17.0°C under the F cloche (uncovered, 16.9°C). Average maximum temperatures were 35.5, 34.8 and 28°C (uncovered, 26.8°C) and average minimum temperatures were 12.8, 10.3 and 9.0°C (uncovered, 7.9°C) under the P, N and F cloches, respectively. The absolute maximum temperature recorded during this period was 37, 41.5, and 34.3°C under the P, N and F cloches, respectively (uncovered, 30.6°C).

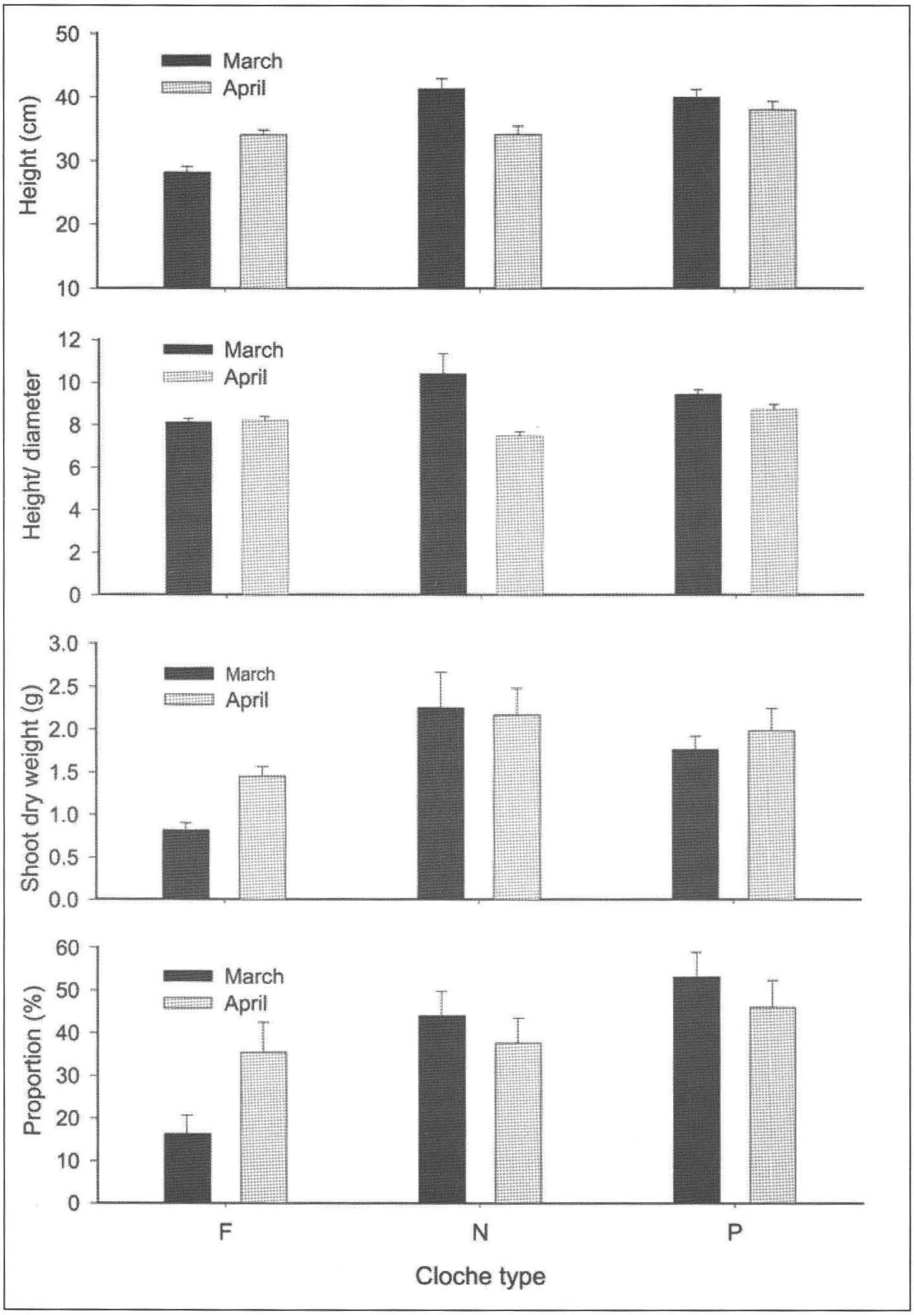

Figure 1. *The effect of cloche type and sow date on height, height/ diameter ratio, shoot dry weight and proportion reaching target size dimensions (>40 cm tall and 4 mm diameter) in birch seedlings in the nursery in 2002. Cloche types: F, fleece; N, non-perforated polythene; and P, perforated polythene. Vertical lines are standard errors.*

Discussion

Seedbed cover type had no consistent effect on germination (and the effect on mean germination time was small) in this study, suggesting that all provided favourable conditions for germination. However, germination was better for seeds sown in March than for those sown on other dates, but the exact reason for this is unclear. The March-sown seeds may have benefited from a longer warm-up period. Although the seeds were pretreated, dormancy may not have been fully released at the time of sowing. Birch seeds are sensitive to chilling temperatures, and temperatures after sowing in March might have been more favourable for breaking dormancy (DeAtrip and O'Reilly 2005). While more seeds germinated after sowing in March than in April, the mean date of germination was later for the former than the latter sowing date (Table 1). While it is likely that environmental conditions favoured seed dormancy release after sowing in March, subsequent progression to germination might have been slow, thus increasing the mean germination time. The seeds sown in June also germinated well, perhaps because they received additional chilling during pre-treatment (sowing was delayed by about 3 weeks). Other environmental conditions (e.g. moisture availability) just after sowing in March may also have favoured germination. Warm temperatures improve the germination, survival and growth of birch (Thompson and Naeem 1996). Cultural factors may also have contributed to these differences. Although great care was taken during all sowing operations, it is impossible to be certain that the method was identical on each date.

Bed cover type had no significant effect on the density of seedlings in the beds at the end of the season, suggesting that plant survival was not affected. As expected, the March-sown bed had the most plants at the end of the season, in agreement with the trend for germination. However, only about 9-12% of the seeds that germinated survived until the autumn (Table 1). Seedbed densities at the end of the season (88-166 plants) were not any higher than might be expected had cloches not been used (target of 175 plants). Thompson and Biggin (1980) found that lodgepole pine (*Pinus contorta* Dougl) survived better under clear polythene cloches than in uncovered (control) beds.

Although the germination data may have exaggerated actual germination, errors of this kind would have been consistent across treatments. The germination data were based on subplots of 0.0625 m^2, compared with 0.50 m^2 used for the autumn counts. If the germination subplots were slightly larger than intended due to errors in demarcating the boundaries, this would magnify differences when converted to values per m^{-2}. Furthermore, the method used to estimate seed germination may have contributed to this outcome. Germinants were counted when they reached the cotyledon stage; the tip of each stem was excised near the bed surface to facilitate this process. More seeds than otherwise might then have germinated, presumably because the topped plants could compete less effectively for available resources, thus perhaps inflating germination values. Nevertheless, it is well recognised that the average yield of plants is low in birch in Irish (data on file) and British (Mason 1994) nurseries, although little information is available on the effect of cloches on yields.

Seedbed density had no significant effect on morphological quality, perhaps because none of the densities at the end of the season exceeded the recommended target (175 m^{-2}). High seedling densities lead to competition for water, nutrients and light, thus reducing plant quality (Mason 1994). In particular, about 50% of the seedlings reached target dimensions under the P cloche, suggesting that the use of this cloche type might be economically viable in the nursery. Birch seedlings grown in Ireland without the aid of cloches are normally only about 10 cm tall at the end of the first growing season (data on file). Although not statistically significant, the results suggest that these values might be less influenced by sowing date for seedlings grown under the N and P cloches than under the F cloche. While the plants reached target planting stock dimensions, they were a little less sturdy (mean ranged from 8-10) than recommended for use in Britain (6-7.5) (Aldhous 1994). Nevertheless, the shoot: root ratio was <3 and the root growth potential of the seedling was excellent (data not shown), regardless of treatment, suggesting that the seedlings were fit for planting in the forest. The benefits of using cloches to improve the growth of several conifer species have been documented previously (Thompson and Biggin 1980, Thompson 1982).

High temperatures under cloches are rarely deleterious for tree growth if high humidity (ca. 95%) levels can be maintained (Kaneski 1968), but only the non-perforated cloche used in this study could potentially maintain very high humidity levels (humidity levels were not monitored). The edges of the cloches were secured with sandbags in this study, which may not be fully effective in sealing the N cloche. For this reason, the N cloche had to be removed earlier than planned because the soil underneath it was getting too dry. Wind damage greatly exacerbated the problem. Ballintemple Nursery is relatively exposed, perhaps making this type of cloche unsuitable for use there. Thompson and Biggin (1980) found that sealed cloches (edges buried in soil) slightly increased the growth of lodgepole pine seedlings, but nearly 20% of the seedlings died under unsealed cloches compared to only 2% under the sealed cloches. A tight seal must be maintained under this type of cloche to retain all the moisture since very little rainfall can enter the system. Sealed non-perforated cloches can maintain adequate soil moisture levels because water vapour produced by evapo-transpiration condenses on the polythene surface and is returned to the soil (Thompson and Biggin 1980). Despite the shorter period of cover, seedlings in this study grew better under the N cloche than under the F cloche.

The growth of seedlings under the perforated cloche was good in this study, suggesting that this cloche type might be preferable to the non-perforated type (since the soil under it is less prone to drying). It is likely that the cloche provided shelter, thus reducing wind and evapo-transpiration and raising temperatures, resulting in better seedling growth.

The results of this study showed that it is possible to produce birch seedlings of planting stock size under cloches in a single growing season. However, some caution is advised. The results reported are for one year only (although it might be considered an average or below average growing season) so the response might differ in other years. The data reported are for seedlings sampled from the centre of the beds; these values might overestimate the growth and yield data for the whole bed.

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Herbicides and forest vegetation management: A review of possible alternatives

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Abstract

A major component of forest management programmes is the suppression or elimination of weeds. This is essential during seedling establishment, as the more vigorous the growth of non-crop vegetation, the more the competition with desired plants for space, light, water and nutrients.

Much of the research into forest vegetation management has been on developing technology to control unwanted species with the main focus being on herbicides. In this paper, four alternative methods of weed control: (1) mowing, (2) cultivation, (3) mulching, and (4) ground cover species, are reviewed and their advantages and disadvantages discussed. Recently, certification initiatives and increasing public and industry awareness of the importance of environmental protection have led to concerns over the continued use of herbicides. It is therefore important to examine some potential alternatives for the Irish forestry situation.

Keywords: Vegetation management, alternatives, mowing, cultivation, mulching, ground cover species.

Introduction

In forestry, control of competing vegetation is essential during seedling establishment. Weeds, particularly grasses are fast-growing and compete aggressively with newly planted trees for moisture and nutrients. Generally, the more vigorous the growth of vegetation on a site, the more the competition with trees for the moisture and nutrients. It is widely acknowledged that a reduction in available moisture and nutrients due to weed competition on a site leads to reduced tree growth and survival (Davies 1987). In effect, weed competition reduces growth and vigour of young seedlings and often results in mortality. Thus, in order to establish a tree crop effectively, the rooting area of seedlings must be freed from competition until rooting is extensive and deep enough for the seedling to compete with weed vegetation. Maximum tree growth is obtained under weed-free conditions (Beaton and Hislop 2000), a contention supported by almost all the literature on the subject. However, maintaining weed-free conditions over the full site is prohibitively expensive. Furthermore, such an approach provides no cover for wildlife and the result is often andunsightly.

In practice weed control is carried out for the first two to three growing seasons after planting (Beaton and Hislop 2000, Lund-Høie 1984). Poorer sites and slower growing trees require a longer establishment time (Atchison and Ricke 1996) and hence competing vegetation may need to be controlled for a longer period. In Ireland,

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since the 1960s the operation has been predominately carried out using herbicides. Recently, however, certification initiatives and increasing public and industry awareness of the importance of environmental protection have led to concerns over the continued use of herbicides. It is therefore important to examine some potential alternatives for the Irish forestry situation.

Wagner and Zasada (1991) defined forest vegetation management, as the management of non-crop vegetation to achieve silvicultural objectives, using a variety of methods that are environmentally sound, economical, and socially acceptable. Although the ability to control unwanted vegetation has been the principal criterion for selecting particular vegetation management treatments, these are only silviculturally effective if they enhance the survival and growth of treated stands (Wagner 1993). On purely economic grounds, vegetation management can only be justified if the value gained from a treatment is greater than its discounted cost (Row 1987, Brodie and Walstead 1987).

Optimising vegetation management in young forest plantations entails finding the most effective time to reduce competing vegetation around the seedling (Wagner et al. 1996). This critical period is the time after planting when herbaceous vegetation must be controlled to avoid significant growth loss. Swanton and Weise (1991) identified this as an important component of integrated weed management for agriculture.

Wagner et al. (1996) also indicated that both timing and duration of herbaceous vegetation control are important to the growth of northern conifers. Weed infestation curves show that herbaceous vegetation can substantially decrease seedling diameter growth in the first year after growth. A study with Norway spruce (*Picea abies* L.) found that the greatest growth occurred when vegetation was controlled during site preparation, with substantial growth decreases occurring as the interval between planting and competition release increased (Lund-Høie 1984). Lauer et al (1993) found that herbaceous vegetation control applied in the first and second year after planting nearly doubled wood volume gains in loblolly pine (*Pinus taeda* L.) at age nine, relative to trees that had received vegetation control in the first year only.

Developing technology to control unwanted vegetation has been the focus of most research in forest vegetation management, with nearly all the work being done on herbicides (Wagner 1993). Their attraction is that they generally kill both sprouting and non-sprouting plants and are therefore effective in controlling many plant communities. They also give the best vegetation control relative to cost (McDonald and Fiddler 1993). In suppressing the undesirable plants, soil moisture and nutrients are made available to the roots of new tree seedlings.

Most new woodlands require weed control to enable trees to establish successfully and although research continues into alternatives, the use of herbicides is currently the only cost effective option in many situations (Willoughby and Claridge 2000).

In new plantations, treating competing vegetation when it is small, not yet fully established and still recovering from any damage incurred in site preparation is fundamental to a successful vegetation control programme (McDonald and Fiddler

1996). When carried out early, weed control treatments are also cost effective. However, one treatment per year all most budgets can afford, and in these circumstances competing plants take advantage and may reduce seedling growth (McDonald and Fiddler 1996).

Over the past few decades, the use of herbicides to manage forest vegetation has generated considerable public debate across North America (Wagner 1994). In one research paper Thomas et al. (2001) stated that in British Columbia there is a growing reluctance on the part of many land-owners and farmers to use herbicides because of the associated permits and training that are required before they can be applied. The recent certification initiative in Britain has confirmed this trend (Willoughby 1999). The Forest Stewardship Council has stated in its principles and criteria, that the aim of forest managers of certified forests, whether they be plantations or natural forest, should be to control disease, pest insects and animals, or unwanted, competing plants only when necessary and without the use of chemical pesticides such as fungicides, insecticides or herbicides (Upton and Bass 1996).

Potential alternatives to herbicides

Mowing

On sites where erosion is a problem, mowing may be an option between tree rows but it does little to reduce the competition for moisture and nutrients. According to Davies (1987), mowing of grass is positively detrimental to tree growth. He also found that in some un-mown grass swards the weeds often die back thereby creating a self-mulching effect in winter that gave the trees a good start the following season.

Mowing does reduce fuel build-up, rodent cover and makes the plantation more accessible for other management activities (Atchison and Ricke 1996) but it is primarily cosmetic.

Weed plant species compete with each another as well as newly-planted trees. Mowing can change the natural balance between weed species in favour of detrimental perennial grasses, which are resistant to cutting. However Willoughby and McDonald (1999) found that maintaining a 1 m wide weed-free strip around the trees, combined with mowing the inter-row to minimize weed seeding, was a cost-effective method of weed control. In their study on vegetation control for the establishment of ash (*Fraxinus excelsior*), Culleton et al. (1995) found that leaving an un-mown strip of grass between lines of ash was of benefit. They speculated that the trees, while profiting from the weed-free zone around them, were sheltered from the wind by the grass.

The conclusion is that mowing on its own is ineffective but combining it with another weed control method could have potential.

Cultivation

Cultivation is the tilling of the soil to provide a favourable environment for tree establishment and growth of plants or regeneration; and, where appropriate, to improve root anchorage for better wind-firmness. Methods include bedding, discing, moling, mounding, peat tunnelling, ploughing, ripping, scalping, scarifying and subsoiling (Paterson and Mason 1999). During the operation weeds are often cut below ground level, uprooted and left to desiccate, or they may be buried.

Cultivation can be vital in ensuring successful and cost-effective establishment. Ploughing before planting is relatively cheap and as well as providing initial weed control, it also improves the ease and quality of planting (Davies 1987). Mounding, used extensively in Ireland, provides the same function.

Cultivation is quite effective in the control of annual weeds, especially at the seeding stage. However this method may bring weed seeds to the surface where they can germinate so it is a better weed control method in countries with a Mediterranean climate where there is little or no summer rainfall. Seeds brought to the surface in summer will not germinate and uprooted weeds and rhizomes soon wither (Davies 1987). Otherwise, shallow cultivation is used to reduce the number of dormant seeds brought to the surface. During the growing season repeated tillage passes may be required as new weeds emerge. Shallow cultivation, not deeper than 7 or 8 cm, also avoids damaging small feeder roots near the surface.

Schuette et al. (1996) suggest that a combination of cultivation to remove the between-row vegetation and herbicide to maintain a weed-free band around the trees is a good way of controlling weeds. Cultivation as a means of controlling weeds is more effective on less fertile sites (Willoughby and Moffat 1996).

Mulching

Mulching (the spreading of material around desired trees to control competing vegetation) is used in agriculture and forestry throughout the world (Gupta 1991, McDonald and Helgerson 1990). It has been used in the western United States for the last thirty years. It provides a means to passively control vegetation and thereby reduce the need for mechanical and chemical weed control (Haywood 1999). Where labour for continual weeding is scarce, machines cannot operate, or the use of herbicides is restricted or not desirable, mulching may be an attractive alternative which can help to conserve soil moisture, improve water infiltration and reduce sedimentation (Walker and McLaughlin 1989, Gupta 1991).

In an agricultural context, mulching is one of the most environmentally benign strategies for weed control, reducing the need for tillage and herbicides, and avoiding associated problems (Feldman et al. 2000).

Although expensive in forestry applications, mulches have proven to be as biologically effective as other treatments (McDonald and Helgerson 1990). Willoughby (1999) estimated that in Britain plastic mulch installation would cost, on average, two and a half times as much per hectare than band spraying with herbicide.

Research has suggested that the use of mulch mats can reduce grass and herbaceous competition for water and improve the initial survival and growth of conifer seedlings. The mats are best applied in spring, soon after planting, before competing vegetation has had an opportunity to develop.

Waggoner et al. (1960) conducted an extensive study on the principles and benefits of polyethylene films. Their results indicated that black films had the least modifying effect on soil energy budgets and had a high ability to conserve soil moisture. The black film, by reducing light transmission, also exerted good control over unwanted vegetation compared to translucent plastic.

Parfitt and Stott (1984) compared the effect of black polyethylene and straw mulch covers with herbicides (which maintained bare ground conditions) on the establishment, growth and nutrition of poplar and willow cuttings. The polyethylene mulch significantly increased the number of shoots per cutting and the length of the longest willow shoot, when compared with straw mulch and herbicide treatments.

Temperature and moisture content under the mulches were higher than for the other treatments. In a previous study Bowersox and Ward (1970) also examined black polyethylene mulch as an alternative to mechanical cultivation in hybrid poplar establishment from dormant cuttings. They concluded that establishment success using black polyethylene mulch could equal or exceed that of mechanical cultivation. Similarly Blain (1984) set up an experiment to study the response of Salix and Populus cuttings to mulching with black polyethylene. The mulch improved shoot extension growth and suppressed weed growth, though occasional weeds appeared where the polyethylene had become torn around the base of the cuttings.

In a study in Canada (VMAP 1994), results indicated that hardwood seedlings treated with brush blanket mulches grew as well as seedlings treated annually with Vision or Simazine herbicide sprays and better than seedlings that received no vegetation control.

Harper et al. (1998) established a trial to compare the effectiveness of the herbicides glyphosate and hexazinone with plastic mulch mat treatments in reducing grass competition and improving Douglas fir seedling performance. They found that pre-plant herbicide application was effective for at least three growing seasons for perennial grasses and that Douglas fir seedling growth and survival improved. Post-planting spot application resulted in a high (65%) seedling mortality rate during the first year even when seedlings were protected. Mat sizes of 1.2 x 1.2 m were found to reduce competing vegetation ground cover for five years.

McDonald and Fiddler (1996) demonstrated that a vigorously sprouting shrub species could be killed with a sheet-type mulch. They tested large and small mulch mats and their efficacy in suppressing non-crop vegetation and enhancing conifer growth. Conclusions reached were that mulching showed promise for application in almost all plant communities, including those with plants that originate from sprouts and rhizomes, with larger mats being especially effective. A durable mulch that persists for several years has obvious benefits for seedling growth. In areas having a high density of widely spaced seedlings surrounded by dense, tall competition, having a visible mulch would be beneficial for evaluating seedling growth and survival. McDonald and Fiddler (1996) also concluded that pore structure is of the mulch important, and ideally it should allow water to percolate downwards but restricting upward movement. This was borne out by Feldman et al. (2000) in their experiment in an agricultural situation where landscape fabric, which is permeable to water, was preferable to polyethylene film.

Although the microclimatic effects of various mulch materials on soil, air temperature and soil moisture have been investigated (McDonald and Helgerson 1990), there is a limited understanding of the relation between mulch area and the growth and survival responses of trees. Increasing growth appears to require a larger diameter mulch than for survival. Thomas et al. (2001) found that 60x60 cm mats only increase tree growth during the first year with no measurable effects in successive years. They concluded that the result was most likely due to the small mat size and postulated that perhaps a larger mat may have prolonged the growth response. Willoughby (1999) included 1x1 m mulch mats in his investigation into reducing herbicide inputs in British forestry and drew the same conclusions with respect to the mat size.

Many types of mulch are marketed but few may actually meet enough of the criteria outlined to be useful. According to McDonald and Helgerson (1990) the ideal silvicultural mulch mat should be opaque, dark, permit water infiltration, retard evaporative water loss, supportive of favourable soil temperatures, sufficiently strong and durable to last until seedlings are established, low in cost and lightweight, non-toxic and of a colour that blends into the landscape. Other factors could include biodegradability and unattractiveness to animals. The authors also indicate that understanding: 1. site conditions, 2. vegetation type, 3. mulch material and 4. combinations of these factors, as the important features of refining mulch technology. Technological advancements in mulch material that increase effectiveness, durability and size while decreasing weight and application costs will improve the attractiveness of this method.

Haywood and Youngquist (1991) investigated plant fibre and plant fibre-polyester mats placed round the root collar of newly planted loblolly pine seedlings and over a cover of grasses, forbs and blackberries. The small sample sizes precluded the detection of any positive response to the mats but it was concluded that the negative effects of the mats on the seedlings were minimal.

Haywood (1999) established two studies to determine the ability of a large selection of mulches to remain intact and in place under field conditions (durability), control weeds, and influence the growth of loblolly pine (*Pinus taeda*) seedlings. Among the mulches tested were jute, pine straw, cellulose, polypropylene and polyethylene. As weather can influence the durability of a mulch, meteorological data were collected. Note was taken of installation difficulties for the various mats as this could be a serious obstacle to their continued use. Pine seedling measurements and weed cover estimations were carried out and mulch durability estimated visually over three growing seasons. In most cases mulches eliminated the established cover and germinants and vegetation did not readily re-establish after the deterioration of a mulch. After three growing seasons, the loblolly pine seedlings grew better where mulches were used.

Adams et al. (1997) examined three alternative weed control strategies in blue oak (*Quercus douglasii*) seedling plantations in California. The effect of herbicides, porous plastic mats and impervious plastic mats were compared. No one strategy was superior, though all resulted in greater seedling survival compared with no weed control. The use of herbicides proved to be the most cost effective.

In a later paper Adams (2000) states that the use of synthetic mulch mats may be competitive with cheaper chemical sprays for weed control where use of natural resources is intensive rather than extensive. Intensive use imparts greater value and the protection, and enhancement of this value often warrants investment that could not be justified under extensive management where value per unit area is low. In addition, environmental and social considerations have a higher priority in areas of intensive use and they may be more easily accommodated. It was also estimated that as the primary benefit of landscape fabric is its durability, thus producing less solid waste, the higher initial expense of fabric compared to black plastic may be offset. Initial labour costs for the fabric mulch were higher than for a bare ground control and organic mulch but this was reversed in the following two years of the trial.

Fertilisers are sometimes necessary to improve tree growth, mostly because of nitrogen deficiency. Various formulations are used such as nitram, urea or the slow release compound Osmocote. When mulch mats are used for weed control, such top dressings may be difficult to apply. Appleton et al. (1990) stated that a feature of mulch mats is that they encourage rooting near the soil surface and that these surface roots, and therefore the trees, become damaged if soluble fertilisers are used beneath the mats. Armstrong and Moffat (1996) began an investigation into the benefits of slow release nitrogen fertiliser compared with conventional formulations on recently planted trees. They examined the effect of mulch mats on fertiliser response and the effect of weed control method on ammonia release from applied urea. They concluded that mulch mats presented few problems for fertiliser applied during the dormant season, but issues such as lifting and replacing the mats during application needed to be considered. No evidence was found that release of ammonia from urea applied at recommended rates reduced tree growth. In fact mulch mats appeared to reduce the loss of nitrogen by volatilisation where urea was applied.

Organic mulches, especially those derived from waste products may in economic, environmental and aesthetic terms be a more favourable option than inorganic products. Froment et al. (2000) reported results of an experiment in which the effectiveness of four organic mulches (farmyard manure, compost, chopped straw and wood chips) applied at two depths was compared with a herbicide treated control. Results showed that all mulch treatments resulted in greater height and stem diameter increment compared with the herbicide treated control. Persistence of the mulches was assessed by comparing mulch depth at the start and end of the growing season. Farmyard manure was the least, and compost the most persistent. Straw and woodchip mulches gave the best weed control but height and stem diameter increments were less than for farmyard manure and household compost.

Smith et al. (2000) used a wood chip mulch (obtained from cleared right of ways) on pecan (*Carya illinoinensis*) seedlings. The chips were stockpiled for three months prior to being applied to a depth of 30 cm. Pecan harvesters sweep the ground so the mulch must deteriorate by the time the trees begin bearing nuts. The wood chipmulch treatments were in factorial combination with two rates of nitrogen, applied as either a single application at budbreak or again three weeks later. Foliar nitrogen concentration during the third year was positively related to mulch width as were stem diameter and tree height.

Lo et al. (2000) carried out a mulching trial in a hybrid poplar plantation using waste fibre from a paper mill. Analysis of the residue showed them to be mainly waste fibre and lime with few contaminants that could pose hazardous to the environment. Weed biomass data showed that weed cover was in the range 9-19%, which represented 80-90% weed suppression, compared with controls. The data also showed that the mulch was largely mineralised and lost its effectiveness as a weed suppressant after the fourth growing season.

Iles and Dosmann (1999) evaluated and compared the effects of five mineral (crushed red brick, pea-gravel, lava rock, carmel rock and river rock) and three organic mulches (finely screened pine bark, pine wood chips and shredded hardwood bark) on soil properties and on the growth of red maple (*Acer rubrum*). The authors concluded that the mineral mulches used in the trial did not create growth-limiting soil environments.

Pickering and Shepherd (2000) undertook a study to investigate nutrient content and nutrient release characteristics of six organic landscape mulches (cocoa shells, coarse conifer bark chips, wood chips, garden compost, horse manure and finely ground conifer bark). Comparisons were made with black polythene mulch and a bare ground control. The mulches were put in place and left for a twelve month period, after which they were removed and the plots sown with agricultural mustard (*Sinapsis alba*). Soil analysis was carried out at the beginning and end of the experiment, fresh and dry masses of the mustard crop were determined and their nutrient contents assessed. It was found that horse manure, garden compost and cocoa shell mulches with low C:N ratios and high potassium content resulted in significant increases in soil nutrients and supported the highest yields. After twelve months there was no evidence of nitrogen immobilisation or growth suppression under wood or bark-based mulches.

Samyn and De Vos (2002) published results of a trial in Flanders, Belgium where the use of mulch sheets made from 100% recycled waste (Ecopla sheets comprised of paper mill sludge 45%, compost (fruit, vegetable and garden waste) 45% and recycled paper or textile fibres 10%) was investigated. along with a number of other treatments. Results showed that the sheet mulches increased the relative growth rate of all species planted in pasture.

A number of experiments have shown that tree growth response often lags suppression of competing vegetation by one or more years. Lanini and Radosevich (1986) attributed the delayed response in conifers to the cyclic nature of their growth, where the current season's growth is partially dependent on carbohydrate produced the year before. It appears that the lag period between resource increase and concomitant increase in growth is species dependant. Flint and Childs (1986) also found that first year growth data did not show statistical differences among treatments and attributed it to a combination of nursery conditions and transplanting stresses on first year out-planted seedlings. This factor would have to be considered in any studies undertaken.

From the literature, it can be seen, that the interaction of factors involved in the response of trees to mulches is extremely complex. These considerations should be taken into account when choosing a mulch. However the variety and choice of materials available, means that growers can choose a mulch most suited to their circumstances while taking into account the material and maintenance cost.

Ground-cover plants

Establishment of ground-cover plants to prevent noxious weed invasion and provide only minimal competition with the tree crop has been suggested as a potential method of controlling weeds in young plantations. During tree establishment perennial broadleaved ground-cover plants are possible alternatives to mulch, provided the cover can be maintained. Clover (*Trifolium* spp.) and lucerne (*Medicago sativa*) are plants that may be used effectively under certain conditions. (Beaton and Hislop 2000).

Experiments in the United Kingdom on ex-agricultural land have shown the value of sowing ground-cover at planting (Williamson 1992, Williamson et al. 1992, Willoughby and McDonald 1999). The sown ground-cover out- competes and suppresses the growth of invasive weeds and thus confines herbicide use to maintaining a 1 m wide, weed-free band along the planting lines.

It is generally acknowledged that the control of weeds in forestry need not extend over the total site area for trees to survive and grow. Maintaining either a 1 m^2 spot round the base of each seedling or a 1 m wide strip along the row will often be adequate (Williamson 1992, Davies 1987, Willoughby and Dewar 1995). The 1 m^2 spot can be maintained with a hand-held, ground based applicator. Strip weeding allows mechanisation with the adaptation of agricultural spraying equipment. there is an open area of ground where weeds would proliferate if left unmanaged.

Williamson (1992) suggests two approaches to maintain good weed control to promote rapid tree establishment and managing the ground flora in the inter-row.

1. The vegetation round the planted trees is controlled and the vegetation naturally develops on the area between the weed-free areas. This then should be mowed regularly in order to prevent it seeding and becoming a problem.
2. Weed control around the planted trees is imposed as before and a ground cover crop is sown in the inter-row.

Williamson et al. (1992) reported the results of an experiment on the effect on tree growth of five inter-row management regimes on - Corsican pine (*Pinus nigra*) and Norway maple (*Acer platanoides*). After two growing seasons the strip-weed-and-mow combination was the cheapest and most practical option for establishing trees. Willoughby and McDonald (1999) reported on the same experiment at the end of four growing seasons and found the same result. One treatment, sowing kale (*Brassica oleracea* var. *viridis*) in the inter-row resulted in tree growth similar to strip-weed-and-mow, though tree growth was not as good as in the bare ground plots. The kale offered some competition but its main period of growth is in June, whereas the trees began their growth in May, before the kale plots had begun to grow. Once sown, kale requires very little management and is provides food and cover for game birds for about three years. It forms a tall, dense canopy and effectively prevents most weeds from establishing.

Coates et al. (1993) studied the efficacy of various grass/legume mixtures in controlling competing vegetation and their effect on survival and growth of Sitka spruce (*Picea sitchensis*) seedlings on a coastal alluvial site in northwestern British Columbia. Legume or grass seeding reduced two out of four major competitors compared to the unseeded control, even though some grasses may provide more severe early competition than native species. It was felt however that the long-term competition effects of one of the native species were likely to be the greatest threat to Sitka spruce performance.

Seeding of clover (*Trifolium repens*) ground-cover was one of number of weed control methods employed by Ferm et al. (1994) to aid in the establishment of a birch plantation. However, vole damage and bark necrosis were associated with a high percentage of clover ground-cover. They found also that the clover did not reduce root competition as effectively as the best herbicides.

Hanninen (1998) compared seven clover species with cultivation and grass sod to determine their influence on birch growth in a nursery field. Contrary to Ferm et al. (1994) damage by voles and other pests was not a problem. It was concluded that annual clovers could have potential as ground-cover. They suppress weed growth during the summer without seeming to compete too much with the trees. During the winter they form a paper-like mat on the ground and delay weed germination in early summer. The one disadvantage was having to sow annually. However herbicide use could be minimised.

Several criteria should be considered when choosing legumes such as clover for ground-cover in young plantations (Ponder 1994). Those that are used must grow well with minimal site preparation. Early benefits of leguminous ground-cover may decline later on because it will normally be shaded-out as the forest develops. However, enough seed may be stored in the soil to allow the legumes to re-establish themselves when the stand is thinned or harvested.

In Britain there has been some research carried out on the practicality of establishing ground-cover through which the trees could be planted directly, without the need for weed-free strips to be maintained. Whereas Hanninen (1998) deemed clovers as non-competitive, Davies (1987) regarded them as highly competitive under UK conditions. Willoughby (1999) published the results of two experiments which investigated the use of nineteen alternative ground cover and silvicultural treatments for newly planted ash (*Fraxinus excelsior*) and Douglas fir (*Pseudotsuga menziesii*) established on fertile ex-agricultural land. He found that most ground-cover was difficult to establish and was more competitive to the trees than naturally occurring vegetation. White clover did show some potential for suppressing weed competition without reducing tree growth.

Conclusion

Although vegetation management is most often directed at reducing competition by removing or suppressing forest weeds, it is important to consider the potential role of non-crop vegetation in the forest ecosystem. Walstad et al. (1987) identified the beneficial aspects of non-crop vegetation that should be considered in arriving at vegetation management prescriptions for conifers:

1. preventing soil erosion on disturbed or unstable sites,
2. uptake, storage and recycling of nutrients that might otherwise be lost from the ecosystem,
3. improvement of soil physical and chemical properties through the addition of organic matter and nutrients,
4. improvement of excessively hot, dry, or cold microclimatic conditions through shade or mulching effects,
5. protection of tree seedlings from browsing animals,
6. reduction or elimination of disease.

These benefits probably apply equally as well in the case of broadleaves.

Good vegetation management seeks to optimise the balance between the positive and negative effects of non-crop vegetation within the context of silvicultural objectives. Broadcast elimination of all vegetation (bare ground) for extended periods of time is rarely desirable or affordable in most situations (Wagner and Zasada 1991).

If the use of herbicides is not sustainable then alternatives must be sought. Research needs to begin well before they are phased-out otherwise it will have little value. If the research is has not been done and feasible alternatives demonstrated then forest scientists have failed to meet their client's needs (Wagner 1993).

Unfortunately, feasible alternatives to herbicides do not currently exist for forest establishment in Ireland. Abrupt reductions in herbicide use, without the knowledge or technology to implement alternatives, will severely threaten our ability to protect the new forest and meet further wood supply demands (Mc Carthy 2001).

The systems outlined may constitute some viable alternatives to the use of herbicides in Ireland. In the final analysis however, the material and and maintenance costs of these alternatives will most probably dictate which will be used. It this regard is of the utmost importance to clearly define the objectives and constraints in establishing new forests. Taking these into account the most appropriate vegetation management approach can be chosen options will be possible.

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Farm forestry in Ireland

Jasmina Behan[a] and Kieran McQuinn[b]

Abstract
Irish afforestation rates have continuously fallen short of targets set out in national policy objective statements. In this study we develop a panel data econometric model to analyse on-farm afforestation and to provide projections of future national planting rates. We do so by utilising the existing FAPRI-Ireland modelling framework and assuming two policy scenarios for the future. First, we generate projections assuming no change in agricultural and forestry policy will take place over the projection period. Second, we examine how the projections of farm forestry change if existing policy is amended to account for more extensive production practices in the beef and sheep sectors.

Keywords: Farm forestry, panel data model, agricultural policy.

Introduction
Forestry has been identified as playing an important role in the economic development of rural areas, as well as the protection of the environment (An Foras Talúntais 1978). With climatic conditions conducive for tree growth Ireland could be largely covered by forests. However, currently only 10% of the total land area is classified as woodland, placing Ireland on the lower end of the EU ranking of forest cover. In its strategic plan for forestry (Department of Agriculture, Rural Development and Forestry 1996) the government sets out an objective of increasing forest cover to 17% by 2030. This is to be achieved by annual afforestation rates of 20,000 ha, with the emphasis on private planting, in particular by farmers. However, to date planting rates have been consistently below the target. This study aims to explain the evolution of farm forestry in the context of competition between forestry and traditional agricultural enterprises. This is done by the development of an econometric model, which is then used to generate projections of future farm afforestation.

The paper begins by discussing the policy environment in which farmers operate. This is followed by a brief review of previous models of Irish forestry. An econometric model is then specified, which addresses the issue of farmer planting in the light of competition between forestry and traditional agriculture. The next section contains the results of the econometric analysis and the projections of on-farm afforestation rates under two different policy scenarios. The first set of projections is based on the assumption that current EU Common Agricultural Policy (CAP) policy framework remains unchanged for the projection period. This is accompanied by a

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set of projections under an assumed change in CAP measures governing extensification practices in the livestock sectors. In addition, more recent policy developments such as the medium term review (MTR) of the CAP are also discussed. A final section offers some conclusions.

The policy environment

For decades, there has been a continuous increase in forest cover in Ireland. However, cover increased at only a modest average rate of 5,000 ha per annum (Figure 1) over the period 1920 to 1980, when forest cover increased from 1.5 to 5%. Moreover, until the mid 1980s planting had been almost exclusively undertaken by the state. From the mid 1980s government decided to shift the emphasis from state to private afforestation. Consequently, state afforestation has declined over the past decade and the likelihood is that it will remain at a negligible level into the future. Since the mid-1980s, therefore, private afforestation has been the main contributor to the increase in forest cover. In addition, farmers have become the key driver for forestry expansion in recent years, they currently account for 93% of private afforestation. However, despite the financial incentives on offer at a national level, the uptake by farmers has not been sufficient to meet the national target of 20,000 ha per annum. In this section we review the incentives available to farmers under both forestry and agricultural policy.

As stated, it was not until the 1980s that private afforestation began to feature as a contributor to the increase in national forest cover. At that time, the government adopted a more determined approach to improve the position of private forestry in Ireland, enhanced by funds provided for forestry by the then EEC (the Western Package launched in 1981, and followed by Regulation 297/85). It was recognized that forestry should be promoted as a profit generating economic activity, which had an important role in rural development, employment, as well as the protection of the environment. Furthermore, it was considered that farmers should have a central role

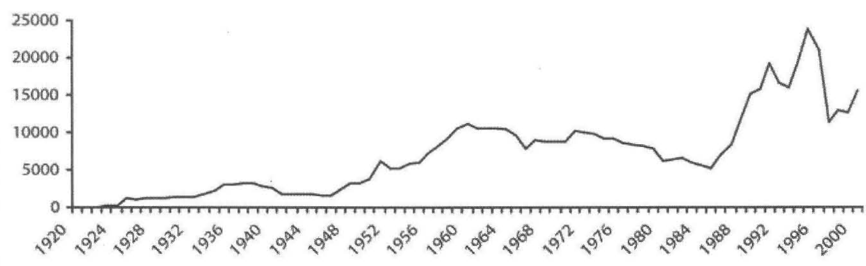

***Figure 1**. Annual afforestation over the period 1920–2003.*

Table 1. *Historical development of grant and annual premium payments for 20% diverse conifer plantings (or equivalent) on enclosed land.*

	Grant		***Premium***	
Year	***£/ha***	***€/ha***	***£/ha***	***€/ha***
1981	800	630		
1985	800	630	74[1]	94
1989	1,100	1,397	86	109
1992			100	127
1994	1,500	1,905	225	286
1998	1,800	2,286	270	343
2000	2,250	2,857	308	391

Source: Afforestation Grant and Premium Schemes, Forest Service, Department of the Marine and Natural Resources – various years.

[1] Paid as a compensatory payment (£30/acre) to only those farmers who were in receipt of headage payments for land which was afforested under the scheme (Connelly 2004).

in forestry development. In that light, the government has since 1986 been introducing a series of financial incentives to farmers to consider forestry as an alternative farm enterprise. The evolution of available grant and premium payments introduced nationally is presented in Table 1.

Significant increases in afforestation by farmers occurred after the introduction of headage[1] payments in 1986. For the first time farmers who were in receipt of headage payments were compensated on an annual basis for moving out of traditional farming into forestry. The approach of providing direct income support to farmers who undertook farm forestry was further developed by the introduction of annual forestry premium payments in 1989. Further promotion of forestry was implemented in 1992 under the CAP reform and EC Regulation 2080/92, when there was another increase in forestry grants and premium payments. These were followed by more increases in 1994, 1998 and 2000.

Grant payments vary depending on the species planted and the quality of land afforested. Table 1 presents payments for the most representative plantation, defined as a 20 percent diverse conifer plantation on enclosed land (Forest Service, Department of Marine and Natural Resources, Department of Agriculture and Food (from 1 January 2004)). The current afforestation scheme (grant and premium

[1] Headage payments are made to agricultural producers who farm in areas designated as 'disadvantaged'. They are paid per animal farmed, and vary depending on the whether the area is defined as less or more disadvantaged.

payments) is applicable only on agricultural land suitable for forestry. The forestry grant is paid in two instalments. The first instalment is paid the first year after the plantation is established and amounts to 75% of the total grant. The remaining 25 percent is paid after four years, when the plantation is assessed and a decision is made as to whether it complies with Forest Service[2] standards in terms of stocking levels, fencing, drainage, etc. The premium is paid to farmers annually, for 20 years (Forest Service, Department of Marine Natural Resources). A farmer in this instance is defined as a person who derives 25% or more of his/her income from farming. The premium is not paid for reforestation. There are additional schemes, which the farmer-forester can avail of over the life of the crop, such as road construction grants, reconstitution of woodlands scheme, etc.

Although there appears to have been a considerable increase in forestry incentives, economic returns from forestry must be placed in the context of existing agricultural policy. This is particularly important given the degree to which the agricultural sector is subsidised. Traditionally, the CAP supported farmer incomes through guaranteed higher prices. The McSharry reform of the CAP in 1992 witnessed a significant philosophical change in the nature of income support measures used within the EU. Direct payments were introduced and subsequently increased under the Agenda 2000 CAP reforms in 1999, while support prices were simultaneously reduced. From 1993, farmers producing livestock and crops were eligible for various premium payments. For livestock producers these include: suckler cow premium, special beef premium, slaughter premium, ewe premium, rural world premium, headage payment and extensification premium. The introduction of the extensification premium has particularly important implications for farm forestry. In order to qualify for this payment, farmers are required to adhere to specified livestock density limits. Most of these payments are on a per hectare basis and are conditional on the producer engaging in livestock or arable production. Consequently, they increase the marginal product of land remaining in these enterprises relative to alternative enterprises such as forestry. Furthermore, farmers can join the Rural Environment Protection Scheme (REPS), which currently does not allow participation in forestry. Thus, the implication for farm forestry of existing agricultural policy as well as market developments must be examined.

Modelling Irish afforestation rates

In terms of farm forestry Ireland is unusual relative to other EU countries in that land has only been privately afforested (first time planted) at significant levels since the mid-1980s. This is allied to the fact that the country still has a low forest cover. The expansion of forestry implies changes in land use and specifically in this case it implies a contraction of land going to traditional agriculture activities. Potential change in land use is also complicated by cultural and historical factors. There is a

[2] The Irish Forest Service is based within the Department of Agriculture and Food (formerly based in the Department of Marine and Natural Resources) and is responsible for the administration of all government grants and premiums in the forest sector.

relatively small area of mature private forests and hence, the predominance of afforestation over reforestation is a feature. This distinguishes Ireland from what is the norm in many European countries. In Ireland, the first clearfell of farmer-owned forests supported under the arrangements since the mid 1980s is expected to occur beyond 2020; only then will reforestation arise as a major issue.

Studies that deal with the issue of Irish farm forestry and its expansion can be divided into either qualitative or quantitative approaches. Qualitative studies are primarily concerned with revealing farmers' attitude to forestry. In general, their findings suggest that Irish farmers are reluctant to plant their land (Ni Dhubháin and Gardiner 1994, Frawley and Leavy 2001). Gillmor (1998) summarises the factors behind the lack of interest in farm forestry as follows: the insufficient information about forestry and financial benefits, historical reasons, competition for land with agriculture, agricultural subsidies, costs and risks associated with forestry and long-term nature of forestry investment. Data from the Irish National Farm Survey in 2000 (see Burke and Roche (2000) for more details) conducted on 1106 farms around the country indicates that only 6% percent of farmers had planted trees. This reinforces earlier findings that despite the financial incentives available, farmers are reluctant to transfer land from existing agriculture into forestry.

Quantitative studies seek to identify the factors behind private forestry planting by means of econometric analysis. They try to explain the pattern exhibited by private planting using relevant economic, forestry and agricultural factors as determining variables in regression analysis (Kula and McKillop 1988, Barrett and Trace 1999, McCarthy et al. 2002). The key findings in these studies are summarised in Table 2. Most conclude that forestry premiums and grants are highly significant in the decision to plant trees. However, of the three studies only McCarthy et al. (2002) has sought to incorporate agricultural policy levers as well as agricultural market returns.

***Table 2**. Factors found to influence the rate of private afforestation.*

	Study	
Kula and McKillop (1988)	***Barrett and Trace (1998)***	***McCarthy et al. (2002)***
	y_{t-} private planting (ha)$_t$	
grant $_{(t-i;\ I=0-5)}^{1\ ***}$	*forestry premium* $_t$	*forestry grant* $_t$***
timber price $_{(t-i;\ I=0-5)}$***	*agricultural subsidies* $_t$	*forestry premium* $_t$***
land price $_{(t-i;\ i=0-5)}$***	*forestry land price* $_t$	*forestry return* $_t$***
agricultural product price $_{(t-i;\ I=0-5)}$***	*accompanying measures* $_t$	*agricultural return* $_t$
income from alternative $_{(t-i;\ i=0-5)}$		*REPS area* $_t$***
interest rate $_{(t-i;\ i=0-5)}$		
tax $_{(t-i;\ i=0-5)}$		

[1] *t-i; i=0-5, where i 0-5 refers to lags used in the regression*

**** significant at the p ≤0.001 level*

Study objectives

The objective of the present study was to develop a model, which would explain the planting patterns exhibited by farmers by explicitly addressing the competition for land between forestry and traditional farming. The model can then be used to generate projections of future planting rates in Ireland. It is designed as an extension to the existing FAPRI-Ireland model. The FAPRI-Ireland model of the Irish agricultural sector is a joint effort of the Food and Agriculture Policy Research Institute (FAPRI) at the University of Missouri, Columbia and Teagasc[3]. It is a dynamic, partial equilibrium model consisting of 200 econometrically estimated equations (for more on the model see Binfield et al. 2000). It compiles a series of interlinking commodity models for the Irish beef, sheep, dairy, crops and inputs sectors. Since 1998 the model has been used to generate an annual series of projections referred to as a 'baseline' result. This result serves as a benchmark, as it represents the projection of key agricultural variables in the absence of any policy change i.e. the present policy climate is held constant for the duration of the projection period. The original FAPRI-Ireland model, which included a land share system for traditional agricultural enterprises, such as cereals and livestock, is now expanded to allow for agricultural land to move into forestry.

Methods

A panel data approach

Over the last decade the proportion of farmers contributing to private planting rates has been continuously increasing. It is expected that for the foreseeable future almost all afforestation in Ireland will be conducted by farmers. In order to project forest cover in the future it is necessary to identify the relationship between planting conducted by farmers and the factors determining it. Hence, our data comprises of private planting conducted by farmers only.

The sample commences in 1986, when private planting first began to feature to a significant extent in national afforestation. While an EU Agricultural Development Programme for the West of Ireland (the Western Package), which provided grant aid for forestry, was introduced in 1981, private planting by agricultural producers did not reach a significant level until the mid 1980s (Figure 2). In 1986, in addition to the Western Package promotion, measures were introduced for the first time to compensate farmers who moved out of traditional livestock production into farm forestry. From this point on, particularly in the western regions of the country, the expansion of farm forestry becomes evident. However, data on farmer planting are only available from 1990 onwards.

Gillmor (1998) states that in the mid-1980s farmers constituted 20 percent of total private plantings. For the four missing observations in the period 1986-1989, it is

[3] The Irish Agriculture and Food Development Agency.

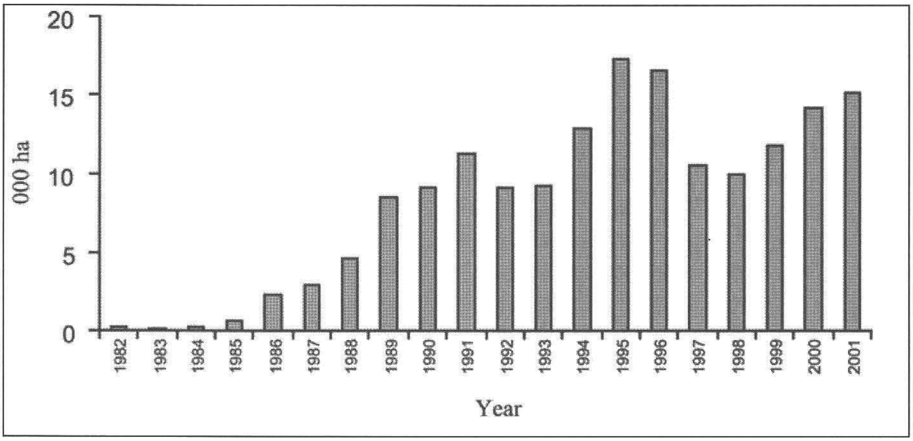

Figure 2. *Private afforestation in Ireland 1982-2001 (Forest Service 2002).*

assumed that the proportion of farmers in private planting steadily increased from 20 to 45 percent.[4]

In the analysis, Ireland was divided into five regions[5] to capture geographical differences, as well as the differences in agricultural production systems between regions. The division follows the categorisation commonly used by the Irish Central Statistics Office (CSO).

The following assumptions were made in the model:

1. most of the planting is of Sitka spruce, which is assumed to grow at yield class 20 m^3 ha^{-1} yr^{-1} (maximum mean annual commercial wood volume production) over a 40-year rotation (used as a reference for discounting),
2. uniform yields from forestry exist across regions
3. the farmer's discount rate is 5%
4. the farmer is a profit maximiser
5. the farmer qualifies for all CAP payments
6. the farmer can earn a minimum wage from an off-farm job.

Current afforestation rates across regions were modelled as a function of a 'returns ratio', which captures the ratio of forestry returns to agricultural returns. It is defined later in the paper. The relationship between the two variables is hypothesised to be positive. An increase in the returns ratio, which is brought about either by an increase in returns from forestry or/and by a decline in agricultural returns, is expected to lead to higher planting rates. It is also likely that the current planting rates of producers are affected by past rates. Producers are likely to be

[4] This issue was discussed through private communication with Professor Des Gillmor at Trinity College Dublin. Rates for 1987, 1988 and 1989 are assumed to be 30, 40 and 45% respectively.

[5] The regions are: the mid-east, the north-west, the west, the south-west and the south-east. The counties in each region are summarised in Table A.1 of the Appendix to the paper.

variable costs. Revenues included both the market revenue and total subsidies provided under both national agricultural policy and the CAP. Costs comprised costs of production, as well as the opportunity cost of labour. The opportunity cost was included to account for the fact that forestry is less labour intensive than farming, and allows for an additional income from off-farm employment. The opportunity cost was calculated by applying the minimum wage rate per hour to the hours spent in farming in excess of those needed for forestry. [6]

The DAR variables were also regionally adjusted. The adjustment was made for both extensification and headage payments. This was done according to the proportion of the national amount of these payments allocatable to each region. For instance, the greatest proportion of extensification payments have been allocated to the western regions of the country, where the average stocking density is below the national average, thus entitling the region to a larger share of the national payment. These regions have also been the main recipients of headage payments, since a higher proportion qualifies as disadvantaged. Both livestock densities and cereal yields were allowed to vary regionally.

Finally, a regional adjustment was also made in the calculation of REPS payments. The adjustment was based on the proportion each region represented of national REPS payments. The greatest participation in REPS was recorded in western regions of the country, and this is reflected in the adjustment.

Results

Returns ratio

The time series for the different regional returns ratios is presented in Figure 3. The key factors that affected the returns variable were the forestry premium, timber prices

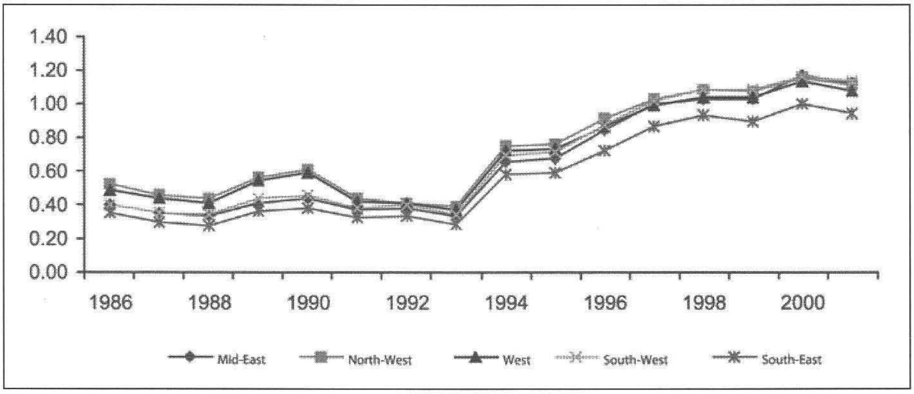

Figure 3*. Returns ratio between forestry and competing enterprises for five regions over the period 1986-2001 (a value greater than 1 indicates forestry is more favourable).*

[6] The amount of hours deemed necessary was taken from the Teagasc Management Data for Farm Planning (1997).

and the adult cattle price. For instance, a 10% increase in adult cattle value can lead to up to a 12% decline in the returns ratio, ceteris paribus. On the other hand, an increase in the forestry premium of 10% can lead to a 7% increase in the returns ratio.

The first increase in the returns ratio for all regions was in 1989, when the forestry premium was introduced and cattle prices declined after several years of an upward trend. The ratio declined in the period 1991-1993 due to an increase in cattle prices at that time. This outweighed the 16% increase in the forestry premium introduced in 1992. In 1994, a 155% increase in the forestry premium led to a sharp upward shift in the returns ratio. The occurrence of BSE resulted in cattle price declines over the period 1994-1998, which were reflected in the steady increase in the returns ratio during this period. The post-BSE recovery of the cattle price, led to a decline in the returns ratio, despite efforts to maintain the competitiveness of forestry through the 1998 increase in the forestry premium. Following the second BSE scare in 2000 and a further increase in the forestry premium, forestry regained its competitiveness in 2000, which is again reflected in the higher returns ratio.

Afforestation level and returns ratio equation

The relationship between the afforestation levels across regions and the associated returns ratio as specified by equation (1) was econometrically estimated. The estimates of the intercept and slope coefficients (as and bs) were obtained using a fixed effects panel data estimation technique. Panel data analysis was used to avoid small sample size bias, which would arise with the single equation Ordinary Least Square estimation procedure. Panel estimation utilizes the information from the entire data set, which comprises of five cross-section elements (regions), each with 15 observations. The region-specific characteristics in terms of land quality and the prevalent production systems were accounted for by the use of a fixed effects panel data estimation technique. Hence, regional dummies for the intercept term are included in the estimation.

Table 3. *Estimated values of the coefficients of the afforestation level equation1 and their corresponding significance levels.*

Coefficient	***Estimate***	***Probability > t***
α	-0.10	-0.390
d1	0.13***	0.000
d2	0.37***	0.000
d3	0.52***	0.000
d4	0.31***	0.000
$\beta 1$	0.57***	0.000
$\beta 2$	0.83***	0.000

**** coefficient significant p $\leq$0.01 level*

[1] *Total sum of squares 77.04; number of observations 75 (15x5); standard error (σ) 0.51; variance ($\sigma 2$) 0.25; residual sum of squares 17.30 (R^2 0.78).*

affected by their previous planting experiences. This effect is modelled by including a lagged dependent variable in the model. All other factors that affect afforestation levels and that are not accounted for by the explanatory variables are captured in the residual term. The model was specified as a following panel data model for the five regions:

$$y_{i,t} = \alpha_i + \beta_1 y_{i,t-1} + \beta_2 x_{i,t} + \varepsilon_t \qquad (1)$$

where,
y – dependant variable: afforestation level (000 ha)
i – one of five regions observed across Ireland
t – time period from sample covering 1986-2001
x – explanatory variable: returns ratio
ε - residual.

The specification of the model was such that it allowed for the intercept to be region-specific. This ensured that geographical, as well as the production differences across regions were accounted for.

The returns ratio (RR) was constructed to capture the competition between forestry and agricultural returns. It was calculated for each region i and time period t, as the ratio of discounted forestry return (DFR) per hectare to discounted agricultural return (DAR) per hectare, plus REPS payments per hectare:

$$RR_{i,t} = \frac{DFR_{i,t}/ha}{DAR_{i,t}/ha + REPS_{i,t}/ha} \qquad (2)$$

The DFR variable was calculated as all revenues that arise from forestry over the rotation period minus costs, discounted at 5% rate. The revenues included premiums, revenue from thinnings and clearfelling. Thinning and clearfelling revenue were determined by applying a timber price index (McCarthy 2002) based on 2000 values to the rest of the sample period. Costs included maintenance and were estimated by applying the 2000 consumer price index (CPI) to the rest of the sample period. All other costs (plants, fencing, vegetation control, fertiliser, planting, ground preparation) were assumed to be covered by the forestry grant and were excluded from the calculations, since they cancelled each other out. Due to a lack of data on regional differences in yield across regions no adjustment was made for this factor in the model

The DAR variable was calculated as a weighted average of the discounted returns per hectare for dairy, cereal, suckler, other cattle and sheep enterprises. The areas under each enterprise were used as weights. In the case of livestock, the area was divided among enterprises according to the proportion each enterprise constituted in the national herd. This was determined by dividing the size of the herd/flock in question by the total national herd and flock. For this calculation both the national herd and the sheep flock were expressed in livestock units.

Each agricultural return was calculated as the difference between revenues and

The estimation results are presented in Table 3.

As hypothesised, the coefficients for both explanatory variables were positive and statistically significant at the $p \leq 0.01$ level. An increase in the returns ratio is estimated to have a positive effect on the up-take of farm forestry. In fact, the elasticity of planting, as derived from the estimated coefficient, suggests that a 1% increase in returns ratio increases the afforestation rate by 0.4%. Although the intercept was statistically insignificant, the differences across regions in terms of land quality and agricultural production were significant (d1, d2, d3 and d4). Overall, the results suggest that 78% of the variation in the afforestation rate is explained by the variations in the returns ratio and past planting rates (denoted as $y_{i,t-1}$ in equation 1).

In the next step, the equation of estimate (1) was used to generate projections of afforestation across regions. The coefficient β2 was applied to the future values of the returns ratio variable to generate projections of on-farm afforestation levels. All the information necessary for the calculation of the future values of the returns ratio variable was supplied by the FAPRI-Ireland model, which projects values for all of the agricultural variables used. Two sets of results – the baseline and a scenario result are presented.

Baseline afforestation projections

First, the projections of afforestation rates were generated assuming that current forestry and agricultural policy will remain constant over the projection period 2001-2010. Therefore, the forestry premium, as well as all agricultural subsidies, is expected to remain in the same form and at the same level for the coming years.

It is expected that afforestation rates will decline in the short run. This is due to the recovery of the beef sector from the second BSE crises experienced in 2000. Beef prices are expected to increase in the early part of the projection period, which will increase the relative profitability of the sector. Given the importance of the cattle sector in Irish agriculture, such developments will improve the overall returns from agriculture and negatively affect the returns ratio. Furthermore, the incentives to extensify agricultural practice increased under the 1999 Agenda 2000 CAP reforms are expected to act as an additional deterrent to farm forestry. In order to comply with the required livestock density limits and qualify for the extensification premium, farmers are expected to either reduce their herd size and/or increase the land area going to livestock production.

However, in the long run, on-farm forestry is expected to increase its competitiveness relative to farming. Beef prices, driven by the underlying trend of falling beef consumption, are expected to return to a long-term downward path. As a result, it is expected that in the second part of the projection period, afforestation rates will increase to approximately 13,000 ha per annum. However, this increase in afforestation by the end of the decade is not expected to reach the 2001 planting rate high. The projection of 13,000 ha per annum is also 7,000 ha below the target set by the national strategic plan.

The projections of farm forestry planting rates would increase, however, if the assumption governing the opportunity cost of labour were amended to include the *average industrial wage* as opposed to *the minimum wage* in the returns ratio. In this case, the opportunity cost of labour associated with farming would increase, which would improve the relative position of forestry compared to agriculture, and consequently lead to greater than originally projected afforestation levels.

Scenario projections

The baseline projections for farmer afforestation are presented in Figure 4.

Under the Agenda 2000 CAP reform, two extensification limits were introduced to influence the level and type of EU beef production. The basic concept behind extensification is to provide incentives for beef producers to hold fewer animals per hectare of land. Producers are compensated for the loss of receipts from these animals by the introduction of extensification payments, which are on a per animal basis. The payments introduced under the extensification scheme are conditional on the adherence of the producer to two different stocking density limits. In an Irish case, producers have the option to stock their farms at either less than 1.4 livestock unit (LU)/ha, or between 1.4 and 1.8 LU/ha. The lower the stocking density rate the higher the payment.

Under a scenario performed on the FAPRI-Ireland model (see Binfield et al. (2002) for more details), the two extensification limits of 1.4 and 1.8 LU/ha were reduced by 0.2 LU. Thus, the new limits for receipt of extensification payments were a stocking density level between 1.2 and 1.6 LU/ha and a stocking density of less than 1.2 LU/ha. By lowering the stocking density limits and increasing the associated payments, the aim of the scenario analysis was to quantify the reduction in beef animals likely to be associated with these new limits[7]. The results suggested a reduction in non-dairy cattle numbers of 274,000 head, which is approximately 5%

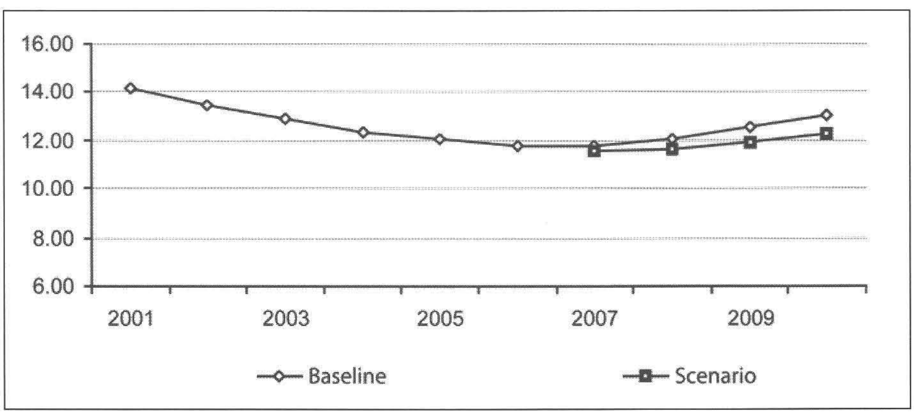

Figure 4*. Projections of farm afforestation over the period 2001-2012 assuming no policy change (Source: FAPRI-Ireland Model).*

[7] The scenario was initially devised in February 2002 as a possible CAP Mid-Term Review policy scenario.

over the period 2000-2010. Furthermore, the reduction in sheep numbers was estimated at 15% over the projection period.

The introduction of incentives to further extensify production has an adverse effect on on-farm afforestation levels. In order to reduce livestock density to the required limit and thus qualify for the payment, farmers are expected to further increase the land area used for animal production. As a result, relative to the baseline result, less land is expected to move into farm forestry, owing to the increased competitiveness of land remaining in livestock production. The impact of such a policy scenario on afforestation levels is quantified by our model and presented as the ancillary line in Figure 4. The recovery of afforestation rates in the long run is expected to be slower than projected under the baseline, with circa additional 1,000 ha/yr remaining in agriculture.

Mid-Term Review of the CAP and decoupling of direct payments

The June 2003 medium term review (MTR) of the CAP paves the way for the decoupling of all EU direct payments from 2005 onwards.[8] Producers will no longer be obligated to produce in order to receive the decoupled payment. The payment, which is based on a historical average of direct payments received by the producer over the 2000-2002 period, is guaranteed until 2013. Under the new CAP, greater emphasis is placed on the concept of 'cross-compliance'. Previously, cross-compliance was voluntary for Member States and applied to environmental standards only. Following the MTR, cross-compliance is now compulsory. Under cross-compliance the producer will be obliged to keep any land, not in production, in good agricultural condition. Crucially, farmers will be able to claim full decoupled payment along with forestry premium as long as they do not plant more than 50% of their land.

In terms of the present model set-up this complicates matters somewhat. Producers are assumed to allocate land between forestry and traditional agriculture on the basis of the relative returns per hectare. However, the land allocation decision now has to be decomposed between (i) agricultural producers who wish to continue to produce and those engaging in forestry and (ii) agricultural producers who do not wish to produce (but still get the decoupled payment) and those engaging in forestry. In the first case the relative returns are agricultural returns plus the decoupled payment versus forestry returns, while in the second case the relative returns are just the decoupled payment versus forestry returns. First, however, the decision of agricultural producers to produce or not must be modelled.

A recent study by Wiemers and Behan (2004) suggests that decoupling could have a positive effect on farm forestry.

[8] On 19/10/03, the Irish Government announced that all direct payments for cattle, sheep and arable crops would be fully decoupled from production as and from January 1, 2005. Full details of the MTR may be accessed online at: http://europa.eu.int/comm/agriculture/mtr/memo_en.pdf.

Conclusions

This paper provides an introduction to the forestry model, which has been added to the FAPRI-Ireland model of the Irish agricultural sector. The new expanded modelling system now has the capability to quantify the implications for farmer afforestation rates of changes in both agricultural policy and markets, as well as changes in the levels of forestry premiums and grants. This is particularly important given the clear implications for farm forestry in Ireland of any changes in the CAP.

The paper proposes a panel data econometric model to investigate the factors underlying farmers' afforestation decisions. The use of a panel data approach allows the model to incorporate differences across national regions in terms of afforestation behaviour. The greater level of information afforded by a panel data approach improves the efficiency and hence the reliability of the parameter estimates obtained. This is particularly important as the model is used to generate projections of likely future patterns of farm afforestation levels.

The projections show that afforestation rates are likely to decline in the short run, as the beef sector recovers from the 2000 BSE scare and livestock production is subject to greater incentives to extensify production practices. However, in the long run, forestry is expected to regain competitiveness vis-à-vis traditional agricultural enterprises for many producers. This is expected to be reflected in greater afforestation rates towards the end of this decade. The expected speed at which afforestation converges to the levels recorded in 2001 depends greatly on the policy environment. If no change in policy is assumed for the projection period, an annual rate of afforestation in excess of 13,000 ha can be expected by 2010. Any change in the forestry grant and/or premium payment would have a significant impact on future afforestation levels. Also, however, if agricultural policy is reformed to include further incentives to extensify livestock production, as defined in our policy scenario, then afforestation rates by the end of this decade are expected to be below the baseline projections and thus, even further from the national target of 20,000 ha per annum.

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Appendix

Table A.1. *County composition of regions.*

Region				
Mid-East	***North-West***	***West***	***South-West***	***South-East***
		County		
Dublin	*Longford*	*Clare*	*Cork*	*Carlow*
Kildare	*Leitrim*	*Galway*	*Kerry*	*Kilkenny*
Laois	*Sligo*	*Mayo*	*Limerick*	*Wexford*
Louth	*Cavan*	*Roscommon*		*Wicklow*
Meath	*Donegal*			*Tipperary*
Offaly	*Monaghan*			*Waterford*
Westmeath				

Forest Perspectives

The woodland vegetation of Ireland, past, present and future

John Feehan[a]

Setting the scene

In the middle of Clongawny bog in south Offaly where I live there are five islands, tree-clad oases surrounded on all sides by an ocean of deep peat. These are the tips of moraine hills the encroaching bog never quite overwhelmed. Many lesser summits still lie buried beneath the peat. About forty years ago the great machines of Bord na Móna moved onto Clongawny and began their slow work of laying the grid of drains that would rob the bog of its life blood, skinning away its vegetation: and then patiently shaving away the peat, centimetre by centimetre. The wooded islands remained as silent watchers. Every spring a carpet of anemones bloomed under the oaks as they had done for tens of centuries, and no eye came to worship or admire.

Gradually, over time, the sea of peat retreated from the islands as the work of harvesting proceeded apace, and then an amazing thing came to light. On the slopes all around the islands, once their shallower blanket of peat was removed, there emerged a forest of fossil pines that had been entombed by the growing bog, their stumps still rooted on the slopes where they were growing before the encroaching bog engulfed them unnumbered centuries ago.

It would be hard to find a more startlingly tangible and immediate demonstration that vegetation, the assemblage of plant communities, has a *history*. This history: the story of Ireland's changing vegetation, and of the shaping influence of humans, is chronicled in the pages of the pollen archive preserved in bogs and lakes. In the half century or so since Frank Mitchell published his inspiring Littleton pollen diagram (Mitchell 1965) the ever-expanding archives preserved for us and presented in the language of palynology chronicle that interplay between ourselves and the natural vegetation of the island. An outstanding example of that ever-growing precision of penetration and detail is a pollen diagram recently prepared by Michael O'Connell and his colleagues at the Palaeoenvironmental Research Unit in NUIG for an area in which the cumulative cultural impact on the forest over time could hardly be more dramatic: for this is Inis Oírr, and is perhaps the most detailed Irish pollen profile to date, with the full post-glacial time span of 11,500 years: from the end of Late-glacial to the end of the 20th century (O'Connell et al. 2005).

What we are seeing in these diagrams is in part a successional process, but not in an otherwise unchanging environment. Strongly superimposed on the succession to

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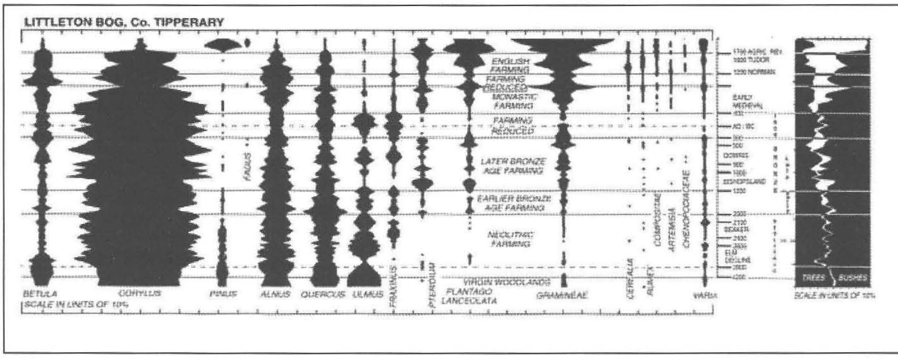

Figure 1. The Littleton pollen diagram (Mitchell 1965). The width of the black bands is proportional to the abundance of the various species in the sample. The width of the white strip on the right, sandwiched between the trees and bushes, corresponds to the extent of open land.

woodland that would have occurred anyway is the powerful shaping and directing influence of the changing climate that followed the Ice Age. And then, at first no more than a faint echo of approaching thunder if you like, the hand of man upon the forest.

Between the palynological runes of these diagrams we can delineate, as though in a parallel text, the uses of timber: we can hear not only the symphony of sound in vanished woods and use our ecological insight to conjure up the anemones and pine martens and bluebells, but hear the fall of the axe and see the explosion of primroses in the felled clearings: and (archaeology coming again to the assistance of imagination) the superstructure of timbercraft enmeshed in these ancient woods.

The drama of the human story through time has, since our arrival on the scene five million or so years ago, increasingly had an impact that is more immediately apparent. So the pattern of vegetation, and more specifically of woodland, was increasingly shaped by this impact, overlain upon the more fundamental shaping forces of geology and climate. When the pine forests of Clongawny were growing the adjacent clay soils beyond the reach of encroaching bog were farmland, in the case of Clongawny tilled and grazed at one time by the prosperous Bronze Age communities whose annual ritual offerings to the dark, revered waters on the edge of the bog grew to what archaeologists would in the course of time label the Dowris Hoard. There are no wooden artefacts in the Dowris Hoard, though we do find the bronze axes for felling and working the trees of the surrounding forests. I often think it is highly appropriate that one of the earliest archaeological finds in the midland bogs should have been a cache of tools belonging to a worker in wood (found in 1786): 'large wooden bowls, some only half made ... with the remains of turning tools; ... obviously the wreck of a workshop' (Commissioners for Bogs (1810-1814).

We sometimes think Ireland was a land of forest when the first people set foot here. Irish mythology contains hazy recollections of a distant, forgotten time when Ireland was covered by dense forest. The earliest name given to Ireland (by a scout of the people of Nin) was *Inis na bhfiodhbhadh*, Island of the Woods. When he landed – this, of course, is not history – the only place he found which was not forest was *Magh-n-ealta* (Moynalty). According to 'ancient record', Ireland was cleared of woodland and subsequently re-afforested three times: 'Three times Éire put three coverings and three barenesses off her' (Keating 1902). The picture of the first farmers landing on an empty island clothed in primeval forest is one which has survived for a long time. And until recently, even archaeologists did not see the Mesolithic eyes peering curiously out from between the trees.

Human communities were to be found throughout Ireland within a few centuries of the retreat of the glaciers, in other words long before woodland succession had reached its climax: and each of the succession of cultures that followed one after the other in Irish prehistory was bound to the woods by *need*. Timber was absolutely central to their essentially self-sufficient rural economy. A minimal need in the beginning, in the long era before people started to farm, little greater perhaps than that of the animals with which they shared the land.

The role of trees and woodland in prehistoric farming

What is often forgotten is that Ireland only lost the last of its woods in the turmoil of the 16th and 17th centuries (Feehan 2003). Before this, and especially in earlier centuries, native trees and the woods that sheltered them were held in an esteem that owed much to the essential part they played in a self-sufficient rural economy, but included also elements of admiration, affection and indeed a reverence whose echoes recur again and again in early Irish literature.

In an earlier Ireland our relationship with trees and woods was vastly richer and more detailed than it is now. Every tree had its uses and everybody knew which trees could be used for what purposes. Woodcraft was not merely the skill of a sort of 'priesthood of the forest' managing a fenced estate, as it is today. It was a community skill, and woodland a community resource, albeit hedged about with protective prescriptions to ensure sustainability. Because timber was so important, the use of woodland resources was carefully regulated. This is well exemplified by the way trees are classified in the Laws of Ancient Ireland on the basis of their usefulness, and the network of penalties and prescriptions that surrounded them (Kelly 1999). Woodland was strictly protected by law. There were severe and very specific fines for damage, and for illegal hunting or trapping. But there were also specific common rights (*dílsi cailli*), such as the right to gather enough wood for a fire, or a handful of ripe nuts if they were needed, and so on. Woods were enclosed by walls or banks and ditches, as would be expected in a society which set such store by the economic value of the many resources they represented, and these early banks can sometimes be traced today. In other words, the access of animals to the woods was not unrestricted.

In Iron Age and Early Christian Ireland there was great skill in carpentry and woodcraft, because nearly everything on the farm was made of wood. A considerable diversity of specialised wooden vessels was needed for the dairy: buckets, churns, tubs, troughs and mugs of various sorts. Wooden bowls and plates were made on a quasi-industrial scale from alder, ash, aspen, and other woods (Lucas 1962-63); pottery seems to have been utilised to a very limited extent.

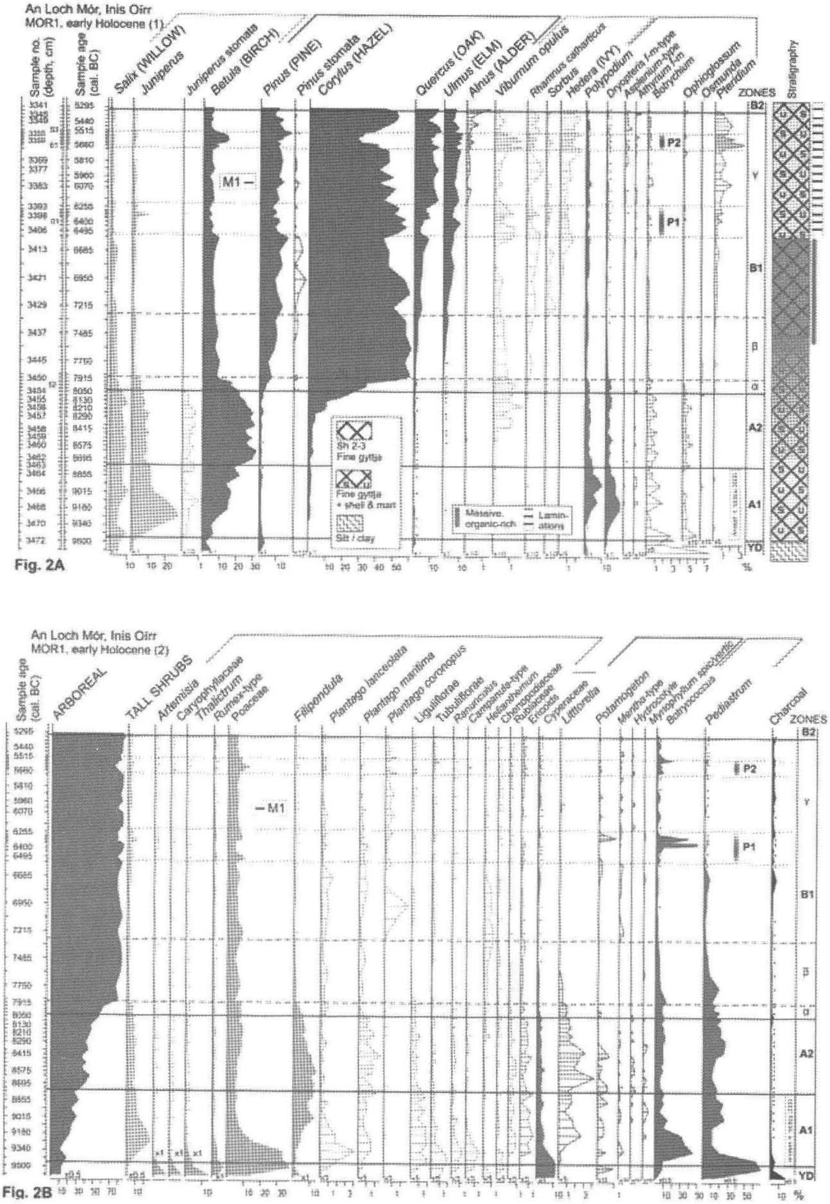

Figure 2. Holocene pollen profile for Inisheer (Inis Oírr) in the Aran Islands. This shows the full Post-glacial sequence (11,500 years) from the end of the Late-glacial to the end of the 20th century. It demonstrates dramatically the extent to which native woodland dominated what is today an almost treeless landscape throughout that time (O'Connell and Molloy 2005: reproduced by kind permission of the authors).

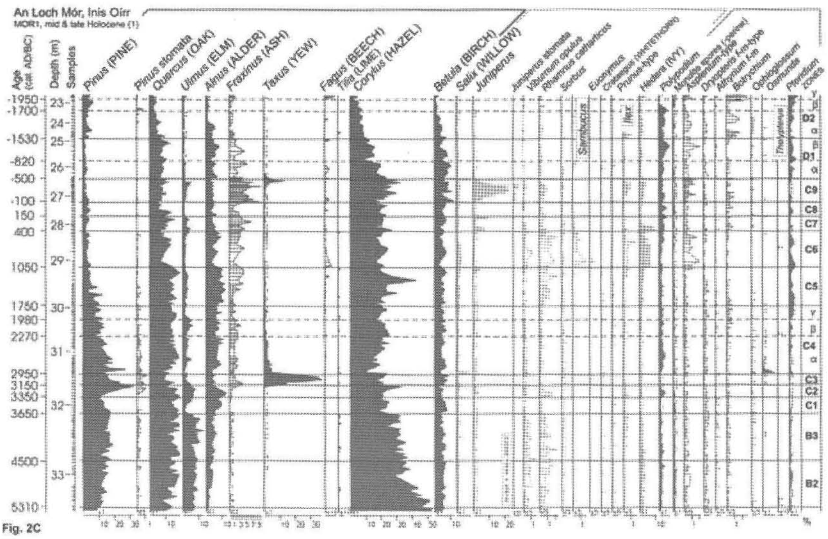
An Loch Mór, Inis Oírr
MOR1, mid & late Holocene (1)

Fig. 2C

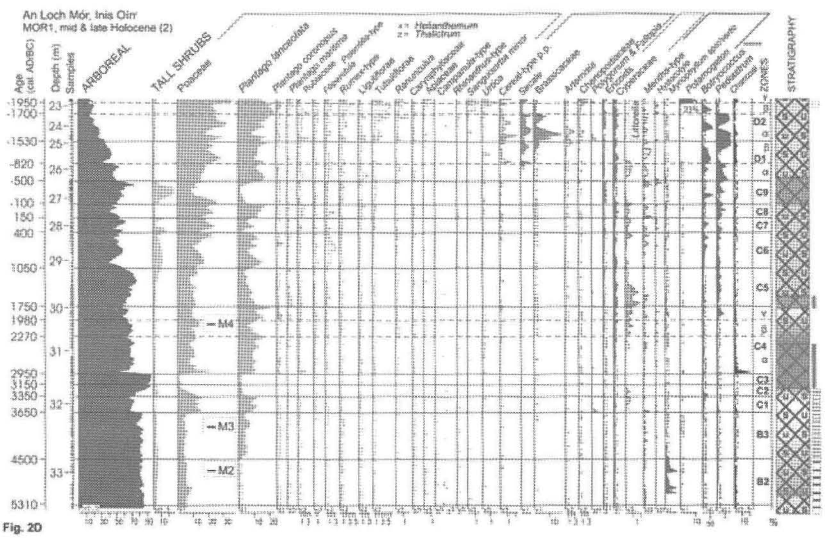
An Loch Mór, Inis Oírr
MOR1, mid & late Holocene (2)
ARBOREAL
TALL SHRUBS
STRATIGRAPHY
ZONES

Fig. 2D

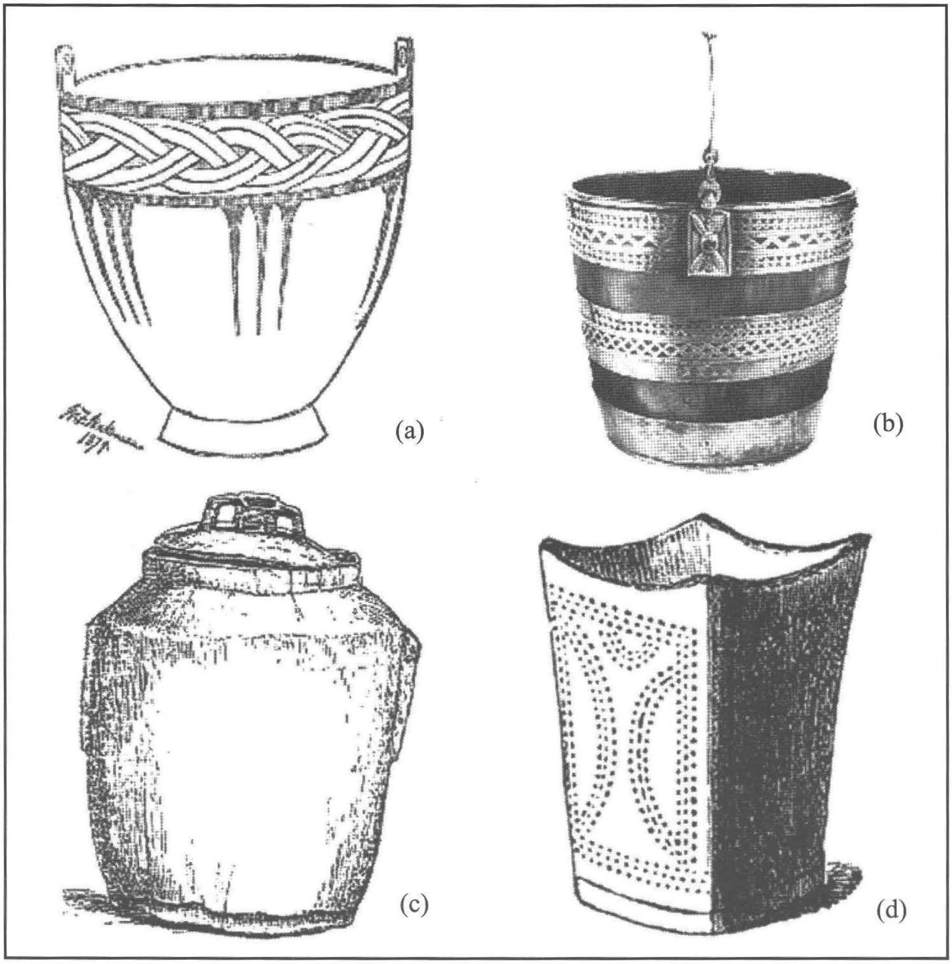

Figure 3. *In Early Ireland sustainable management of woodland was essential to maintain the supply of the various timbers necessary for the making of tools and utensils. (a) wooden vessel of oak, with an alder base: from a bog at Cavancarragh, Co Fermanagh; (b) yew bucket from Derrymullan, Co Laois; (c) butter churn made from a solid piece of pine, from a bog in Co Derry; (d) Drinking vessel made from yew: from Tamlaght O'Crilly in Co Derry.*

The woods were also important for pasturing cattle. A poem by the 14th century poet Maol Seachluinn Ó hEoghasa on the death of the Cavan chieftain Tomás Mag Shamhradháin (Magauran) tells us that after Tomás's death 'wasted and barren now is every cow in his wood after the death of round-eyed Mag Shamhrdháin; few are the fields showing sustenance for a cow now that Tomás is gone'. The suggestion is that these woods were important farm assets not only because of the timber they produced, but for the pasture and shelter of animals – though as we have seen access was not unrestricted. Nor should we ignore the information in placenames. Although places with such names as Moynure (*mágh an iubhair* – plain of the yew), Aghanure (*áth an iubhair* – ford of the yew) or the multitude of places with *derry* (oakwood) in them often stand in a virtually treeless landscape today, their names carry an echo of a time when woods of yew or oak were so prominent as to merit calling the townland after them. People knew and valued their trees, and names like this will not have been given casually.

As long as the woods remained central to the farming economy, they were safe, and so was much of the fauna that lived in them. But however ancient in origin or in their degree of ecological continuity, they were greatly modified by farming practice. One major affect of stock must have been its restricting influence on natural regeneration. These woods will have been essentially clear of undergrowth, and the composition of the ground flora strongly influenced by the grazing preferences of pigs, cattle and goats.

Woodland remained an integral part of the farm landscape in many areas until the 16th century. There were still great forests which remained to some extent outside agriculture, but there were also smaller woods in every district which were managed as a necessary part of the resource base of the early farm. Woods at this time were still extensive enough to harbour wolves, deer and wild boars as well as fox, badger and the smaller mammals. Woodland is everywhere in the medieval lives of the Irish saints: trees, birds and wild mammals are their constant companions. The ghosts of these managed local woods survived in some few places into the 18th century.

The respect for trees in early Ireland

But this early relationship with trees and woods was not shaped by need only, though of course because of their economic value trees occupied a special importance in the Gaelic experience of the world; they were the dominant voice in the living language of landscape. A wonderful reflection of this is seen in the way in which, at the time writing was introduced to Irish, at first as ogham and then through the Latin alphabet, the druids reached for trees in their attempts to try to convey the magic of the written word. When a written Irish alphabet was first adopted, the names given to the new letters were the names of trees (Kelly 1976, Feehan 2000).

Several species were considered to have magical properties and powers, notably yew, hazel, hawthorn, elder and mountain ash. The hawthorn was linked with spring and with marriage. Individual trees of stature and meaning were reverenced in a particular way, and the penalties for damaging sacred or privileged trees were higher than for other trees. We so hardly ever see and experience majestic trees any more that we can hardly appreciate the awe they rightly evoke.

People were so surrounded by nature that it provided much of the imagery for poetry and the sagas, and trees are prominent in this imagery. But there was an element of something else in the old Gaelic attitude to trees which is deeply woven into the mythology of early Europe. Celtic society was a rural society, without cities or towns, and the religion of the Celts – and indeed of the peoples who were here before them – was essentially animist, a nature religion in which sacred places in the wilderness, usually associated with forests or water, took the place of temples. The sacred places of pre-Christian Ireland were not the caves and buildings of stone which Christianity inherited from Rome, nor were they like the temples of the other great religions. For the Celts the sacred place was the *nemeton*: the grove of trees, living, full of spirit, whispering of things in our own spirit we can hardly comprehend and barely articulate.

Groves and individual trees played an important role in the lore of the druids, and there is no doubt of the pre-eminence of the oak, the tree which of all trees was most full of symbolism for the European druids and the Celtic people they served. The druids belonged to the caste of those who studied the science and mystery of the world in order to guide their communities in life. In the early agricultural world in which they had their beginnings the oak was at the heart of such science in an immediately practical way.

However, what survives of the early Irish lore of woods and trees is only the faintest whisper, because pre-Christian Ireland was not a literate society and that lore was communicated orally. But if we look carefully through the dense screen which early Christianity has thrown up between pagan Ireland and our time, we can see a little more. The reason for this is that the sacred groves of pre-Christian belief were carried over into the Christianity of the 5th century. It is more than likely that many or even most of the early Christian churches were founded on the site of druidic oaks or other sacred trees, which still echo faintly in the names of these places: *cill dara* (Kildare), *dair-mhagh* (Durrow), *doire Calgaich* (Derry). It is no accident that where the epithet 'cill' (church) occurs in a placename, it is more frequently associated with the name of a tree than with any other topographical feature. In all probability, every church and monastic foundation in the early Christian centuries had its sacred tree (*bile*) or its *fidnemed* – the word for a sacred grove in early Christian Ireland – which were the Christianised descendants of the sacred groves that went before.

Woodland disappears from the farm landscape

There was extensive woodland cover over the whole of medieval Ireland. According to Giraldus Cambrensis woodland occupied more ground than open grassland in his time. Some of this was forested wilderness, but much more was productive woodland within the farming economy. It is estimated that by the 1400s 12% of Ireland was still forested, mainly along the river valleys of the lowlands, and as we have seen woodland remained extensive until the early 16th century. There were still extensive forests in most upland areas and on the undrained floodplains of the larger rivers at this time, and beyond the confines of the Pale woods had been allowed to overgrow many of the old highways which ran through them (Falkiner 1904).

However, the remaining forests began to dwindle during the Elizabethan wars, when woods were cleared because they were seen as the hiding places of rebels and priests, as well as a refuge for wolves. By the end of the century most of these woods had gone. The Pale had lost most of its timber long before this. A law had to be passed in 1534 obliging every farmer 'to plant twelve ashes within the ditches and closes of his farm.' In Stafford's time, extensive woods remained in Laois, Wicklow, Wexford and Carlow, but these declined as the 17th century advanced, and little remained by its end.

With the collapse of the old farming system in a new economic and cultural climate, the ancient Gaelic tradition under which woods had been managed for numberless centuries broke down. A market price was placed on trees as the doors of a modern economy opened on Irish farming, and timber was one of the principal exports from Ireland in the decades that followed. This onslaught on the remaining woods was due in large measure to the high market value of trees for the manufacture of pipe staves, barrels and great quantities of charcoal for iron manufacture (Boate 1652). Such were the quantities of pipe staves exported that 'this last commodity hath wasted much the woods in Ireland for want of good husbandry' (*ibid.*). With the loss of the woods, people now turned to the bogs for their everyday firing. In his journal Thomas Dinely wrote: 'The wars and their rebellions having destroyed almost all their woods both for timber and firing, their want is supplyed by the bogs' (Dineley 1870).

As the century progressed more and more of the surviving forests showed increasing signs of neglect and exploitation. Until this time, 'Ireland was not inferior to England in plenty of woods, fit for the repair or building of ships and edifices, till within these few years they were all wasted by ill husbandry ... For the natives and possessors of these woods, not observing any seasons nor dividing them into coppices, as they do here, they do always cut down the main timber in all times of the year for their private benefit. Much thereof was and is consumed in iron works there; in pipe staves, transported to Spain and France; and in building foreign navies' (O'Brien 1923).

In North Kerry, no high timber of a quality sufficiently good for shipbuilding remained by 1598, the time of the Desmond Survey, only 'underwood of the age of fifty or sixty years, filled with doted [decayed] trees, ash-trees, hazels, sallows, willows, alders, birches, whitethorns and such like.' In parts of Wicklow, north Wexford and east Carlow however, in spite of their continued exploitation for timber for ship-building and pipe-staves, the woods still had extensive stands of good oak timber at the end of the 16th century. Woods in which yew were dominant or prominent still existed along some of the rivers of Co Cork in 1600, and in such remote areas as the Curlew Mountains pine woods still hung on (Litton Falkine 1904). There were few woods left 'in the English shires near Dublin, in half Connacht, and in a great part of the other provinces' (O'Brien 1923). But some at least were still extensive enough to harbour the larger mammals and birds: 'Great store of great hawks, wild deer, wild boars and wild swine are there to be seen in the large woods, with the perquisites belonging to the same and enjoyned therewith' (*ibid.*).

As population recovered after the devastation of the 16th and 17th century wars, a new pressure on the remaining woods was the need for more farmland. In 1570 extensive forests of 'great oaks and much small woods as crabtree, thorn, hazel, with such like' were recorded in the Barony of Athlone; by 1637 they had all gone, except for those surviving on rocky and steep land, and on the inaccessible wooded islands in the middle of the bogs. Gerald Boate recorded in 1654 that many areas well wooded in 1600 had been completely cleared in his lifetime. He recounted how '... in some parts you might travel whole days without seeing any trees save a few about gentlemen's houses.' This was especially so on the northern road, where for a distance of sixty miles from the capital not a wood worth speaking of was to be seen: 'For the great woods which the maps do represent to us upon the mountains between Dundalk and the Newry are quite vanished, there being nothing left of them these many years since, but only one tree standing close by the highway, at the very top of one of the mountains so as it may be seen a great way off, and therefore serveth travellers for a mark' (Boate 1654).

The second half of the 17th century saw the final act in the disappearance of Ireland's forests, as the new landowners set about taking their farms in hand. Another cause of the devaluation and destruction of the remaining woods was the tendency of many of the Cromwellian soldiers who were allocated lands under titles of doubtful permanency to sell off the standing timber as quickly as they could. Only 10% of the woods that survived in the mid-17th century were still in existence two centuries later (Aalen et al. 1997).

The modern period

As the population soared in the 18th and on into the 19th centuries, woods disappeared from the countryside to an extent we would hardly credit today were it not for the numerous accounts left by contemporary travellers. An observation by Arthur Young in the late 18th century echoes the time when every townland had its 'great wood':

'Through every part of Ireland, in which I have been, one hundred contiguous acres are not to be found without evident signs that they were once wood, or at least very well wooded. In the cultivated countries, the stumps of trees destroyed shew that the destruction has not been of any antient date' (Young 1790).

Yet already by the time of Young's visit the country had become denuded of trees. He instanced an area of 100,000 acres around Mitchelstown: 'in which you must take a breathing gallop to find a stick large enough to beat a dog; yet is there not an enclosure without the remnant of trees, many of them large; nor is it a peculiarity to that estate: in a word, the greatest part of the kingdom exhibits a naked, bleak, dreary view for want of wood, which has been destroyed for a century past, with the most thoughtless prodigality, and still continues to be cut and wasted, as if it were not worth the preservation' (*ibid.*).

A mature tree of any kind could hardly be seen outside the walls of the great demesnes, and in many places the only wood available for building was timber dredged from the depths of the bogs. There were no longer groves or great trees to relate to, and human need for the wild was perhaps the last thing people in their growing millions thought of in their struggle to make ends meet. The ancient reverence withered with the progress of deforestation and the smothering of tradition. By the turn of the century, woodland cover in Ireland had dwindled to half of one percent, the lowest in Europe.

With the loss of the woods the ancient consideration accorded to trees was smothered and an ages-old tradition in woodcraft faded away. But the reverence survived as best it could in popular tradition. The traditional regard for great and special trees shrank to a superstitious reverence for those that grew on ringforts, and the ancient hawthorns that shaded the country's holy wells, of which over 3,000 still survived at the beginning of the 20th century. Great respect was always paid to 'lone bushes', generally whitethorn, growing alone out in the open, such as the so-called monument trees and bushes associated with funerals, the revered bushes which often stood at road crossings, or at places where some tragic event had occurred. It was not considered 'right' to cut these, and they were widely believed to be under the protection of the *sidhe*, the good people, and misfortune invariably befell anybody who cut them down.

The start of recovery

Numerous attempts were made to repair the destruction and subsequent neglect of the woodlands, which accompanied and followed the collapse of the Gaelic woodland management tradition and the arrival of a new landed order in the late 17th century, but there was no longer any sense of community responsibility for woodlands. It proved very difficult to stop people cutting the timber they required for everyday needs, and some few were quick to exploit this breakdown in tradition in an unscrupulous way. Time and again measures were passed in an attempt to put a stop to this, but for a long time they were ineffective.

Something more was needed to make the legislation effective. This was provided with the important Act of 1784-85, which gave the tenant the right to do what he liked (within certain limits) with any trees he planted. It also granted for the first time the right to enclose any piece of ground with coppice wood, and reinforced the obligation to register the details of what was planted. Some of these records must still survive, though few have come to light; the study of tree-planting in Derry at this period by the McCrackens gives a good idea of the detailed and fascinating information they can contain (McCracken 1971).

This persistent legislative and incentive effort did finally bear fruit. Although no detailed study has been carried out so far, a rough estimate suggests that some 50 million trees may have been planted under these Acts in the 60 years between 1790 and 1850, totalling in all an area of some 25,000 ha. Some 53,500 ha of woods were planted in the 18th century; by 1841 this had risen to 140,000 ha. (Aalen et al.1997). For comparison, Forbes calculated that over a period of 40 years only 2,800 acres had been planted with premiums awarded by the Dublin Society (Forbes 1933). Most of the old trees still surviving in Ireland date to this period of active afforestation. Although broadleaved species were well-represented in the new plantings, pride of place often went to new conifers from North America such as Douglas and grand fir, along with Scots pine, European larch, and small numbers of Norway spruce; conifers accounted for considerably more than half the total of trees planted. The main broadleaved species – in approximate order of popularity – were ash, beech, oak, sycamore, alder, elm, birch, horse chestnut, Spanish chestnut, willows, poplars, hornbeam, lime, plane and walnut. Most of the plantations were mixed; hardwoods were accompanied by nurse plantings of conifers, alder or birch.

The planting of new woods by improving landlords went some way towards restoring trees to a landscape now largely bare of woodland, but the new woods were sheltered within protective demesne walls, no longer part of the vernacular farmed landscape. Moreover, one of the most immediate results of the 19th - early 20th century Land Acts was that landlords and tenants, uncertain of the future, sold much of the timber in the growing woods to provide capital. The new tenants did not identify with tree planting; this was something associated with landlords and subsequently with the new State. There was 'wholesale cutting-down of trees' in the second half of the 19th century (Dennis 1887). By the early 1920s woodland cover in Ireland had declined to 100,700 ha.

It is understandable in the Irish situation that afforestation policy for so long focused simply on timber production, when one considers that only 1.5% of the island was under woods at the turn of the century. In a country denuded of trees, the need for timber took priority; once that was achieved maybe there would be time and space to think of less material aspects of woods. When Wolfe Tone was in France at the end of the 18th century he remarked with envy the orchards which people planted everywhere, and which the children looked after, whereas nobody was planting trees in Ireland. His explanation was that 'he who can barely find potatoes for his family is little solicitous about apples; he whose constant beverage is water dreams neither of cider or mead. Well, if we succeed we may put our poor countrymen on somewhat a better establishment' (Gregory 1931). It is hardly surprising under the circumstances that the aim of government policy in the later 19th and early 20th centuries was timber at any cost, and yet planting was anathema on farmland, and so was largely concentrated on marginal land and the narrow range of alien conifers that would grow well under such limiting conditions.

But in recent decades there has been something of a conversion: the recovery of at least some elements of the earlier multifunctional valuation of trees – and indeed an appreciation of some new elements of value: the birth of a realisation that trees and woods serve a multiplicity of functions in all our lives: not merely the production of needed timber, but recreation and easing of the human spirit: and that these needs are better fulfilled by forest that approaches native broadleaf woodland in its composition. However, and hardly surprisingly, the production of timber and economic considerations still remain uppermost in the policy of Coillte and the Forest Service: except for the 15% of forest land that must be managed primarily for biodiversity.

But even our best broadleaved forests are not the woods that evoked the ancient reverence, or the awareness of how great trees are rooted in the mists of time and all that awareness carries with it for our human spirit. In an earlier time the yew was revered in Ireland not merely for its superb timber but because it was considered the most ancient of living things. We have very few trees like that today: yew or oak, elm or alder or any other. But we may have again, and there must be room in our forest policy, a small corner of consideration though it be, that will nurture the earlier attitude of planting for a human future far beyond the horizon. The Oxford botanist A.H. Church once wrote that because there are so few really ancient trees in our midst we have almost come to doubt the records of the truly venerable trees we once had: 'The most majestic productions of the vegetable kingdom are rapidly disappearing, and will never be replaced. No future scheme of forest-cultivation will even countenance a tree growing to maturity in 500-1,000 years, and persisting for 3,000-4,000. The records of an older generation are already often regarded with scepticism. ... Modern forestry prefers a tree of 2 ft. diameter in 100 years' (Church 1920).

We can think of the People's Millennium Forests as a first step in the recovery of a determination that though the experience of truly ancient woods is lost now to us, there will once again in time be woods in Ireland where children in May can wander amazed among bluebells and primroses beneath oaks of five hundred years.

Into the future

I am allowed to visit in my dreams, sometimes, the pinewoods of Clongawny and Derrinlough with which I began. Ordinarily that dreaming is as far as the reach of hope and imagination could hope to go, except for those few among us who can divine further and deeper in spirit. But here at Clongawny something special is about to happen. This is an area of exceptional landscape heritage interest; sections of it are already beginning to exhibit the high natural species diversity of decommissioned cutaway bog, and it is an area of special archaeological value and interest because it encompasses both the mesolithic site at Lough Boora, and the site of Lough Coura, beside which the Dowris Hoard was found in 1825.

There is a plan in hand to restore, in part at least, this forest that once was. The aim of a Future Landscape Plan is to ensure that the key values in a particular landscape are sustained, and to facilitate access to the areas and features that embody these values. Such access is mediated by the provision of infrastructure on an appropriately unobtrusive scale, and of appropriate explanatory documentation (Feehan and Egan, in prep.). Considered intervention may be necessary to enhance or maximise future landscape value.

The Future Landscape Plan for these bogs envisages a mosaic of wetland and forest, and this is a model which may also be applied elsewhere. When peat extraction ceases, the lower-lying areas between the moraine hills will flood, and this flooding will be promoted by blocking the drainage of the bog put in place forty years ago by Bord na Móna. On the slopes and summits of the land exhumed from the peat, the forest will be restored, Scots pine and oak, the idea being to restore something of the wooded landscape that was here before the bog had entirely overwhelmed the landscape. Indeed, the process of recolonisation by pine has already begun spontaneously.

The first layer of this landscape plan has already been prepared by Bord na Móna, pinpointing areas where the development of new wetland is ecologically feasible. Offaly County Council have incorporated a new Forest Service Neighbourwood Scheme into the plan that will involve the restoration of Scots pine forest to the higher areas of the cutaway, above the water table. Conservation or restoration (as appropriate) of the small areas of broadleaved woodland that occur as islands of mineral ground in the bog will be implemented through the Forest Service Native Woodlands Scheme. All of these will be linked by a trackway that will follow the line of the Bord na Móna railway, which will become a permanent walkway when harvesting activity has ceased. It may be possible to incorporate areas of woodland on adjacent farmland at a later stage of the project.

The significance of the proposed forest of Scots pine is twofold. It dominated the landscape before the encroachment of bog, and appears a likely outcome of spontaneous ecological regeneration on extensive areas of cutaway in the future. The stumps of the ancient pine forests overwhelmed by the encroaching bog are still dramatically displayed in many places in the area, most notably perhaps at Drinagh and Clongawny. Secondly, it may be envisaged that the pinewoods were in existence in the Bronze Age, and therefore during the period in which the Dowris Hoard was deposited in the waters of a then greater Lough Coura, and subsequently entombed by the expanding raised bog. We propose to use the new forest to *facilitate imaginative access* to the Dowris Hoard and its Bronze Age world for the community at large. The native pines will be restored to the slopes of the island woods, and though perhaps not in our lifetime, our children certainly in theirs, will be able to walk again beneath the majestic pines we could only dream of before, in this Once and Future Forest.

Lough Coura itself, which was a splendid area of open water, with an island on which a tower house was situated, was drained in the second half of the 19th century – to the immense loss of future generations. No open water remains, although there is a considerable expanse of reedmarsh. Coillte owns the marshy land on its southern margins, and it is now proposed to develop the coniferous forest here in ways that will facilitate the physical and imaginative access already referred to, and to restore lost biodiversity in whatever ways are feasible.

We used to think that forestry would be a major land use on these cutaway bogs. The experience of recent decades has somewhat blighted that hope, in the short term at least, but that in fact has increased the possibility for forest that enshrines all the values other than the narrowly commercial, in an imaginative way: a haven for biodiversity, especially with the habitat mosaic envisaged; of enormous cultural and aesthetic value, enhanced by access along the Bord na Móna railways which will evolve into a public walkway in time; and as a long-term carbon store of significance. It is the image of Clongawny I have in mind as I sketch this future, but this is essentially a vision of a possible future for much of the Bord na Móna cutaway in the midlands, which is spread over an area of no less than 80,000 hectares (Feehan 2004).

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Trees, Woods and Literature – 29

My love's an arbutus
B the borders of the Lene,
So slender and shapely
In her girdle of green;
And I measure the pleasure
Of her eye's sapphire sheen
By the blue skies that sparkle
Through that branching screen.

But though ruddy the berry
And snowy the flower
That brighten together
The arbutus bower,
Perfuming and blooming
Through sunshine and shower,
Give me her bright lips
And her laugh's pearly dower.

Alas! fruit and blossom
Shall scatter the lea,
And Time's jealous fingers
Dim your young charms, machree.
But unranging, unchanging,
You'll still cling to me,
Like an evergreen leaf
To the arbutus tree.

Alfred Perceval Graves

Alfred Perceval Graves (1846-1931), best known today as the father of the writer Robert Graves, was well-known in his own day as a poet, and as an author of popular ballads, including *A Jug of Punch* and *Father O'Flynn (Of priests we can offer a charmin' variety/Far renown'd for learnin' and piety/Still, I'd advance ye widout impropriety/Father O'Flynn as the flow'r of them all).*

Graves was born in Dublin in 1846, the son of Dr James Perceval Graves, Bishop of Limerick. He graduated from Trinity College Dublin in 1869, and entered the Civil Service in London as a clerk in Home Office, where he remained until 1874, when he became an inspector of schools. A prolific contributor of prose and verse to publications such the *Spectator*, *The Athenaeum*, *John Bull*, and *Punch*, he was also the author, with Charles Stanford, of *Songs of Old Ireland*. Although based in London, he maintained a close interest in Irish affairs, and was a leading figure the

Irish literary renaissance at the turn of the nineteenth century, being twice a president of the Irish Literary Society.

The arbutus of the title is, of course, *Arbutus unedo*, the strawberry tree – in Irish *caithne*. A native species, it grows upwards of 10 m in height, with one record of 14 m. An evergreen (*Like an evergreen leaf/To the arbutus tree*), the name strawberry tree comes from the prominent red berries (*But though ruddy the berry*), which ripen in November/December. The fruit is edible but, according to most accounts, not very appetising, hence the species name - *unedo* – eat one or once.

A member of the heather family, the species is mostly native to the Mediterranean region. The Irish population is confined to West Cork, Co Kerry (in the native woodlands of Killarney - hence *By borders of the Lene* – a reference to Lough Lene), and a small area around Lough Gill in Co Sligo. Its status as a native is based on its presence in the pollen record as far back as 3000 BP. The pathway it took in reaching Ireland in the postglacial period is not known, nor is why it has such a restricted present-day distribution on the island.

(Selection by Mick O'Donovan with notes by *Lia coille*)

Book review

Tree and Forest Measurement. West, P.W. Springer. 167 p. 17 illus., 9 tabs. €29.95 exclusive of VAT and carriage charges, softcover. ISBN 30540-40390-6.

West is clearly an experienced lecturer as his text is succinct and very readable. The book presents a list of very useful and up-to-date references. He presents an elementary exposé of basic forest mensuration techniques for diameter, height and stem wood volume estimation of individual standing and felled trees.

Tree and Forest Measurement includes a very welcome chapter on tree biomass and the difficulties in developing functions for roots, leaf and whole-tree biomass. The chapter on stand measurement provides a useful exposé on the use of point sampling in basal area and volume per hectare estimation. The use top height of a stand at any age in estimating the site productive capacity and site index from top height-age functions is very relevant in Ireland. West states that the quadratic mean diameter "is largely historical and it is becoming a less important stand measurement today". This is certainly not the case in forestry in Ireland or Great Britain.

He presents the three classic graphs of the cumulative volume per hectare (m^3 ha^{-1}) function and the derived functions for mean and current annual increment (m^3 ha^{-1} a^{-1}) versus age (years). However, nowhere in the text is reference made to the age of maximum mean annual increment or the associated concept of yield class, which define the age of biological maturity and the sustained yield of the stand respectively. The last topic covered in the book was the plane survey. He provides an analysis of direction (°), slope (°) and distance (m) data to compute X and Y coordinates for all points in a plane survey and the use of triangular sub-sections to compute the area (m^2 or ha). The above topics are important to all with a professional interest in the measurement of trees, stands and land.

West then delves into stem volume and taper functions. Eight stem volume functions, from the international literature, for different species are presented. Each function provides an estimate of individual tree volume to tip (m^3) as a function of diameter at breast height (m) and height (m). Six of the eight functions provide underbark volume estimates, which contrasts with the overbark volume estimates widely used in Ireland and Great Britain. Examples of taper functions for different species are also presented, which model the rate of change in upper stem diameter (m) as a function of any height along the stem (m). Using integral calculus estimates of total volume (m^3) and or volume or length assortments may be easily estimated from the taper functions before trees are felled. West emphasises the greater utility associated with taper functions compared to volume functions.

Elementary sampling concepts and measures of variability including the mean, Y_M, variance, V_M, and confidence intervals, C_M, are presented, albeit with non-standard statistical notation. The chapter on sampling theory quantifies the sampling efficiency associated with six common sampling designs which were used, for illustrative purposes, to estimate the mean stem wood volume (m^3) using a sample size of n=15 from a population of size N=107 trees. The methods of sampling illustrated are: simple random sampling, sampling with probability proportional to size (PPS), sampling with probability proportional to prediction (3P), stratified random sampling, model-based sampling and bootstrap sampling. The sampling efficiency for each of the six sampling designs was evaluated by comparison of the 95% confidence intervals for the mean and or total for each method of sampling. For the data analysed the model-based sampling design produced the most precise estimates of the population mean and total with a 95% sampling error percent of 9.4% compared to 70% for simple random sampling, 17.1% for PPS sampling, 14.6% for 3P sampling, 45.4% for stratified random sampling and 12.5% for bootstrap sampling. West's text indicates where each method of sampling is appropriate. He also provides practical advice on conducting a forest inventory.

West emphasises the necessity for computing confidence intervals for estimates arising from sampling designs in forest inventory. However, no statements of precision are presented for the predicted values or estimated parameters for any of the stem volume, taper or growth functions presented. All estimates should indicate their precision at a specified level of confidence.

Springer, the publisher, used the same font for both text and equations, with all equations presented on one line. This detracts from the presentation, which could easily have been rectified had all the equations had been formatted using an equation editor. Lecturers, in particular, and indeed all professionals, must always be aware of the danger of propagation of errors. The use of non-standard statistical notation and units of measurement, such as m^2/ha and m^3/ha/year, in this book only serve to propagate such errors. Throughout this book the term parameter is used to refer to "a variable in an equation". However, the term 'parameter' in forest biometrics refers to a true, usually unknown, characteristic of a population, the determination of which requires data on all n observations in the population. A parameter may be estimated from an unbiased 'statistic' or 'estimate' computed from a randomly selected sample of n observations. Population parameters are usually represented by Greek letters, while sample statistics are represented by lowercase Latin letters. West's use of the term 'parameter' throughout the text is inconsistent with the normal statistical definition and use of the term.

The chapters on individual tree, stand and land measurement are very relevant to all with an interest in tree, forest and land measurement and I commend this book for this. The chapters on stem volume, taper equations and sampling designs are clearly of more relevance to professional foresters with specific requirements for more specialized knowledge. Overall, *Tree and Forest Measurement* is a useful addition to the library of the professional forester and is affordable.

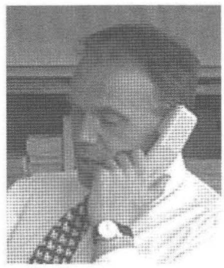
This book has relevance in Ireland at the present time given the considerable body of research on biomass expansion factors sponsored by COFORD, the introduction of the site index by Coillte for selected commercial species, and the National Forest Inventory being undertaken by the Forest Service, Department of Agriculture and Food.

Máirtín Mac Siúrtáin

(Dr Máirtín Mac Siúrtáin has been a lecturer in forestry in the School of Biology and Environmental Science at University College Dublin since 1982. He has lectured, and conducted research, in mensuration, biometrics, forest inventory and related fields).

Obituaries

John McGhie
1957 – 2005



John McGhie, who died far too young in March 2005, was a consummate forester and environmentalist, and good friend to many of us.

The fact that he had somewhat dubious tastes in both music and football has already been chronicled by Rab McNeill in his tribute in the Scotsman, and so I will not dwell on these. The first time I knowingly met John was in Aberdeen in 1976, when co-incidentally the worst excesses of progressive rock were starting to give way to new wave and punk. We were both freshers embarking on a route that was designed to lead to a degree in forestry. I say that this is the first time I knowingly met John, because when we started to compare notes over our studies in the St Machar, the Kirkgate or the Dungeon it transpired that his mother used to babysit me. Even as a first year student John challenged the accepted norms, a practice that became a hallmark of his professional career. Unfortunately he was defeated in these early challenges and found that in order to progress towards a degree he really ought to have spent more time in establishments more directly linked to academic life at the university than those mentioned above.

He did not return to Aberdeen for a second year, but went to seek his fortune in the real world. His tales of the characters he got involved with as a forester in the new town of Livingston in West Lothian, or planting up the Flow Country in Sutherland with Fountain Forestry did not make it any easier to define the real world. After a year or two out he resumed his forestry studies at Newton Rigg where he fell in with a particularly dubious crowd from Northern Ireland, most of whom are now senior managers in the Forest Service. I recall visiting John, Susan and newly arrived daughter Mhaire in Thetford in May 1982 where he was working for the Forestry Commission as part of his sandwich year. The Falklands War was in full fling and the amount of red, white and blue bunting in that part of England would have done Sandy Row proud in July. Working in that pine-dominated forest, John confessed that he was missing Sitka spruce.

His Thetford experiences may have contributed to his decision to accept a post with the Forest Service in 1983. He started work in Antrim District as an Assistant Forester, moving to Belvoir in 1986 where he took over from John Gault and won temporary promotion to Head Forester, before resuming his substantive grade and moving to Trostan to assist Ian Wright-Turner. In 1987 he moved to Pomeroy to assist George Holbrook, where in 1992 after almost nine years of service he was promoted to Forest Officer III. The following year he finally got his degree, and not a BSc, a Masters in Environmental Management awarded with distinction by the

University of Ulster. In 1997 he was promoted again to Conservation Officer, followed rapidly with another promotion to Head of Environment Branch which morphed with re-organisation of the Service into Head of Forest Practice. Things had gone full circle with he and I working together again, only slightly older, but still staring into our pints contemplating the meaning of life. I sometimes wonder whether it was intimations of his own mortality that finally persuaded him to give up the chicken run from Parkanaur to Dundonald House and escape to the relative freedom of living and working on the island of Islay.

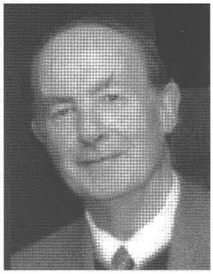
John leaves behind an important legacy in forestry in Northern Ireland. He can take much credit for the huge shift in emphasis that has brought environmental matters to be such a mainstream part of all our lives. He was here at the birth of forest certification and nursed it well in its early years. The good relations the Forest Service enjoys today with colleagues in the Environment and Heritage Service, and the community and voluntary sector are in many ways a tribute to John. His professional legacy on Islay must include the vastly improved relations between RSPB and landowners on the island. But the most important legacy he leaves is happy memories for many of us. Sue, Mhaire and Roy the thoughts of the Forest Service are with you at the loss of a husband and father, and to misquote Christy Moore, an extraordinary man.

It's coming yet for a'that,
That man to man, the world o'er,
Shall brithers be for a'that

Robert Burns

Pat Hunter Blair

Séamus O'Donnell
1937– 2004



On a beautiful sunny December morning Séamus O'Donnell was laid to rest in his beloved Gortahork, following a short illness borne bravely and privately.

For although Séamus was a very private man he had a huge circle of friends from all walks of life. His integrity, his sense of fairness, his charitableness and his generosity attracted life long friendships. Although only out of County Donegal for a short period in his career he maintained lasting friendships with people everywhere he went.

Séamus began his career in Kinnitty in 1956, following a year in St Patricks Agricultural College and a year in The National Botanic Gardens. He completed his studies at Shelton Abbey in 1959 and was appointed initially to Glen Imaal forest and later to Glenealy Forest. The late Dan O'Sullivan of Glenealy Forest often related the story of arriving with five young children in the official residence to find a roaring fire lit by Seamus, a small example of his thoughtfulness.

Séamus then transferred to Crossmolina and it was there that he developed his love of fishing and every year he went back to the Moy and Lough Mask to fish. In fact in a period when relations with fisheries interest were fraught Séamus appeared in a video on the life of the salmon produced by the North Western Fisheries Board, the Board were totally unaware that Séamus was a forester.

Finally in 1967 Séamus returned to Donegal to take charge of the newly created Raphoe Forest where he was Forester in Charge for 30 years before he took over Innishowen. He took early retirement in 1997 and then enjoyed his contract work. Unfortunately when it came to the time for him to fully retire his health failed.

Séamus had total commitment to his work; he dedicated himself completely to the task and was very contented with his lot.

Rugadh agus tógadh Séamus in gceantar stairiúl Chaiseal na gCorr i lár ghaeltacht Thír Chonaill. Le cois an ghrá mhór a bhí aige don iascaireacht, peileadóireacht agus foraoiseacht, choinnigh sé suim i gcónaí in gcúrsai gaelinne agus polaitiochta in a cheantar dhúchais, bá mhór an bród a bhí air nuair toghadh a neacht Brian mar Chomhairleoir Condae go goirid roimh a bhás. Bhí sé fosta brodúil as a theanga dúchais agus bá é gaeilge a chéad teanga i gcónaí.

Ar dheis lámh Dé go raibh a anam dhílis.

We extend our sympathy to his five sisters Grace, Margaret, Bríd, Mary and Kathleen and his four brothers Paddy, Denis, Hugh and Micheál.

Micheál Mc Fadden

-- N O T E S --

-- N O T E S --

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