IRISH FORESTRY

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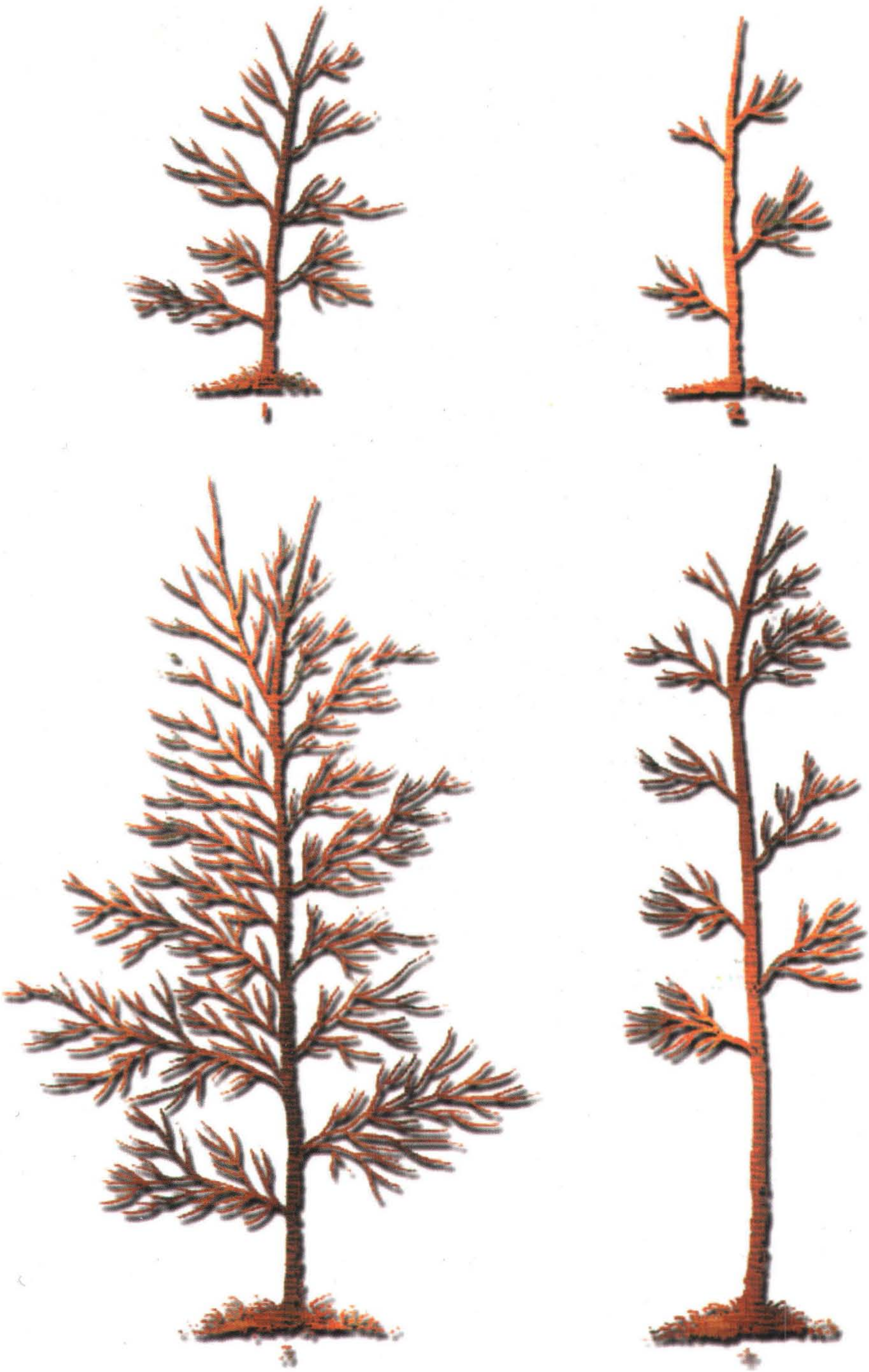
THE SOCIETY OF IRISH FORESTERS



Vol. 58 Nos. 1 & 2, 2001

IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

Volume 58, Nos. 1 & 2 , 2001

Contents

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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

Regenerating forests

Whoever coined the phrase continuous cover must have had a rush of blood to the head, for there are very few silvicultural systems that involve keeping the forest floor under the cover of a full canopy during regeneration. In the past few years the phrase has gradually seeded itself into forestry usage, even state forestry bodies have not been immune! The fact is that light demanding species such as oak will simply not develop under a canopy; germinate they will but they need full light to grow on. Why not call it simply natural regeneration, or, where it is practised, underplanting – far more accurate terms.

Leaving these considerations aside natural regeneration has been practised successfully for centuries in Europe and there is now increasing interest in it in Ireland. This has been spurred on by forest certification, and a growing interest among practitioners. They have seen spontaneous regeneration following clearfelling of species such as Sitka spruce and lodgepole pine, and have asked the obvious question: why go to the cost of planting where there is already a new forest crop in the making?

As the paper by O'Leary and his collaborators in this issue shows, spontaneous natural regeneration, often involving native species such as birch, is now occurring on a reasonably widespread basis after clearfelling of spruce and pine crops. While experience of predicting and managing natural regeneration is limited here – field research began but five years ago – some progress has been made, its occurrence after clearfelling can at least be partially predicted and silvicultural systems to encourage its development are now under investigation. Like all innovative processes it will take time to get it right and for it to gain acceptance.

There is little doubt that planting after clearfelling will continue to be the dominant form of regeneration on most sites over the coming decade. For the present it is far more reliable and offers the opportunity to either change species entirely or move to faster growing forests with improved wood quality. Considerable investment has been made in tree improvement over the past decades, especially in Sitka spruce, and it would make little sense not to avail of these improvements when the opportunity arises in reforestation. Improved material will make a big difference in the rate of return to the grower and will have further beneficial downstream effects in wood processing and utilisation.

Once deployed, improved genetic material can itself be perpetuated and further improved through natural regeneration – there is a great deal of evidence of adaptation and improved performance in second and subsequent generations of planted tree species. This is only to be expected where thinning to favour faster growing, better quality stems takes place and is followed by natural regeneration. The stems that remain at the final seeding felling will pass on these superior traits to the next generation. Even the process of natural regeneration itself favours faster growing, healthier seedlings.

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ISSN 0021-1192
Volume 58
Nos. 1 & 2, 2001

Designed, laid out and printed by:
Elo Press Ltd.,
Dublin 8, Ireland.

Volume production patterns in six downy birch stands in Ireland

Maarten Nieuwenhuis[1] and Frank Barrett[2]

Abstract

Six well-stocked, unthinned downy birch (*Betula pubescens* (Ehrh.)) stands in Cos Wexford, Laois, Wicklow, Offaly and Westmeath were selected for study. A total of 100 sample trees were felled at the six sites. Tree ring data were collected from a total of 1333 tree discs. Using the ring data the historic growth patterns of the six stands were reconstructed, examined and analysed. Local volume equations (volume/basal area lines) expressing the relationship between sample tree over-bark volume (to tip) and basal area were fit to data from two 0.04 ha plots at each site. These were used to determine per ha over-bark standing volume estimates.

For well-stocked, unthinned even-aged stands of downy birch the period of maximum radial growth occurred between the ages of 5 and 20 years. The fastest growing tree achieved a diameter of 25 cm in 32 years. Maximum height growth occurred before the trees were twenty years old; fast growing trees achieved a height growth of more than 1 m yr^{-1} during this period. The results showed that a well-stocked, unthinned downy birch stand could achieve a standing volume of 203 m^3 ha^{-1} in 42 years. Comparison with Forestry Commission yield models showed that stands of downy birch in Ireland may achieve a potential yield class of 8 and, given the appropriate thinning regime, total recovered volume production could possibly be raised to that equivalent with yield class 10.

Keywords: *Betula pubescens* (Ehrh.), downy birch, mean annual increment, mean periodic increment, volume production patterns, tree ring analysis.

Introduction

Birch is one of the most common native woodland trees in Ireland. However, its potential for commercial wood production is often ignored, because existing birch woodlands are often poorly stocked and are generally comprised trees of poor form. Birch has a poor reputation amongst foresters, with the result that many existing birch stands have suffered neglect. Interest in native tree species such as silver birch (*Betula pendula* (Roth)) and downy birch (*Betula pubescens* (Ehrh.)) is now growing. There has been increasing pressure to diversify the range of species in the national forest estate and, in particular, to increase the proportion of native broadleaved species. A growing emphasis is also being placed on the need to preserve and extend existing semi-natural woodland, of which birch is a major constituent.

Aside from the problems of poor stem form, birch has many attributes considered advantageous in a forest tree species, e.g. rapid growth, ease of regeneration, ability to grow on a range of site types, self-pruning and relatively short rotation lengths (Evans 1984).

To date research on birch in Ireland has been limited. Little is known about the abundance or distribution of the two species (silver and downy birch), the quality of the birch resource or the growth performance of existing stands. Those provenance trials that have been laid down have been small in scale and of poor experimental design, and they

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have not yielded any pertinent information on the performance of the Irish birch (O'Dowd 1998). The consequent lack of quantitative data relating to height growth, diameter growth and volume increment of birch in this country is of particular concern.

To this end a study was initiated in 1998 with the aim of examining the growth potential of birch in Ireland. Historic patterns of radial growth at breast height, height growth and volume growth of selected birch stands were examined using stem analysis. We focus in this paper on a comparison of historic volume increment patterns between six stands.

Literature review

Taxonomy of birch

Birch (*Betula* spp.) is an important and diverse deciduous tree genus of the family Betulaceae. About 60 species of the genus occur in the northern hemisphere (Savill 1991). Three species are native to Great Britain and Ireland: silver birch (*Betula pendula* (Roth) or *Betula verrucosa* (Ehrh.)), downy birch (*Betula pubescens* (Ehrh.)) and dwarf birch (*Betula nana* L.). Of these three species, only silver and downy birch are now extant in Ireland. Dwarf birch disappeared from Ireland and lowland Britain during the transition from the last glaciation to the present interglacial (Godwin 1975). In Britain two sub-species of downy birch have been recognised (Figure 1): sub-species *pubescens* is found in lowland and valley locations while ssp. *odorata* is a shrubbier tree of bog and mountain (Clapham *et al.* 1981). In continental Europe three sub-species of downy birch (*Betula pubescens*) have been recognised: *pubescens*, *carpatica* and *tortuosa*.

History and ecology of birch in Ireland

Birch dominated the Irish landscape about 11,000-10,000 BP (Nelson and Walsh 1993), at the end of the most recent ice age, but went into decline thereafter. *Betula* woodland was succeeded by *Corylus-Pinus* and finally by mixed *Ulmus-Quercus* woodland which had covered much of the land by 8000 BP (Mitchell and Ryan 1998). Atkinson (1992) summarised the history of birch species in the British Isles and reported that birch forest was still present at 9000-7000 BP, but in central and western Ireland was giving way to pine. In the Atlantic period (6000-5000 BP) the extent of birch woodland was reduced and in the period 5000-2500 BP, birch receded further in central and eastern parts of Ireland.

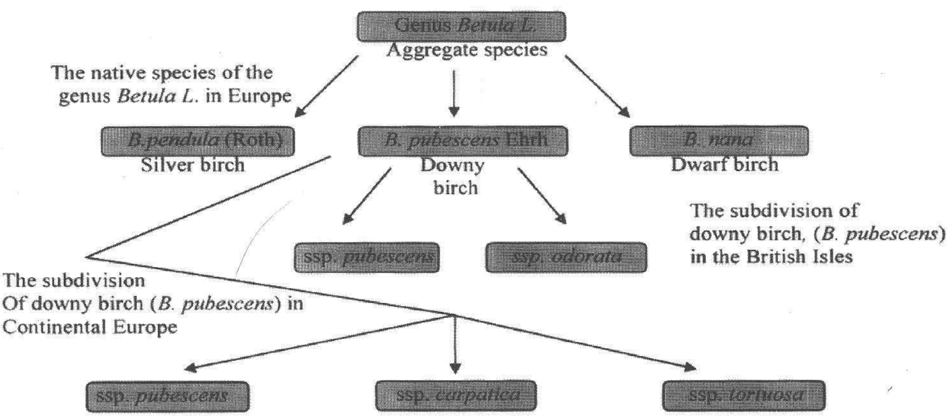

Figure 1: *The nomenclature of European birch (after Brown 1991).*

Rackham (1980) noted that in the last hundred years in England, birch had become one of the commonest trees both of ancient woodland and of secondary woods on the site of heaths, fens and in plantations. A similar pattern of birch colonisation and development is also likely to have occurred in Ireland.

Keogh (1987) indicated that there were some 5,000 ha of birch woodland in Ireland (9% of the total broadleaf resource), although no records existed of the relative abundance of the two different species.

Today birch woods and small groups of trees are common in many parts of Ireland on bog margins, on cutaway (Jones and Farrell 2000) and on clearfelled sites. In most cases they are seral stages to oak or ash woodland and, except where they are on sites of former woodland, are characterised by a rather impoverished flora (Cross 1987).

Yield of birch

In Britain, it is generally agreed that a yield class (YC) of 6 m^3 ha^{-1} yr^{-1} is above average for birch (Brown 1991). Savill (1991) maintains that a maximum yield of 7 m^3 ha^{-1} yr^{-1} may be obtained on the best sites. Current annual volume increment culminates at around 15 to 30 years, while maximum mean annual increment is generally achieved at an age of 40 to 50 years. The highest growth rates in Europe appear to occur in Poland (Philip 1978).

In England potential cumulative production on good sites after 40 years (estimated to be close to the age of maximum mean annual increment at YC 8) is around 170-200 m^3 ha^{-1} (Cameron 1996). In Finland, stands originating from genetically improved planting stock can reach the final target size in as little as 40 years and produce over 400 m^3 ha^{-1} (equivalent to a YC of at least 10) (Vihera-Aarnio 1994). Niemisto (1996) studied silver birch plantations in Finland and found that stands achieved a total yield of 230 m^3 ha^{-1} on average (nearly 400 m^3 ha^{-1} maximum) at 30 years of age.

It is generally recognised in Europe that the growth and yield of silver birch is greater than that of downy birch. Seaman (1994) noted that downy birch is known to grow more slowly than silver birch although the differences are difficult to quantify owing to interactions with site. Koski (1991) reported that downy birch is ecologically more flexible than silver birch, but from a forestry point of view is less productive. Worrell (1999) reported that silver birch grows approximately 20-100% faster than downy birch depending on the site. In both Finland and Sweden, studies have shown that silver birch gives a 15-20% greater volume yield than downy birch (Frivold and Mielikaninen 1991). Braastad (1985) reported a 1.5 m^3 ha^{-1} yr^{-1} higher potential yield of silver birch than downy birch. Yield models constructed by Koivisto (1959) show that, on similar site classes, the total yield of silver birch over a period of 60 years is over 100 m^3 ha^{-1} greater than that of downy birch.

Materials and methods

Selection of stands

Stands with a minimum area of 1 ha, having a stocking greater than 80% of full (normal stocking) and with an age within the range of 15 to 60 years were selected as candidate study sites. Thirty-three stands, including a number that were privately owned, were visited. Six stands, which were considered to meet the selection criteria, were selected for inclusion in the study (Table 1). No distinction was made between stands originating from natural regeneration, planted stands, or stands comprised of the two forms of regeneration.

Table 1: *Study sites - location, stand and site characteristics, and sample plot data.*

Site description	*Site 1*	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Site 6*
Coillte forest	Bunclody	Portlaoise	Private	Portlaoise	Kinnitty	Lough Owel
County	Wexford	Laois	Wicklow	Laois	Offaly	Westmeath
Aspect	SE	NW	SW	NW	S	W
Elevation (m)	180	120	150	60	50	80
Exposure	Exposed	Moderate	Sheltered	Sheltered	Moderate	Moderate
Soil	Brown pod-zolic	Raised bog	Grey-brown podzolic	Gley	Raised bog	Fen peat
Stand area (ha)	2.3	1.0	2.0	2.9	2.3	4.8
Form of regeneration	Planted	Mixed	Natural	Planted	Planted	Planted
% birch	100	97	81	100	97	100
Birch stocking (trees ha^{-1})	2750	3263	975	1513	1763	1413
Stand age[1] (yr)	34	21-22	49-52	41-43	32-38	58-68
No. sample trees	14	14	20	18	17	17
No. sample discs	181	162	286	271	223	210
Basal area (m^2 ha^{-1})	33	19	29	32	31	22
Mean dbh (cm)	12.4	8.6	19.4	16.3	14.8	14.0
Total volume ob[2] (m^3 ha^{-1})	172	100	170	203	191	115
Annualised volume (m^3 yr^{-1})	5.06	4.76	3.40	4.83	5.46	1.85
Top height (m)	14.03	12.83	17.08	16.40	14.86	14.63

Field measurements and sample tree analysis

Two 0.04 ha plots were randomly located in each of the six stands. Care was taken to avoid locating the plots near the edge of the selected stands. A complete tally was made of all stems within the plots. The diameter at breast height (dbh) of all living stems (greater than or equal to 7 cm) was recorded to the nearest millimetre. The sample tree selection method followed a procedure adopted by Borowski (1954) and Turnbull (1958). In one of the two plots on each site, the trees were classified into 20 mm (2 cm) diameter classes. The average basal area in each diameter class was calculated. Two trees of average basal area from each diameter class were located within the plot. (It was assumed that the selected sample trees had volume increments typical of their diameter class.) Where the average dbh did not correspond to an actual tree diameter within a given diameter class, trees with a diameter nearest to the average were selected. In instances where only one tree was recorded for a given diameter class, only this tree was selected as a representative sample tree.

[1] Age or age range determined from sample tree ring counts

[2] Over-bark

One hundred sample trees were felled in all. Tree ring data were collected from 1333 sample tree discs. The discs (2-3 cm thick) were cut were cut at the stump and at 1 m intervals along the main stem of the selected sample trees, up to top diameter of 2-3 cm. A disc was also taken from each tree at breast height. Disc sections were labelled according to the position (stem length) they were taken at on the main stem.

Discs were dried, sanded and prepared for stem analysis. The WinDENDRO system, comprising a specially designed software package and computer linked digital scanner, was the main tool used in capturing and calculating and ring width measurements from sample tree disk sections.

Height/age curves for the felled sample trees were calculated using Carmean's (1972) method of height estimation in stem analysis, including Newberry's (1991) adjustment. Sample tree volume under-bark (ub) to tip was calculated using the ring width and height data (calculated using Carmean's algorithm) from discs taken at fixed lengths (intervals of 1 m) along the main stem of the sample trees. A detailed account of the procedures adopted for field measurements, sample tree selection, sample preparation, stem analysis and sample tree height and volume growth calculations is given in Barrett (2000).

A linear model (i.e. a volume/basal area line) expressing the relationship between sample tree volume over-bark (ob) to tip and basal area was produced based on the sample trees in the two 0.04 ha plots at each site. These local volume equations were used to predict the total over-bark standing volume.

Determination of volume production and increment patterns

The historic patterns of under-bark volume production, mean annual increment (MAI) and mean (5-year) periodic increment (MPI) were calculated and plotted for each sample tree. Mean periodic increment instead of CAI (current annual increment) was used as it smoothes out the fluctuations that occur where annual growth rates are used. Historic patterns of under-bark volume production were calculated for each diameter class. Graphs depicting the under-bark volume production, MAI and MPI, for each of the diameter classes represented at each site, were constructed. Weighted curves describing the under-bark volume production and volume increment (MAI and MPI) for each of the 0.04 ha study plots were also constructed. These weighted curves were derived by multiplying the number of trees in a given diameter class, in the relevant study plot, by the average volume production values obtained for the two representative trees selected in that diameter class. The under-bark volumes for all diameter classes were summed to determine plot volume at 5-year intervals and MAI and MPI for each plot were then calculated. The weighted under-bark volume increment curves were used to summarise the historic pattern of under-bark volume production and increment for each stand. Over-bark, total standing volume estimates were determined based on the output of the site-specific volume/basal area equations. Confidence limits for the volume estimates were also determined.

In this paper we focus on a comparison between the six sites in the historical volume production and increment patterns and of the total standing volume estimates.

Results

Study sites/stands

All six stands included in the study contained trees with morphological characteristics commonly associated with downy birch. The test devised by Lungren *et al.* (1995) was used to make a conclusive determination of species. As no precipitate of platyphylloside was formed for any of the sample trees tested it was concluded that all stands consisted of downy birch.

Mean annual and mean periodic increment patterns

Site 1: Tombrick, Co Wexford

Mean annual increment and MPI were calculated and plotted for the 0.04 ha study plot at site 1 (Figure 2). Mean periodic increment culminated at approximately year 27, while mean annual increment slowed to almost negligible levels after 30 years. The level of current annual increment will fall below that of mean annual increment at approximately 35 years when the latter will reach a maximum of approximately 4.75 m^3 ha^{-1} yr^{-1} (or 0.19 m^3 $plot^{-1}$ yr^{-1}).

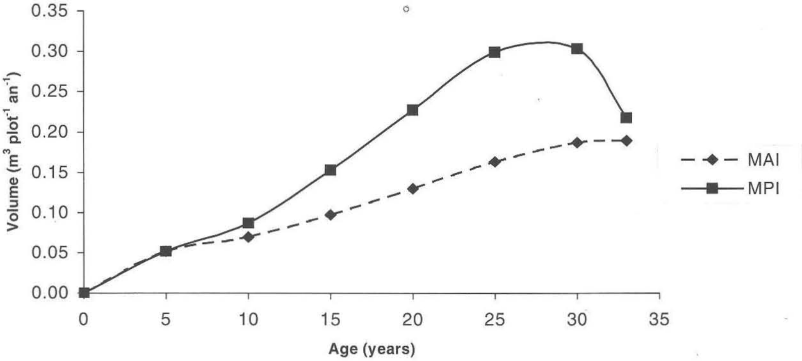

Figure 2: *SITE 1 - mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Site 2: Colt, Co Laois

Mean annual increment and mean periodic increment for the 0.04 ha study plot at Colt were calculated and plotted (Figure 3). Both mean annual and mean periodic increment (at 3.75 and 7.5 m^3 ha^{-1} yr^{-1} respectively) were still increasing after 21 years growth. Site 2 had the highest stocking level of the six sites, with 3263 trees ha^{-1}.

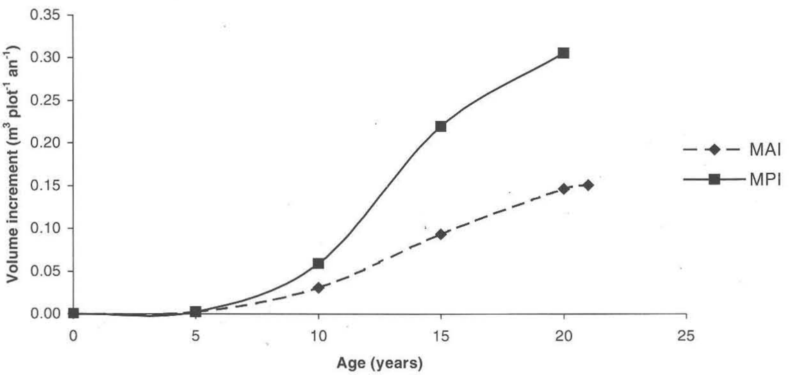

Figure 3: *SITE 2 - Mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Site 3: Croneybyrne, Co Wicklow

Mean periodic increment culminated at 35 years (Figure 4). There was a temporary decrease in plot MPI at year 30. Mean annual increment was still slowly increasing after 48 years. Culmination of mean annual increment is likely to occur within the next five years at an approximate level of 3.00 m^3 ha^{-1} yr^{-1} (or 0.12 m^3 $plot^{-1}$ yr^{-1}).

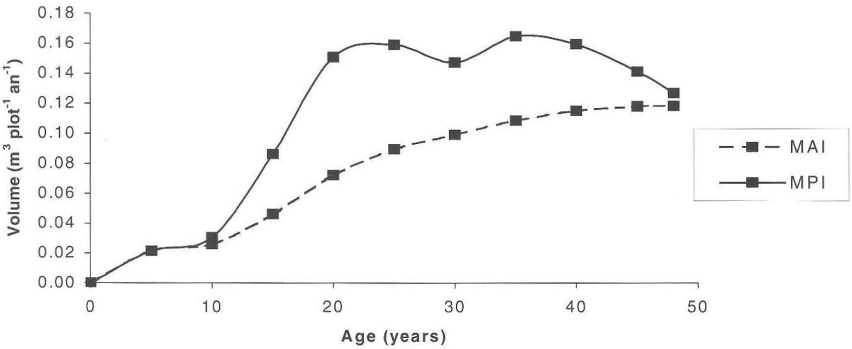

Figure 4: *SITE 3 - Mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Site 4: Togher, Co Laois

Maximum mean periodic increment for the plot occurred at approximately year 23. Mean annual increment culminated at year 35 (Figure 5). It appears that MPI will be equal to MAI at approximately 41 years, at an approximate level of 4.87 m^3 ha^{-1} yr^{-1} (or 0.195 m^3 $plot^{-1}$ yr^{-1}).

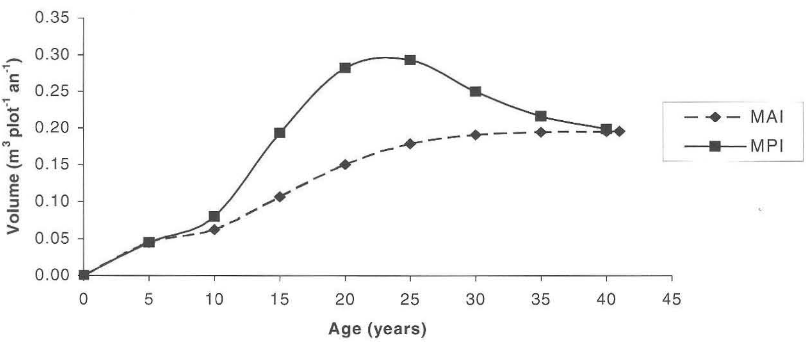

Figure 5: *SITE 4 - mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Site 5: Falsk, Co Offaly

Mean annual volume increment and MPI were determined to age 32 (the age of the youngest tree on the plot) (Figure 6). Both MAI (at 4.38 m^3 ha^{-1} yr^{-1}) and MPI (at 7.00 m^3 ha^{-1} yr^{-1}) were still increasing after 32 years. A temporary dip in the pattern of MPI was evident at 25 years, corresponding to similar occurrences in most of the diameter classes present in the stand.

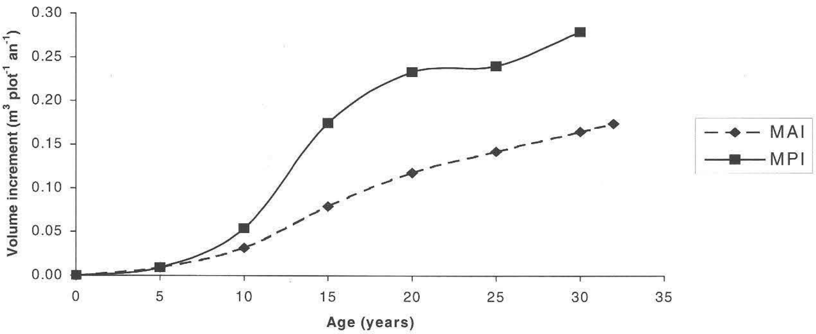

Figure 6: *SITE 5 - Mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Site 6: Cloonagh, Co Westmeath

Mean periodic increment culminated at 2.93 m^3 ha^{-1} yr^{-1} at 55 years (Figure 7). Mean annual increment was still increasing after 58 years. The assumption of a linear growth pattern in trees in the suppressed diameter classes (8-10 cm and 10-12 cm) introduced a slight distortion in the plotted MAI and MPI curves up until approximately 15 years, similar to those in the curves for sites 1, 3 and 4.

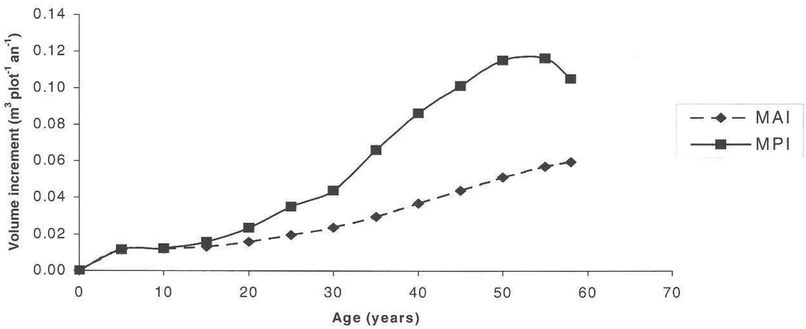

Figure 7: *Site 6 - Mean annual (MAI) and mean periodic (MPI) volume increment patterns.*

Under-bark volume production patterns

Curves of weighted under-bark volume production at 5-year intervals were calculated based on the tree ring analysis data (Figure 8). Birch growing at site 4 reached the highest volume production at 200.0 m^3 ha^{-1} (or 8.0 m^3 $plot^{-1}$) after 41 years. The production of the birch growing at site 6 at 87.5 m^3 ha^{-1} (or 3.5 m^3 $plot^{-1}$) after 58 years was the lowest of the stands examined.

The varying stocking densities and ages of the six stands (Table 1) resulted in confounding of site productivity and stocking. As a result, direct comparison of the six sites based on the historical patterns of volume production may not be truly indicative of potential site productivity.

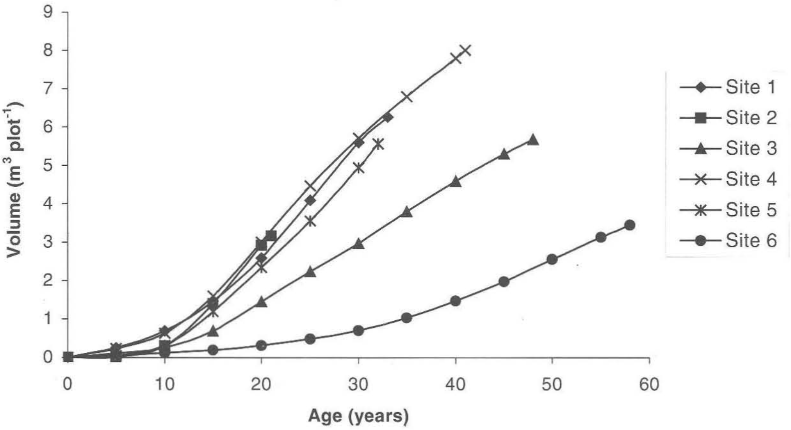

Figure 8: *Under-bark volume production patterns for the six sites, based on tree ring analysis.*

Over-bark standing volume estimation

Volume/basal area equations

A linear model (i.e. a volume/basal area line) expressing the relationship between sample tree over-bark volume (to tip) and basal area was developed based on the sample trees selected and felled in the 0.04 ha plots at each site. These local volume equations were used to predict the total over-bark standing volume (to tip).

A strong positive linear relationship between over-bark volume and basal area was evident across the range of diameter classes sampled. Regression analysis was used to express this relationship for each site (Table 2). The form of the regression equation was:

$$volume = a + b\,BA$$

where, volume = total stem volume to tip (m^3),
BA = basal area (m^2),
a and b are regression coefficients.

The inclusion of an outlying volume value for one tree in the analysis for site 4 resulted in a poorer correlation between sample tree volume and basal area than the values found for the other sites.

Table 2: *Regression coefficients and R^2 values for the volume/basal area relationships for the six sites.*

Site	*a*	*b*	R^2
1. Tombrick	-0.0040	5.5320	0.9803
2. Colt	-0.0038	5.8765	0.9732
3. Croneybyrne	-0.0054	6.0859	0.9713
4. Togher	0.0040	6.2031	0.8942
5. Falsk	0.0023	6.1336	0.9803
6. Cloonagh	-0.0094	5.8960	0.9643

Total volume estimates

The volume / basal area equations were used to derive total plot and per ha over-bark volume estimates for each site. Basal area was calculated for each of the trees recorded in the two 0.04 ha study plots at each site. Volume per tree was calculated by substituting the basal area for each tree into the volume/basal area equation for the site. Tree, plot and per ha volume estimates and associated 95% confidence intervals were then determined (Table.3).

Table 3: *Standing volume estimates and confidence limits obtained using the volume/basal area equations, for each of the six sites.*

Site	*Predicted standing volume*	*95% confidence limit*	
		Lower	*Upper*
		$m^3\ ha^{-1}$	
1. Tombrick	172.49	118.29	226.74
2. Colt	99.73	46.99	152.41
3. Croneybyrne	170.19	124.59	215.80
4. Togher	203.00	98.26	307.73
5. Falsk	191.19	144.46	237.90
6. Cloonagh	114.59	51.70	177.49

Discussion

The objective of the study was to examine the growth potential of birch in Ireland. The growth patterns, in terms of volume increment and total volume production, of selected birch stands were examined and contrasted in detail, using stem analysis.

Volume increment patterns

Examination of the patterns of volume increment revealed that culmination of mean periodic increment (MPI) occurred after 27 years for site 1, after 35 years for site 3, after 23 years for site 4 and after 55 years for site 6. The levels of MPI were still increasing at sites 2 and 5 after 20 and 30 years respectively. Mean annual increment (MAI) became almost constant after 30 years at site 1, after 45 years at site 3 and after 35 years at site 4. MAI was still increasing at sites 2, 5 and 6 after 21, 32 and 58 years respectively. A temporary fall-off in the level of MPI was evident at site 3 and site 5 after 25 and 30 years respectively. This may have been caused by intermittent waterlogging or flooding, combined with the effects of exposure.

Under-bark volume production patterns

A comparison of the historical patterns of under-bark volume production revealed that the under-bark volume production patterns at sites 1, 2, 4 and 5 were very similar. The rate of volume production was increasing at site 1 to 30 years, at site 2 to 20 years, at site 3 to 35 years, at site 4 to 25 years and at site 6 to 55 years. After these points the rate of volume production began to decrease. The rate of volume production at site 5 was still increasing after 32 years of stand growth. The highest rate of volume growth occurred at site 5 between the ages of 30 and 32 years.

Over-bark total standing volume estimation

As expected, there was a strong positive correlation between sample tree basal area and (over-bark) tree volume at all sites (i.e. R^2 greater than or equal to 0.96 for sites 1, 2, 3, 5, and 6 and 0.89 for site 4). The volume/basal area equations used to estimate plot and per ha standing volumes showed that over-bark standing volume estimates ranged from a high of 203 m^3 ha^{-1} for site 4 to a low of 100 m^3 ha^{-1} for site 2 (Table 3). Annualised standing volume production (derived by dividing the estimated standing volume by the average age of sample trees for each site) ranged from a high of 5.46 m^3 ha^{-1} yr^{-1} for site 5 to a low of 1.85 m^3 ha^{-1} yr^{-1} for site 6 (Table 1). However, a direct comparison of total standing volume at the 6 sites may not give a true picture of site productivity because of the lack of stand management, varying stand ages and varying stocking densities.

Comparison of total volume production with Forestry Commission yield models

A detailed comparison of the patterns of volume production found at the six study sites with the patterns of volume production indicated by the Forestry Commission (FC) yield models has not been carried out for three main reasons. First, the volume production values presented in the FC yield models are over-bark volume values. The volume production values for the stands included in this study, calculated using the stem analysis method, are under-bark. Second, the per ha volume values presented in the FC yield models are to 7 cm top diameter, or to the point at which no main stem is distinguishable, whichever comes first. The volume growth of trees in this study was calculated to the tip of the tree. Third, the characteristics of the stands included in this study deviated significantly from the particular treatment regimes set out in the FC models (i.e. the thinning regime and stocking rates), so that direct comparisons of the patterns of volume production were not valid. However, despite these discrepancies, it does appear that total volume production in (unthinned) birch stands in Ireland is very similar to the total volume (i.e. the volume of the main crop and the thinnings) for crops of similar yield class as presented in the FC yield tables. Assuming that significant mortality has occurred due to a lack of thinning, it would appear that the total volume production of Irish stands could exceed the corresponding values in the FC yield tables.

Conclusions and recommendations

This study has successfully demonstrated the usefulness of stem analysis as a technique for determining the past growth history of stands and trees where records are lacking. The results showed that for well stocked, unthinned, even-aged stands of downy birch, the period of maximum radial growth occurred during the period from 5 to 20 years of age. The fastest growing tree was capable of achieving a diameter of 25 cm in 32 years. Maximum height growth occurred before 20 years and fast growing trees achieved a height growth of more than 1 m per year during this period. However, the lack of management, in particular the lack of adequate thinning, may have resulted in excessive crown competition and consequently reduced diameter growth in all of the stands included in this study.

The results showed that a well-stocked, unthinned stand of downy birch achieved a standing volume of 203 m^3 ha^{-1} in 42 years (site 4). Annualised volume production reached 5.46 m^3 ha^{-1} yr^{-1} in a 35-year-old stand (site 5). While some of the stands included had not reached the age of maximum mean annual increment, comparison with the FC yield models showed that stands of downy birch can achieve a YC of 8 (m^3 ha^{-1} yr^{-1}). Given the appropriate thinning regime, the total harvested volume production could potentially be raised to a level equivalent with YC 10, assuming that these regimes would allow for the recovery of significant amounts of volume currently lost due to high mortality rates in the overstocked stands. As this study represented only a preliminary investigation into the volume production of a small number of (unmanaged) birch stands, further research on the growth and yield of birch in this country is necessary. In particular, there is a need for a yield model, more specific to and more appropriate for the birch stands and site conditions found in this country.

Acknowledgements

This research project was carried out in co-operation with Coillte and was co-funded by COFORD (the National Council for Forest Research and Development) and University College Dublin.

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The field performance of bare-root stock compared with container stock of western hemlock and western red cedar under Irish conditions

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Abstract

The first-year survival and height growth of container-grown seedlings were compared with those achieved by bare-root stock of western red cedar (*Thuja plicata* D. Don) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) planted in field trials in Ireland. In the first experiment using western hemlock planted in 1995/96 on a reforestation site, there was no consistent effect of stock type or date of planting (October, December, January and March) on field performance. Seedlings planted on part of the site that was mounded survived better and suffered less weevil damage than those planted on the part that was not mounded. In the second experiment carried out in 1997/98, seedlings of both species were stored in co-extruded polythene bags at ambient temperatures for up to four weeks after lifting in November, December, January and March, and then planted on a reforestation site. Containerised seedlings of both species survived well in the field regardless of date of planting or duration of storage. However, bare-root western red cedar stock had a lower survival than containerised seedlings. Survival was reduced further by extended storage for plants lifted on some dates. Western hemlock bare-root stock survived well except for seedlings stored after lifting in February. Seedlings planted in March had the lowest survival (bare-root western red cedar only) and height increment (both species). Despite the superior tolerance of container stock to handling stresses, better performance can be expected for such seedlings planted before the end of February. Well-conditioned, carefully handled bare-root western hemlock should perform well if planted from November to February.

Introduction

The proportion of planting of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) in Ireland has been recognised in the government's forest strategy, *Growing for the Future* (Anon. 1996), as undesirably high. In order to increase species diversity there are higher grants available for planting 'diverse' conifers other than Sitka spruce or lodgepole pine (*Pinus contorta* (Dougl.)). Therefore, western red cedar (*Thuja plicata* D. Don) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) are among the species that are likely to become more widely planted in Ireland. Both can have a significantly higher end-use value than Sitka spruce, and may be viable alternatives to spruce on some sites. Both species can also be used in mixtures. However, achieving good establishment success has been a major problem with both species.

Currently, most planting in Ireland is done using bare-root stock. Bare-root seedlings[4], however, may be more prone to adverse handling stresses than container-grown stock

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[4] The term seedling is used in the broadest generic sense to include all phases of growth of planting stock in the nursery, including transplanted seedlings.

(Hobbs 1984, Tinus and Owston 1984), and western red cedar and western hemlock are considered relatively sensitive to poor handling. The use of containerised stock may also facilitate an extension of the planting season (Tinus and Owston 1984, Brissette *et al.* 1991). Another advantage is that the length of the production cycle is shorter for containerised seedlings (about 1 year) than for bare-root stock (2-4 years), thus making it easier to match supply with expected demand. However, containerised planting stock is more expensive to produce in Ireland, is limited in supply and is usually smaller than bare-root stock.

The main objective of this study was to compare the first-year field survival and growth of container-grown and bare-root stock of western red cedar and western hemlock planted in Ireland. The effect of planting date and plant storage duration (under ambient conditions) on field survival and growth was examined also.

Materials and methods

Bare-root and containerised seedlings were obtained from commercial nurseries and planted in a series of experiments established in 1995/96 and 1997/98. All of the western hemlock seedlings used in 1995/96 were derived from seeds that originated in the same seed zone in coastal Washington, USA (seed zone 030 (797); 0-150 m elevation). The containerised western red cedar seedlings used in 1996/97 were of Qualicum, Vancouver Island, BC, Canada seed origin (93(711) C1 Lot 2; 0-150 m). The western hemlock and western red cedar bare-root stock supplied from the Forestry Commission, Wykeham Nursery in 1997/98, were derived from seed that originated from Vancouver Island (probably from the only one recommended by the Forestry Commission (711) C1; 0-150 m)), but the exact origin is not known.

1995/96 experiment (Clogheen)

Bare-root and containerised western hemlock (western red cedar was not available that year) seedlings of four different stock types were used (Table 1). The seedlings were planted on four different dates: the 27 October and 12 December, 1995, and the 6 January and 26 March, 1996 at a site at Clogheen Forest (52° 16' N, 8° 00 W; 119 m elevation). A full factorial combination of the four stock types and four planting dates was used. The trial was established on a north-facing, sheltered reforestation site that previously had carried a crop of Scots pine (*Pinus sylvestris* L.). The soil was a peaty podsol of old red sandstone origin. The dominant vegetation consisted of *Calluna vulgaris, Ulex europaeus* and *Rhododendron ponticum*. No weed control measures were undertaken. The bare-root seedlings were carefully lifted a few days before planting, packed in co-extruded polythene bags and dispatched for planting. Similarly, the containerised stock was placed in waxed cardboard boxes and dispatched for planting. The site consisted of two separate areas, which were adjacent to each other (about 2-4 m apart at the closest point). One area was mounded while the other area was not. Each area had an identical design, containing a fully randomised block experiment with a full factorial combination of all treatments in each of three blocks. The plots were established as rows containing 30 seedlings. Because of the coarse nature of the soil (including stones and boulders), mound quality was poor. Seedlings were planted on top of the mounds. Plant spacing was 2 m within and between rows.

Table 1. *Western hemlock stock types used in 1995/96 at Clogheen, Co Tipperary. Values in parentheses are standard errors of the mean.*

Production system	*Stock description and age*	*Nursery of origin*	*Mean height cm*
Bareroot	2+2 transplant (4 years)	Cappagh Nursery Aughrim, Co Wicklow.	37.6 (1.10)
Bareroot	Transplanted miniplug[5], MP+1 (2 years)	Coillte Rathluirc, Co Cork.	25.8 (0.39)
Container	'Quick Pot' plug (2 years) 200 cm³ container	D. Buckley, Carrigtwohill, Co Cork.	29.3 (0.50)
Container	Finnpot[6] No. 628 (1 year) 148 cm³ container	M. Smith Tralee, Co Kerry.	17.3 (0.28)

1997/98 experiment (Aughrim)

In addition to evaluating the effect of stock type, the effect of temporary storage under ambient conditions prior to planting on the subsequent survival and first-year height increment of seedlings was investigated. One bare-root and one Finnpot containerised stock type each of western red cedar and western hemlock were used (Table 2). The Finnpot seedlings were dispatched in the container trays to the Coillte Tree Improvement Centre, Kilmacurra, Co Wicklow in November 1997 and held outside under ambient conditions until placed in bags for long-term storage.

Table 2. *Western red cedar and western hemlock stock types used in 1997/98, at the Aughrim, Co Wicklow experiment site. Values in parentheses are standard errors of the mean (n=60 and 84 for western hemlock and western red cedar, respectively).*

Species	*Production system*	*Stock description and age*	*Nursery of origin*	*Initial diameter[7] mm*	*Initial height[7] cm*
Western red cedar	Transplant	1u1 (2 years)	Forestry Commission, Wykeham Nursery, Yorkshire.	4.80 (0.286)	49.0 (2.55)
Western red cedar	Container	Finnpot No. 628 (1 year) 148 cm³ container volume	M. Smith, Tralee, Co Kerry.	2.79 (0.167)	27.7 (1.44)
Western hemlock	Transplant	1u1 (2 years)	Forestry Commission, Wykeham Nursery, Yorkshire.	2.67 (0.116)	28.2 (0.73)
Western hemlock	Container	Finnpot No. 628 (1 year) 148 cm³ container volume	M. Smith, Tralee, Co Kerry.	1.57 (0.054)	22.3 (0.48)

[5] Originated as miniplug container (16 cm³) seedlings (4-6 weeks old) that were transplanted in a bare-root nursery for remainder of cycle.

[6] Finnpots are made from a mixture of paper and peat with the entire pot being planted.

[7] Initial height and diameter values are based upon measurements made in the field immediately after planting.

Three hundred and fifty bare-root seedlings of each species were lifted on each occasion on 25 November 1997 and on 13 January, 20 February and 31 March 1998, dispatched in polythene co-extruded bags and arrived the next day at Kilmacurra. The stock was stored overnight at 2 to 4 °C. Seedlings of both stock types of each species were then subjected to 0 (no storage), 2 or 4 weeks storage under ambient conditions. The air (minimum and maximum) temperatures at Dublin Airport (data not available for Kilmacurra) during the period after lifting until the last date of planting for each lift date ranged from -3.4 to 13.3 °C, -4.8 to 12.2 °C, -0.7 to 14.5 °C, and -4.0 to 15.3 °C for the November, January, February and March lift dates, respectively. The bare-root plants were removed from the original co-extruded bags, bulked and mixed, and then divided into three bundles (containing at least 116 seedlings each). Each bundle was placed in a new co-extruded bag and assigned at random to one of the three storage-duration treatments. Similarly, 350 containerised seedlings were sampled at random from the container trays and placed in co-extruded bags on the same date as the bare-root stock was treated. The sealed co-extruded bags were placed in the shade at Kilmacurra.

After storage, the seedlings were dispatched to a reforestation site at Aughrim, Co Wicklow (52° 16' N, 8° 00' W; 119 m elevation) and planted within two days. The date of planting varied with the storage-duration treatment for each lift date. The trial was established on a moderately exposed reforestation site that previously had a crop of Scots pine. The soil was a free-draining podsol. Glyphosate (3 l ha^{-1} a.i.) was applied prior to planting to control competing vegetation. The experiment was a randomised block, factorial design with seven blocks. Each block contained a single replication of each of the 48 treatment combinations (two species x two stock types x four lift dates x three storage durations). Each replicate was a row containing 10 seedlings. The site was 'spot' mounded (i.e. without additional drainage) at 2 m intervals. The seedlings were planted on the top of the mounds.

Measurements, observations and data analyses

Survival, initial height (measured shortly after planting) and height at the end of the first growing season were recorded for plants in each experiment. Height increment as a percent of initial height was determined from these data (this parameter is a good indicator of relative height increment of seedlings when initial height differs). Weevil damage levels were recorded for the 1995/96 trial at Clogheen, but little or no damage was noted on seedlings growing at Aughrim.

The data were analysed using a randomised block factorial design using replicate means at each site to test for the effects of stock type, planting date and the interaction of stock type with planting date. Storage duration and its interaction with stock type and planting date were used as additional factors for the 1997/98 data. Performance of the stock on the two areas at Clogheen could not be statistically compared because the design did not permit this (i.e. the soil preparation treatment was not randomised within the site). The data for percentage survival and percentage of seedlings that suffered from weevil damage were transformed to arc-sine square root proportion before analyses.

Results

1995/96 experiment (Clogheen)

Although the effect of soil preparation could not be compared statistically (confounded with separate areas of site), survival was better for seedlings planted on the mounded area (92%, averaged across all treatments) than on the uncultivated area (84%). However, percent height increment in the first year after planting (increment as percentage of initial height) was similar for seedlings growing on the mounded area (137%) and on the uncultivated area (141%).

Stock type (two bare-root and two containerised stock types), lift date and their interactions significantly influenced survival at each area of the site (Table 3). In general, survival was high (>80%) for all stock types, except for some seedlings planted in March (Figure 1). The MP+1 (containerised minplugs transplanted in a bare-root nursery) transplants (70%) growing on the uncultivated area, and the Finnpot containerised seedlings planted in March on both the uncultivated and mounded areas had poor survival (43 and 54%, respectively).

Table 3. *The effect of stock type and lift date and their interaction on the survival and growth of western hemlock seedlings planted on uncultivated area and mounded areas at Clogheen in 1995/96. Values in bold font are significant at the p≤ 0.05 level.*

Treatment	*Survival*		*Percent height increment*		*Weevil damage*	
	Uncultivated	*Mounded*	*Uncultivated*	*Mounded*	*Uncultivated*	*Mounded*
	p≤					
Stock (S)	**0.0007**	**0.0001**	**0.0005**	0.1979	**0.0037**	**0.0023**
Lift date (L)	**0.0015**	**0.0054**	**0.0001**	**0.0001**	**0.0031**	0.3891
S x L	**0.0021**	**0.0024**	**0.0001**	**0.0005**	0.3653	0.2018

Stock type, lift date and their interactions significantly affected percent height increment for seedlings growing on the uncultivated area, whereas stock type effects alone were significant for those growing on the mounded area (Table 3). In general, percent height increment of the containerised stock was similar to that of the bare-root stock (Figure 2). The difference between planting dates in height increment was greatest for seedlings planted on the uncultivated area. Except for the March lift date, there was little or no difference in height increment between stock types for seedlings lifted on other dates. Percent height increment was particularly low for seedlings planted in March. The Finnpot seedlings planted that month had the lowest increment (88%); survival was also low for these seedlings. However, percent height increment after planting was high for seedlings of this stock type lifted on other dates, especially for seedlings planted on the uncultivated area.

Weevil damage to seedlings was more frequent on seedlings growing on the uncultivated area (46%) than on the mounded area (20%), although differences between the two areas could not be validated statistically. Stock type and planting date significantly influenced the amount of weevil damage within each area, but their interactions were not significant (Table 3). On average, weevil damage was less severe for seedlings lifted and planted in March (Figure 3). There was no consistent effect of stock type on the frequency of weevil damage.

1997/98 experiment (Aughrim)

Lift date, and the interaction of stock type with lift date influenced survival of both species, while stock type alone also affected survival of western red cedar (Table 4). In general, the survival of containerised stock was high (86-100%), regardless of species, planting date, or duration of storage in co-extruded bags under ambient conditions prior to planting

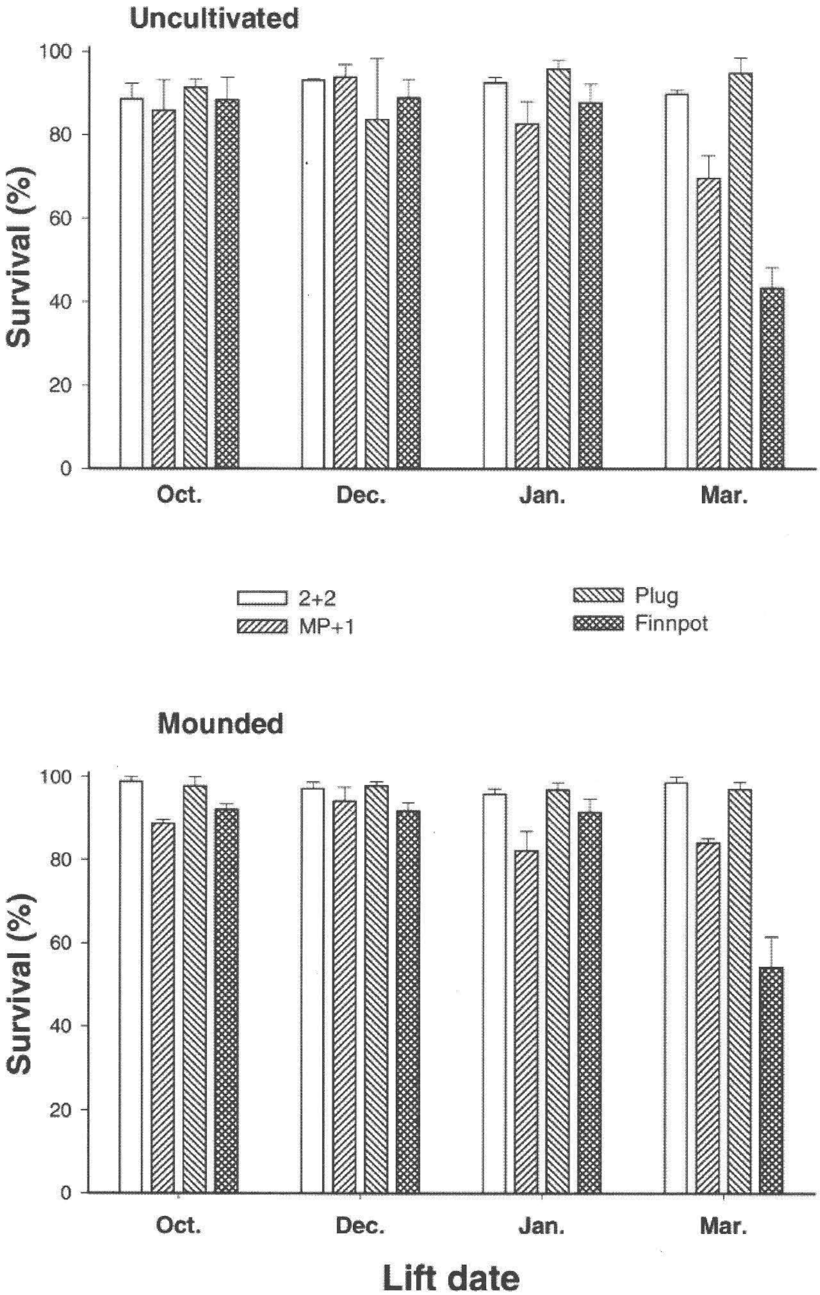

Figure 1. *Survival of western hemlock seedlings at the end of the first growing season at Clogheen. Vertical lines are standard errors.*

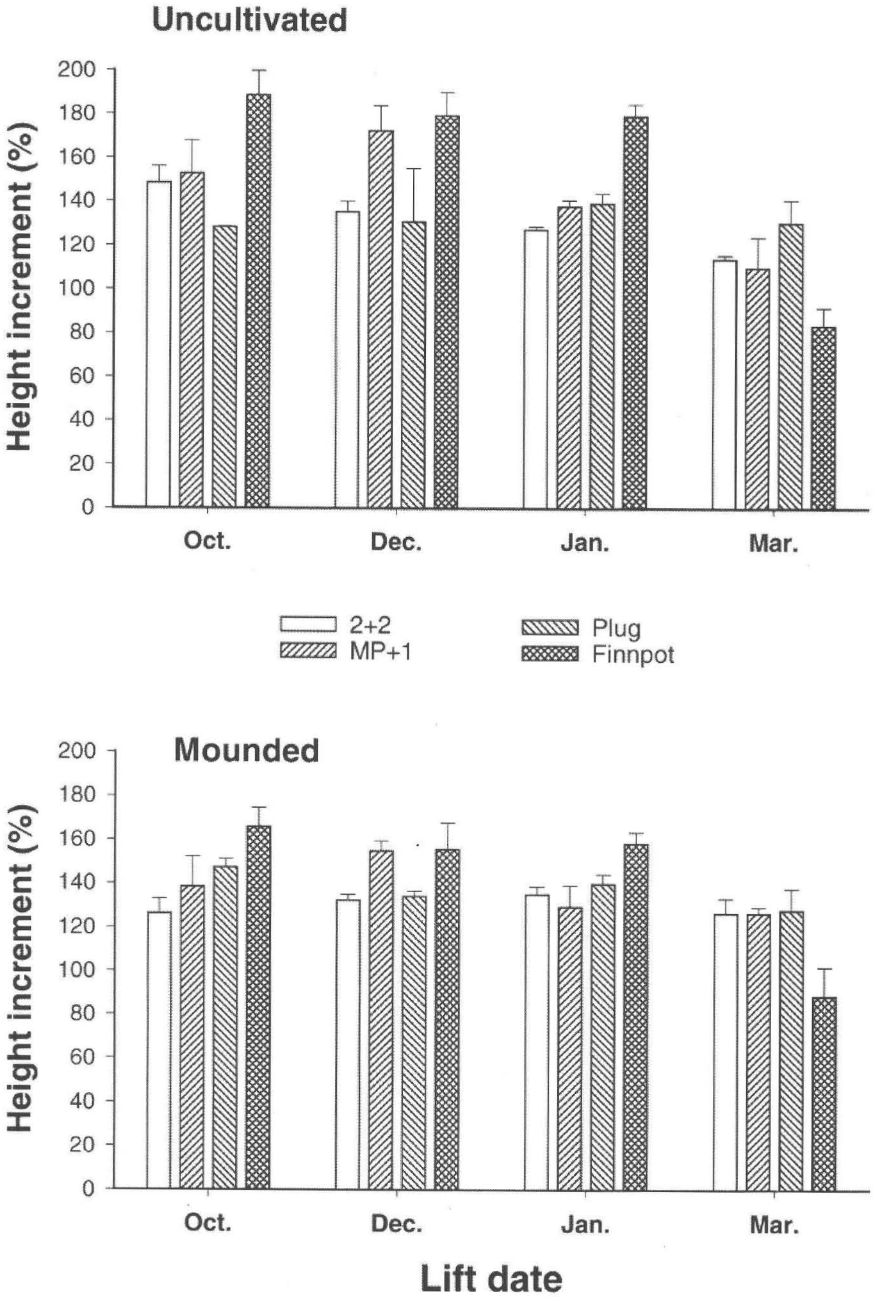

Figure 2. *Height increment of western hemlock seedlings at the end of the first growing season at Clogheen. Vertical lines are standard errors.*

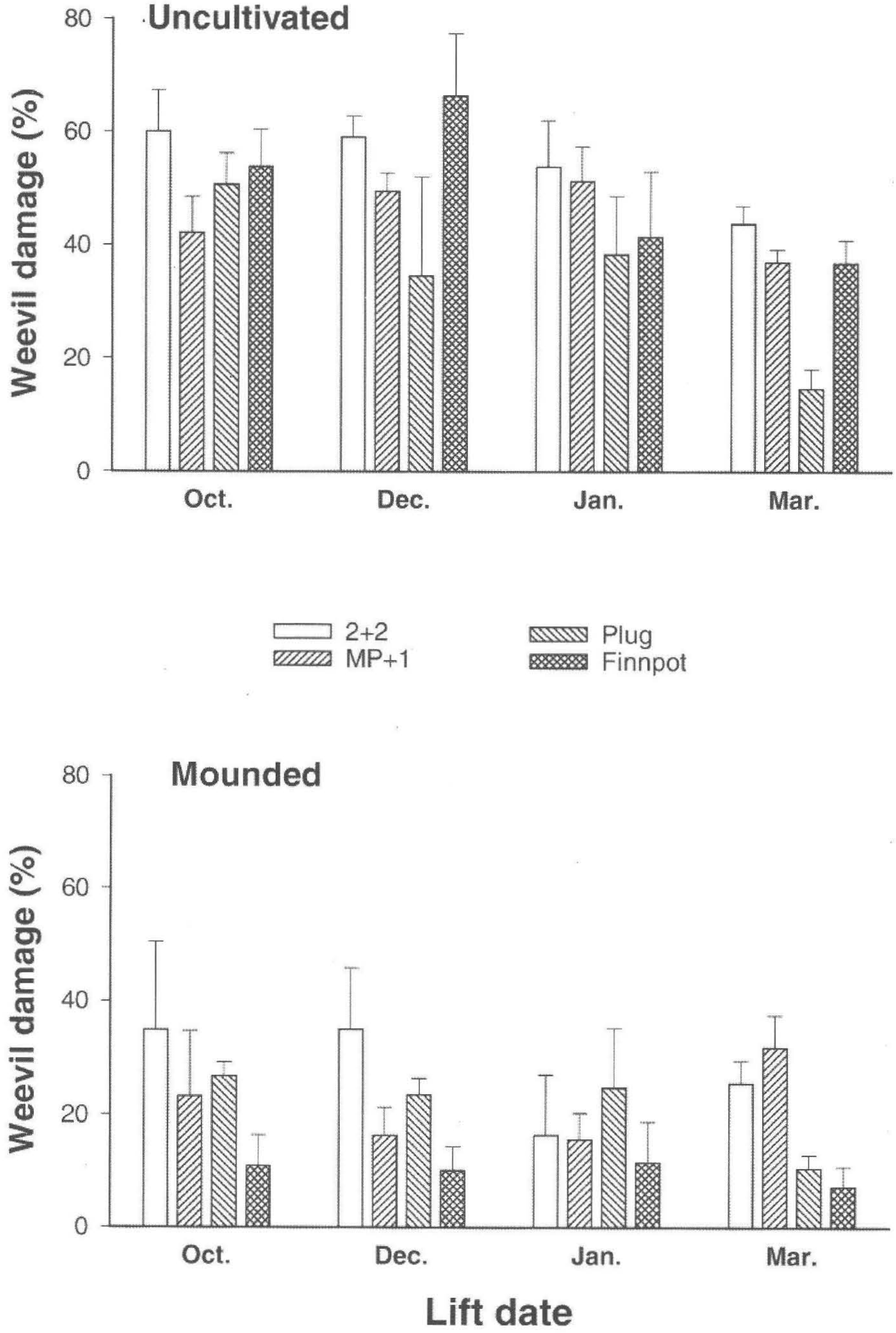

Figure 3. *Proportion of western hemlock seedlings damaged by large pine weevil at the end of the first growing season at Clogheen. Vertical lines are standard errors.*

(Figure 4). Treatment effects were larger for the transplants, especially in western red cedar. Survival of western red cedar was low for the transplants planted soon after lifting (0 days storage) in November (56%) and March (53%), but was good for those lifted in January (86%) and February (98%). Storage for up to four weeks had little effect on survival for seedlings lifted in November or February, but reduced it for those lifted in January or March. Storage for four weeks reduced survival from 86% to 60% for western red cedar seedlings lifted in January and from 54% to 22% for those lifted in March. In contrast, lift date had a small effect on survival in western hemlock. Storage reduced survival from 91% to 61% (two weeks) and 70% (4 weeks) for seedlings lifted in February, but storage had little effect for seedlings lifted on other dates.

Percent height increment was influenced by stock type and lift date for both species, but many treatment interactions were also significant for western hemlock (Table 4). On average, percent height increment after planting of seedlings lifted in March was lower than for those lifted on other dates in both species (Figure 5). For freshly planted (0 days storage) western red cedar, bare-root (41%) and containerised (71%) seedlings lifted in November grew well compared with those lifted in March (0% and 23%, respectively). However, survival of bare root western red cedar seedlings was poor, except for stock lifted in February (Figure 4). Ambient storage duration had no effect on percent height increment in western red cedar, except for stock lifted in March (Figure 5). The shoots of plants stored after lifting in March died back after planting, reducing increment from 0% to -25% (25% shorter than at the time of planting). In general, containerised western hemlock grew better than the bare-root stock. Storage had no consistent effect on height increment in western hemlock, although it appeared to increase increment for containerised stock lifted in November.

Table 4. *The effect of planting stock type, lift date, and storage duration on the survival and height increment of western red cedar and western hemlock seedlings planted at Aughrim in 1997/98. Values in bold font are significant at the p≤ 0.05 level.*

Treatment	*Survival*		*Percent height increment*	
	Western red cedar	*Western hemlock*	*Western red cedar*	*Western hemlock*
		p≤		
Stock (S)	**0.0001**	0.3016	**0.0001**	**0.0001**
Lift date (L)	**0.0001**	**0.0001**	**0.0003**	**0.0001**
Storage (ST)	0.1093	0.2563	0.8029	0.8143
S x L	**0.0001**	**0.0135**	0.5778	**0.0009**
S x ST	**0.0302**	0.4215	0.5274	0.5125
L x ST	0.9942	0.2318	0.9867	**0.0194**
S x L x ST	**0.0015**	0.0651	0.7590	**0.0236**

Discussion

The results of this study showed that survival and early height growth could be improved by using containerised stock of western red cedar and western hemlock compared with using bare-root stock. In particular, mortality after planting is likely to be lower for containerised stock than for bare-root stock, especially following adverse handling. Bare-root western red cedar seedlings were more sensitive to duration of ambient storage than

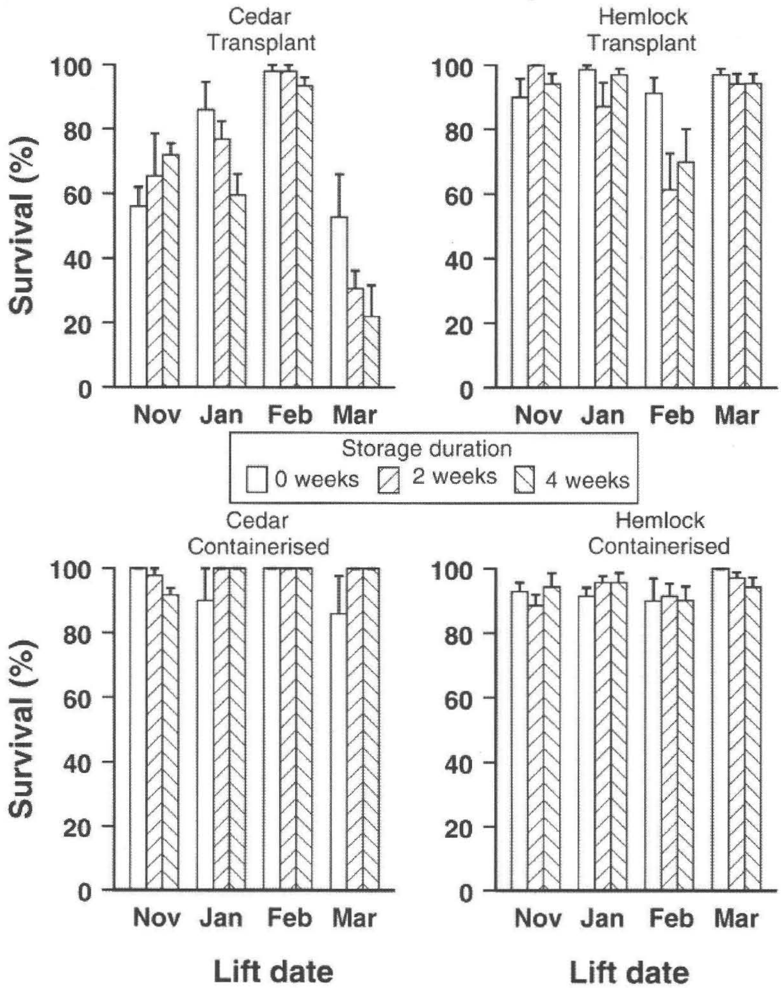

Figure 4. *Survival at the end of the first growing season of bare-root and containerised western red cedar and western hemlock seedlings stored for up to four weeks under ambient condition prior to planting at Aughrim. Vertical lines are standard errors.*

bare-root western hemlock seedlings. Nevertheless, bare-root western hemlock should perform well in the field provided the stock is carefully handled and planted between November and March.

In general, height growth (western hemlock only) was better at the Clogheen site than at the Aughrim site. Differences in soil and weather conditions after planting and/or other site factors and differences in the characteristics of the stock used may have contributed to the variation in seedling height growth between sites, but the exact reason(s) is (are) unknown.

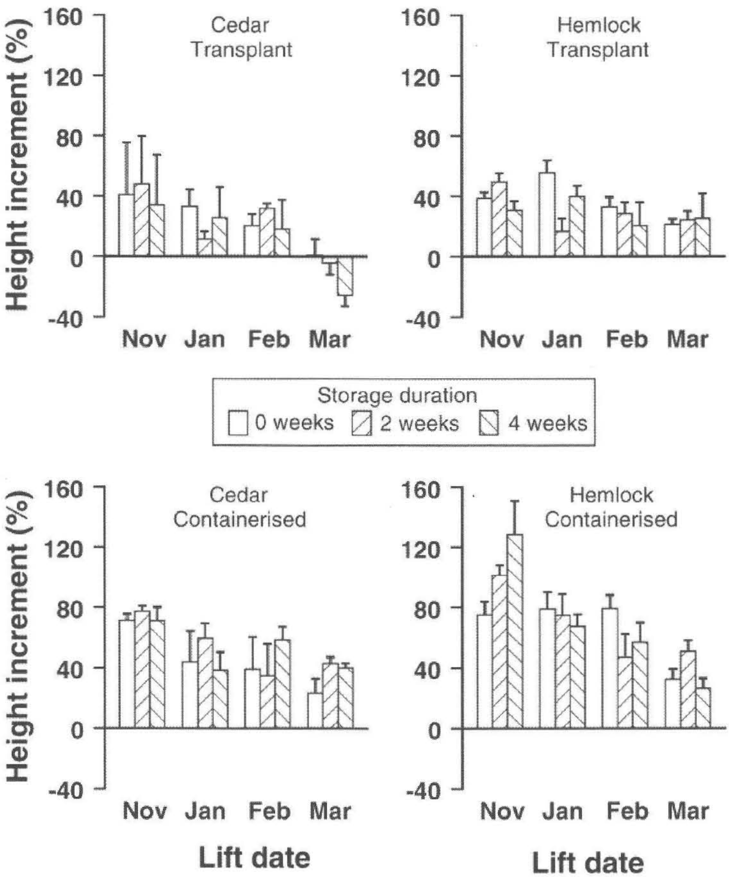

Figure 5. *Height increment at the end of the first growing season as a percent of initial height of bare-root and containerised western red cedar and western hemlock seedlings stored for up to four weeks under ambient condition prior to planting at Aughrim. Vertical lines are standard errors.*

For seedlings planted at Clogheen in 1995/96 (western hemlock only), survival was slightly better on the mounded than on the uncultivated area, but percent height increment was similar for seedlings growing on both areas. Since mounded ground is usually warmer, drier, and has less vegetation, thus favouring root growth (Nelson and Ray 1990), it is not surprising that the seedlings were observed to have survived better on mounds.

Seedlings growing on the mounded area also suffered less weevil damage than those grown on the uncultivated area. This effect has been found for other species (Orlander and Nilsson 1999). Although smaller on average at planting than the bare-root stock (Table 1), both stock types suffered similar levels of weevil damage.

There was no consistent effect of stock type or planting date on survival or growth of seedlings in the 1995/96 experiment at Clogheen, perhaps because all stock was handled carefully prior to planting. However, results from the 1997/98 experiment indicate that while western hemlock bare-root seedlings survived well, better height growth could be expected from container stock.

The main finding of the second experiment, carried out at Aughrim in 1997/98, was that containerised seedlings of western red cedar and western hemlock survived well in the field regardless of date of planting or duration of storage. Survival of bare-root stock was lower than that of containerised stock of western red cedar and was reduced further by storage treatment for seedlings lifted on some dates. Western hemlock bare-root stock survived well, except for those stored after lifting in February. In addition, seedlings lifted in March (and planted into April) had poor survival (bare-root western red cedar only) and/or height increment, similar to the results for western hemlock in the first experiment. In Ireland, much planting is carried out in March and April, but the results from this study indicate that field performance might not be consistent for seedlings planted during this period, as found previously in Ireland for bare root seedling of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) (O'Reilly *et al.* 1999a&b), hybrid larch (*Larix* x *eurolepsis* Henry) (O'Reilly *et al.* 2001) and some broadleaved species (O'Reilly *et al.* 1999c).

Results from many other studies have shown that containerised stock outperform bare-root stock, especially on demanding sites (Arnott 1976, Amidon *et al.* 1982, Hobbs *et al.* 1982, Hahn and Smith 1983), although this may not always be the case (Mason and Biggin 1988, Helgerson *et al.* 1989). The effect may be species-specific. For example, in one study conducted in British Columbia, bare-root stock of Douglas fir performed best, but containerised stock outperformed bare-root stock in western hemlock (Arnott 1975).

Although the duration of storage prior to planting either reduced or had little effect on field performance in most cases in this study, it appeared to improve height increment for containerised western hemlock lifted in November in the Aughrim experiment. It is not clear if this is an anomalous or real effect. Perhaps the roots of the seedlings lifted in November became active (in the plug) while in storage prior to planting, thus allowing them to become established quickly following planting. However, a longer period of storage might have caused deterioration. Since the date of planting also varied with duration of storage, environmental conditions that favour establishment success after planting may have been more favourable for those stored for the longest period after lifting in November. Nevertheless, the results show that storage prior to planting generally reduced field performance, especially for bare-root stock.

Because of differences in initial height, percent height increment was used as a measure of plant growth in this study. While the relative growth of tall plants may be less than that of shorter plants, absolute height growth is often greater. Tall seedlings frequently outperform shorter seedlings in the long term on many sites, as shown for bare-root Sitka spruce seedlings in Britain (South and Mason 1993). Absolute height increment of the taller bare-root stock was compared with that of the shorter containerised seedlings in this study also, and this would slightly reduce differences between stock types (data not shown). Nevertheless, the survival and height growth responses of the containerised stock were more consistent, regardless of treatment.

The advantage of using containerised rather than bare-root stock of western red cedar and western hemlock may be much greater in operational forestry than is suggested from the results presented here. Under operational forestry conditions, seedlings are subjected to a variety of handling stresses, including the possibility of suffering from desiccation damage (McKay 1997, McKay *et al.* 1994). Container seedlings are likely to withstand desiccation stress better than bare-root seedlings (*ibid.*), thus probably magnifying the differences between stock types. Nevertheless, some caution should be exercised in extrapolating these results to operational forestry.

Results from the first year's (western hemlock only) experiment revealed that is important to use good quality seedlings, regardless of stock type. Good field performance cannot be expected from using poor quality containerised stock. Furthermore, containerised seedlings are not immune to adverse handling; they are particularly prone to damage if handled when the shoots are succulent (Brissette *et al.* 1991). There is a general perception that the growth of container stock is not influenced greatly by planting date, but the results of this study showed that planting date influenced height growth of container stock (proportionally) more than that of bare-root stock. Therefore, container stock should not be used to extend the planting season if first-year height increment is considered important, but they can be used successfully if high survival alone is considered sufficient. Container stock may need more early post-planting care (e.g. weed control), although this may not be a major factor since they may grow more quickly.

It is unlikely that provenance differences could have greatly influenced the results reported in this study since most of the stock originated from similar part of the species range (most from the same seed zones). The cultural practices used in the nurseries and differences in stock size (as discussed above) may have confounded differences due to production system used. Finally, only one year's data are available for western red cedar.

Conclusions and recommendations

1. Containerised seedlings of western hemlock and western red cedar are likely to suffer less from handling stresses and therefore are likely to outperform bare-root stock in the field. The advantage of using containerised stock is greater for western red cedar than for western hemlock. Despite the superior tolerance of handling stresses, better performance can be expected from container stock planted before the end of February.
2. Well conditioned and carefully handled bare-root western hemlock may perform well if planted from November to February, and because they are generally larger than container stock, may need less weed control.
3. Mounding may improve the growth performance of western hemlock (western red cedar not tested) and may reduce the incidence of weevil damage. Surprisingly, although the transplants were taller than the container seedlings at Clogheen, weevil damage was similar in both stock types.

Acknowledgements

Financial support was provided by COFORD and Coillte. Several Coillte personnel assisted in carrying out this work, including John Fennessy (Kilmacurra), Joe Kilbride (Clogheen) and John Hogan (Aughrim).

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A review of historical literature on the pruning (formative shaping) of broadleaved trees from the sixteenth to the nineteenth century

Michael Bulfin[1] and Toddy Radford[2]

Abstract
This paper is a review of selected historical British literature on tree pruning from 1595 to about 1840. The authors strongly promoted the use of early pruning (formative shaping) to improve stem quality in broadleaved trees, especially in beech (*Fagus sylvatica* L.) and oak (*Quercus* spp.). They indicated that pruning was needed despite the high planting density used at that time. Most authors advocated pruning in the first year. All authors indicated that pruning should be a continuous process over a number of years. Those who examined the correct season for pruning advocated summer pruning. Some authors advised against the use of 'flush' pruning or leaving 'snags'.

Keywords: Broadleaves, historical review, formative shaping, pruning, time of pruning, leader training, stumping-back.

Introduction
As part of a research programme on formative shaping of broadleaved species at Teagasc, Kinsealy Research Centre (Bulfin and Radford 1998a&b) an extensive contemporary scientific literature review was carried out. This review highlighted references to earlier papers and books dealing with the history of broadleaved management, including early shaping and pruning practices. We have identified, located and transcribed a number of treatises and publications on this topic, written by authors from the 16th to the 19th centuries. The level of insight and skill shown by these authors was striking. It was decided to extract and publish this information to enlighten and inform, and to stir debate among those now involved in the early management of young broadleaved plantations.

There is strong evidence in the literature that significant knowledge, skill and expertise existed in previous centuries – albeit somewhat contradictory at times – in relation to broadleaf shaping and pruning. This may explain why the remnants of some very fine old broadleaved woodlands exist containing trees with good straight and clean boles.

A number of the treatises written on this subject over the centuries are reviewed below. At times these texts gave the present authors the distinct feeling that our work on formative shaping was a 'reinvention of the wheel'. The one new element that we have brought to this area of silviculture – and which encouraged us to persevere – was the application of a rigorous scientific methodology to the study of formative shaping. However, it was great encouragement to look over our shoulders – so to speak – and find corroboration of our findings from such historic sources. This paper has been written as a tribute to these early woodsmen, in an effort to highlight their contributions to silviculture and to reconnect with their expertise. If some of the comments appear somewhat stilted it may be that we have

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unconsciously adopted the authors' more courtly and circumlocutory style. The authors' exact words and spelling have been retained, as are some archaic words such as "shew" and "timeous".

In most cases it is clear from the text that the authors' discussions on pruning refer to the early shaping of young broadleaved trees. In the context of Irish broadleaf silviculture the term early pruning is more correctly referred to as formative shaping (of young broadleaves). The aim of formative shaping is to produce a single straight stem up to 3-4 m long. Many of the recommendations indicate that the authors had an intuitive grasp of tree physiology and directed their efforts to enhancing nature's own natural processes.

Timely pruning

A strong reminder on the value of timely and skilful pruning is given by Evelyn (1662) when he stated:

> *I shall therefore in the first Place speak of the* Manual *Operation of* Pruning, *and other Instructions as they afterwards occur...* Putatio; Pruning *I call all Purgation of Trees in general, from what is superfluous: The* Antients *found such benefit in Pruning, that they feigned a Goddess presided over it, as* Arnobius *tell us: And in Truth, it is in the discreet Performance of this* Work, *that the Improvement of our* Timber *and* Woods *does as much consist as in any Thing whatsoever. A skilful planter should therefore be early at this Work:*
>
> > *Twigs of themselves never rise straight and high*
> > *And under-woods are bow'd as first they shoot*
> > *Then prune the Boughs, and Suckers from the Root*
>
> *And here it is that I am (once for all) to warn our disorderly* Husband-men *from coveting to let their* Lops *grow to an extraordinary Size before they take them off as conceiving them it furnishes them with more* Wood *for the fire; not considering how much gashly Wounds mortally affect the whole Body of the* Tree;... *In the mean while, that young* Oaks *prosper much in Growth, by timely* Pruning,

Samuel Hayes (1794), the owner of Avondale before the Parnells, did not over-elaborate on the shaping or pruning of trees; however, he recognised the need for timely and careful pruning:

> *I shall not however greatly enlarge upon the subject of* pruning,...*it being universally admitted, that the heavy use of the knife or saw on the side branches, though prevented from being injurious by the admission of frost or rain,...whilst on the other hand the neglect of cutting off in time the ill placed luxuriant branches, permits improper boughs to take the lead, and fills the timber with unsightly knots;...*

Pontey (1808) addressed doubters of early timely pruning as an effective management practice:

> *But, probably, the reader may ask, Will* Pruning *cause any deciduous tree to assume such form? The question is fair, and the answer shall be explicit.* Yes, *any one that will grow; provided the business be commenced in due time.*

He also advanced the positive benefits of timely formative shaping or pruning on a regular basis. Such practices prevent branches from competing with the leader; therefore, the branches should not be allowed to grow so large that a knife (or nowadays a secateurs) cannot be used to remove them, when he recommended:

> *We next proceed to notice the consequences, or advantages of this very* simple method, *in order to shew whether or not it possesses the other requisites, beforementioned. In doing which, we observe, in the first place, that the real, or pretended, danger, incurred by taking off large branches, is completely done away; provided the business is begun in proper, time, namely, when a knife will perform the operation, and repeated every second or third year, till the stem is cleared to the desired height, as then the branches to be displaced must always prove somewhat small; and, therefore, when taken ...the wounds will heal very soon.*

Nicol (1820) underlined the importance of early and timely pruning. The principal insight from this extract is the recommendation that pruning should start in the first year. He maintained that some of his recommendations were not recent or new and that there were well-defined principles, already established by earlier authors, with a strong emphasis on producing quality stems:

> *It is not, then, here pretended to set forth some new scheme of management, but to call the attention to established principles, which are well known to produce the most beneficial effects...We have shown that pruning of such trees commence at a very early period...Indeed, the right pruning of a tree, to the procuring of good, clean timber, must, in every situation, consist in a timeous and effectual removal of all competing or superfluous branches. Timely pruning is, therefore, a matter of the utmost importance...The pruning of groves of deciduous trees, must be commenced the first year after planting; and will at that time consist in removing every branch competing with the leader for the ascendancy; and thinning the smaller side shoots and twigs on the boles of the plants; leaving a sufficient number on each to promote an equal distribution of the sap over the whole plant.*

A clear signal is given that close spacing has great merit in helping to produce quality stems, but he nevertheless stated that there is no substitution for early pruning:

> *Notwithstanding that we here fully admit the great utility of close masses for the procuring of straight clean timber, it must be obvious to every one, that, for a number of the earlier years of the forest, however extensive it may be, the plants will not feel that influence from proximity which is necessary to give them the upright tendency or direction that is so highly desirable. Hence the necessity of early pruning of forest plantations.*

Main (1839) reminded his readership of the need for pruning. In a very striking and forceful manner he stated that the use of close spacing and optimum thinning regimes would not result in the production of quality timber unless some form of pruning or formative shaping is undertaken at the correct time:

> *It has been asserted, that no pruning at all is required in order to have good timber;*

> *indeed, a book has been published expressly to make this declaration! But the author has failed in his proofs: for it is a well ascertained fact that clear-grained timber cannot be grown unless the tree has some kind of pruning,* either by art or by accident. *Accidental pruning is performed by browsing animals, as is so frequently seen in parks and forests. There the trees have usually short butts, and large branchy heads. Or, trees may be made to grow for many years very close together. In the latter case, as already has been observed, the lower boughs quickly perish and drop off by being deprived of air and light…If it be found then that timber of the first quality is produced by accident surely the same result may be accomplished by a little labour and the application of skill. And when it is understood how a tree is increased in diameter, and also how the added additions of alburnum* [sapwood] *may be distorted by lateral branches remaining too long where they do harm rather than good, the necessity of timely pruning will be perfectly evident.*

Main (1839) went on to state that the purpose of pruning is to produce high quality stems. He strongly emphasised that if this approach is to have any real benefits on wood quality then pruning must commence when the tree is young:

> *This is the real and sole use of pruning forest trees, and the business can only be executed with the propriety and effect when the trees are young. Pruning an aged tree which has arrived at full form and stature can answer no good purpose; for after an irregular branch has acquired a diameter of from four to six inches, it had better be left where it is; because if cut off, the wound will never be thoroughly healed, and will remain a flaw in the timber. So that it is as much the aim of the pruner to prevent the growth of living knots which distorts the grain, as it is to hinder the formation of dead ones, which deteriorates the wood.*

Main grasped the concept that large knots, whether live or dead, cause serious defects in timber. The definitive results of recent research by Shigo (1989), whereby he dissected and examined thousands of trees, have largely confirmed Main's (1839) conclusions.

Judicious pruning

Evelyn (1662) drew attention to the need to prune trees in a 'discreet' fashion and to concentrate on protecting the tree's leader:

> *It is by the Discreet leaving the* Side-boughs *in convenient Places, sparing the smaller, and taking away the bigger, that you may advance a Tree to what determined Height you desire: Thus, bring up the* Leader, *and when you would have that spread and break out, cut off all the* Side-boughs, *and especially at* Midsummer, *if you espy them breaking out.*

Hayes (1794) was conscious of the need to ensure that plantations become well established, but he also referred to the need for skilful pruning when he stated:

> *…I shall offer a few observations on the management of plantations of some years standing, when the care and attention which has been bestowed on them at the time of planting, shall have produced that* luxuriant growth, *which, whilst it gratifies the*

planter's wishes at the moment, would utterly defeat them in the end, if not skilfully directed and kept within proper bounds.

Nicol (1820) emphasised the need for judicious pruning to produce quality tree stems, but he also recognised that this objective can only be achieved if woodland owners acquired greater knowledge of the use of this technique:

But while we thus inculcate the pruning of forest trees, we would, at the same time, deprecate in the strongest terms what, in many instances, bears the name without possessing a single character of judicious pruning.

Nicol (1820) further stated:

...its abundantly evident, that pruning can never be properly, or even tolerably done, unless the proprietor understands the subject, and himself take the trouble of directing...The proportion which the top of a grove tree, from twenty years old and upwards, should occupy, is about a third part of the height of the plant; thus if the tree be thirty feet high, the top should be ten feet. But in infancy, grove trees should be feathered from the bottom upwards, keeping the tops light and spiral, something resembling a young Larch...The proportion of the tops should be gradually diminished, year by year, till about the twentieth year... In cutting, or pruning off the branches, the utmost care must be taken not to leave any stumps sticking out... It is only by this means that clean timber can be procured for the joiner...

Nicol (1820) illustrated correct and incorrect pruning methods for broadleaved trees growing in a dense stand (Figure 1).

Main (1839) contrasted the knowledge obtained from the practices of nursery management and forest establishment with that achieved using judicious and careful pruning in the management of young woodlands when he stated:

The business of raising and nursing young trees, - the best method of preparing the ground for their reception when fit to transplant – manner of transplanting – the soils most suitable for each species – together with staking and fencing – are all thoroughly understood. But the only part of the woodsman's duty which does not appear to be well defined; or at least not generally agreed upon by practical men, is relative to the necessity of carefully pruning and managing the trees during the first fifteen or twenty years of their growth.

Leader training

The earliest reference found on the use of leader training methods was by Lawson in 1597. However, the original publication is not available, but his work was reviewed by Evelyn *(1662)*. He quoted Lawson, who recommended leader training, as follows:

The waste Boughs *closely and skilfully taken away, would give us more of Fences and Fuel: and the Bulk of the* Tree *in Time would grow of huge length and Bigness: But here (methinks) I hear an unskilful* Arborist *say, that* Trees *have their several* Forms, *even by* Nature;*...The Oak by Nature broad, and such like. All this I grant: But grant*

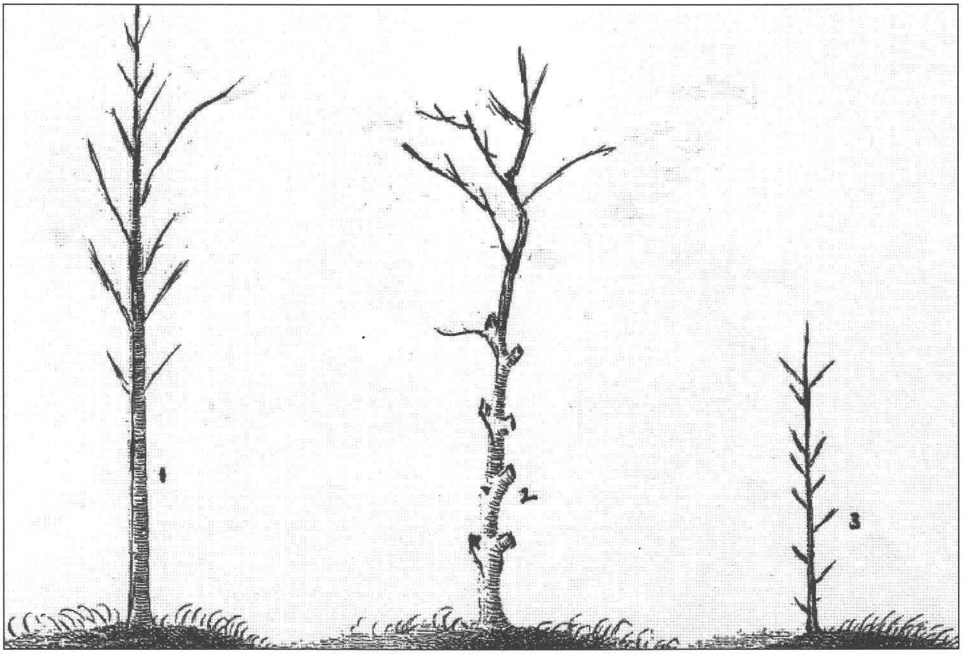

Figure 1. *Illustration of the effects of pruning practices (from Nicol 1820). The original caption is reproduced here unaltered:* (1) Represents a tree in a grove or thick plantation of thirty years of age, which has been regularly and properly pruned from infancy onwards. (2) Represents a tree of the same age, on the skirts of a plantation, which has been neglected in the pruning from infancy onwards; and which is now been pruned in a way too frequently practised, is left in a state highly injurious to its health, and destructive of the soundness of its timber. (3) Represents a grove, or an ordinary plantation hardwood tree of ten years of age, clothed with a sufficient number of branches to secure the extension and enlargement of the bole.

> *me also, that there is a profitable End and Use of every* Tree, *from which if it decline (though by Nature) yet Man by Art may (nay must) correct it... Neither let any* Man *ever so much as think, that it is unprofitable much less unpossible, to reform any* Tree *of what kind soever: for (believe me) I have tried it: I can bring any* Tree *(beginning betime) to any form.*

Lawson (1597) made a very bold claim for apical leader training, stating that he could "bring any tree to any form" if he could treat the tree while young. While we agree with the need for timely shaping, we are not so sanguine as to believe that all trees can be redeemed in this way. It may be acceptable under current forestry conditions if sixty-percent or greater of a crop could be improved at time of first shaping.

Pontey (1808) compared the importance of tree leader training to that of the invention of the plough, when he stated:

> *It is not said that the training of timber is of equal importance with the invention of a* Plough...

If broadleaved trees are allowed to grow and mature as nature dictates, it is unlikely that they will have, clean lower stems. The benefits of using leader training to produce a clean stem to a given height are explained as follows:

> *Every tree with a clean stem, from four feet and upwards in length, being completely a trained one; as unassisted nature forms none of the sort. It is proved then, that such practise has been abundantly successful, so far as it has been extended;* to *it we are obviously indebted, for most of the good timber we possess. Surely, then, the success is a sufficient reason to* extend *the practice. If a tree has been benefited in a certain degree, by clearing the stem, a few feet in length, undoubtedly the same, or similar means, extended higher, would have increased the effect.*

Pontey (1808) illustrated the value of apical leader training, for a particular beech (*Fagus sylvatica* L.) tree (Figure 2) that had been trained on a regular basis. This remarkable tree had a clean, cylindrical, branch free and straight stem to 15 m:

> *In order to give a clear idea of what may be expected from a good method of training timber...a drawing of a Beech in Woburn Park; to which the Grandfather of the present Duke of Bedford is said to have paid very particular attention...We may observe also, that the stem is in no place either* flat, *or* furrowed; *a s uffcient proof that the branches were taken off at no late period... There are several other Beech Trees in the Park, that seem little, if at all, inferior to it in weight, while in every other respect, this maintains so clear and decided a superiority, that it furnishes a decisive proof of the beneficial consequences of training timber, as the most sceptical mind require.*

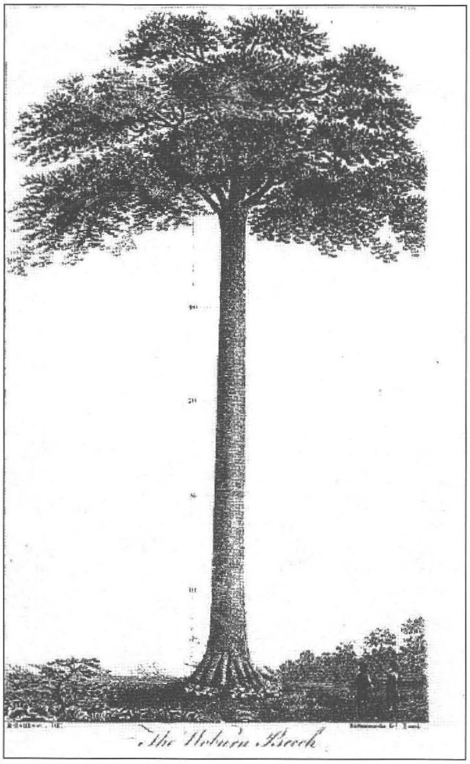

Figure 2. *Pontey's (1808) illustration of a beech at Woburn park showing the beneficial effect of apical leader training.*

Nicol (1820) described the characteristics of a properly trained tree. He discussed the importance of the role of small branches and twigs in producing a well-balanced tree:

> *It is of importance that the tree be equally poised; and therefore if it have stronger branches on the one side than the other, they should either be removed or be shortened. Thus a properly trained tree, under twenty feet in height, should appear light and spiral from within a yard or two of the ground to the upper extremity; its stem being furnished with a moderate number of twigs and small branches, in order to detain the sap, and circulate it more*

equally through the plant.

Main (1839) fully supported the concept of prudent leader training in developing a single straight and superior stem. He advised that competing shoots or side branches should be removed carefully:

Let us suppose, again, that a similar tree is put under the care of a forester, who resolves by regulating the growth to train it into the finest and most valuable form, securing an erect and straight butt, divested of branch which by possibility could deteriorate the quality of the timber, and without checking the growth by extreme mutilation (for in his proceedings both these circumstances must be considered).

Proper pruning practice

Evelyn (1662) deplored the low quality of pruning practised in forestry, leading to the production of poor quality timber, when he stated:

For 'tis a Misery to see how our fairest Trees *are defaced and mangled by unskilful Wood-men, ...As much to be reprehended are those who either begin this Work at unseasonable Times, or so maim the poor* Branches, *that out of Laziness, or want of Skill, they leave most of them Stubs, and instead of cutting the arms and branches close to the Bole, hack them off a Foot or two from the Body of the* Tree, *by which Means they become* hollow *and* rotten, *and are as so many Conduits to receive the Rain and Weather, which conveys the Wet to the very* Matrix *and* Heart, *deforming the whole Tree with many ugly Botches, which shortens its Life, and utterly mars the* Timber.

About 350 years before Shigo's research work, Evelyn was aware of the correct methods of branch removal to avoid leaving stubs -to make the cut close to the bole while avoiding damage to the stem.

Pontey (1808) described in detail the principles of best pruning practice to produce good quality stems. He also illustrated the effect of pruning on stem form just after treatment (Figure 3).

Pontey considered the value of branches, their contribution to tree growth and the problem of large or disproportionate branch development. He suggested that all large branches should be removed in preference to smaller ones to ensure growth is concentrated in the leading shoot:

Consistent with above principles, there seems no difficulty, in directing a good and safe method of pruning such young trees *as are intended to grow into* long, clean, and straight timber. *For, knowing that our business is to consolidate nature's efforts, as much as possible, to one point, we consider branches as no further useful, than as subservient to the purposes of the stem; and finding that small ones are every way preferable to such as are large, the head and stem of the plant are constantly kept light, by* thinning out all the largest branches, *every time the tree is pruned....It is not at all necessary to be exact, as to the quantity of such branches, provided some general ideas are attended to; such as that,* the larger branches only *are to be taken off, while the smaller are to remain, not upon a few feet only, but a considerable length*

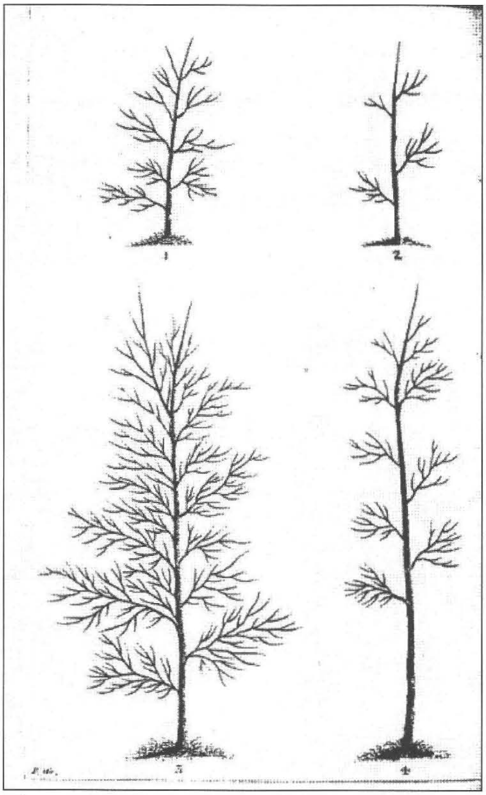

Figure 3. *Illustrations of the application of the principles of best pruning practice (from Pontey 1808). Pontey explained these illustrations as follows*: (1) is a tree, which has been planted small, and grown for three or four years. (2) exhibits the same figure pruned. (3) is an illustration of the same tree, three years afterwards. (4) is the same tree pruned.

down the leader, never suffering a branch to remain, that is at all likely to attract an equal quantity of sap, and, consequently, become its rival. It is unnecessary to give directions for the subsequent prunings, as the method above directed will be applicable, whether the trees are five or fifty feet in height; supposing them such as have not been previously neglected.

Pontey (1808) maintained that the correct method of pruning is easily understood and should be performed in a quick and efficient manner to provide value for money. We agree that shaping or pruning is easily understood and a matter of common sense in practice. Pontey (*op. cit.*) is extremely practical about this work when he states:

Probably, we may be here anticipated, by the reader's observing, that the means directed are exceedingly simple. Undoubtedly, they are so; and we trust too he will likewise observe, that much of their value must depend upon that *circumstance. We are not to expect the nicety of Garden practice, to be introduced here; and therefore, in recommending what is* useful, *we have to consider how far it can be called* expedient, *or practicable, upon a large scale. A method, that is not at once simple, expeditious, and effectual, cannot be highly valuable, because few have the means, and fewer would find the inclination to practise it to any considerable extent.*

On the problem of tree forking and choosing the preferred leader Pontey (1808) had no doubts, and recommended the following practice:

Sometimes persons are perplexed in choosing leaders for trees; - one may be the straightest, and another the strongest: - in this case, the point should be decided by considering, that we want one the most capable of attracting the sap sufficiently; for if that be done, it is of very trifling consequence, whether the leader stands only half upright, or perfectly so; as, by growing freely, it will soon cease to bend, and, therefore, we usually choose the strongest.

Nicol (1820) advocated a methodical approach to deal with many different forms of stem defects, and described a number of pruning steps that should be taken to protect the leader of the tree, when he stated:

> *From the importance of this subject, we beg here to repeat, that the pruning of all deciduous trees should be begun at the top, or at least those branches which are to be removed from thence should never be lost sight of. Having fixed upon what may be deemed the best shoot for a leader, or that by which the stem is most evidently to be elongated and enlarged, every other branch on the plant should be rendered subservient to it, either by removing them instantly, or by shortening them.*

In dealing with stem defects such as forks he advised that the strongest and most promising shoot should be chosen:

> *Where a plant has branched into two or more rival stems, and there are no other very strong branches upon it, nothing more is required, than simply to lop off the weakest clean by the bole, leaving only the strongest and most promising shoot.*

Competition with the leader from codominant side shoots – a common problem with ash and sycamore – was also recognised:

> *If three or four shoots or branches be contending for the ascendancy, they should, in like manner, be lopped off, leaving only the most promising.*

On the problem of stem defects, such as multiple competing branches, large branches or whorls, Nicol (1820) made this suggestion:

> *It is manifest that, by removing competing branches, when they have attained perhaps half the diameter of the trunk of the tree, the* grain *of the* timber *must be abruptly broken over, and consequently, at such places, be less strong than it otherwise would have been...Is it not evident, that if these branches had been timeously checked, the greater part of the matter forming their solid contents, would have settled in the trunk itself? We have known plantations which have been carefully pruned from infancy upwards, make a better figure at* twelve *years of age, and each tree have more solid wood in its bole, than trees in a neglected plantation of* twenty *years of age...If any of the branches which have been left further down on the bole of the plant at former prunings have become very strong, or have extended their extremities far, they should either be taken clean off by the bole or be shortened at a proper distance from it; observing always to shorten at a lateral twig of considerable length.*

The results of research by Shigo (1989) have shown that shaping or pruning of branches should not involve the excision of branches "clean off by the bole". This incorrect practice is called flush pruning. He advocated that the branch collar and branch/bark ridge should not be injured, but should be protected at all times when branches are being removed. Current thinking is that such disproportionately large side branches should be removed before their individual diameters reach half that of the main stem. Nicol (1820) also advocated, in the extract quoted above, using 'tipping' i.e. the removal of the distal ends of large branches that are likely to compete with the leader. There is now some doubt about the efficacy of this process, with the argument being made that these large branches might not be checked and instead they might initiate a number of lateral shoots that grow vigorously. The diameters of these large branches might then continue to expand. More research and observation need to be carried out on before conclusions are reached on the effect of tipping.

Despite the impressive published work of Pontey (1808) and Nicol (1820), it was disconcerting to learn from Main (1839) of his grave concern that pruning practices differed and there was no agreed standard. He wrote:

On this very material branch of management, many different opinions are held, as well as to the season in which it should be performed, as to the manner in which it should be executed. Some persons imagine that pruning at any stage of the growth is altogether unnecessary, while others maintain the contrary; though the latter have omitted to lay down any practical rules for performing the work except only as regards some of the regular species of the coniferae: some foresters advising all the tiers of branches to be constantly, that is, annually cut off, except three or four at the top; while others advise no branch to be dissevered...

Even in those days sawmillers were not happy with the quality of the roundwood supplied to their mills. At the time many felt that poor quality was due to the lack of pruning:

At the time when the very great complaint was made of the great quantities of defective oak timber which was constantly received and rejected in the royal and merchant's dockyard of this country, an urgent inquiry was instituted to discover the probable cause... Some persons were of opinion that the defective timber was owing to the want of pruning, as too many of the lower branches were allowed to grow, which very much distorted the grain of the stem, and if any of these branches chanced to die, they in time dropped off, leaving a hollow and rotten scar, which admitted rain and gradually extended the rottenness to the heart of the trunk.

Resulting from the sawmillers' concern about log quality many owners who had little expertise or knowledge about formative pruning, started to prune trees in a variety of ways. These practices inadvertently led to a deterioration in stem quality over time. While the instruction not to leave stubs or 'snaggs' or 'flush prune' was well aired in earlier literature, (Evelyn, 1662) the message does not seem to have spread widely, as evidenced by the destructive practice of snagg-pruning mentioned by Main (1839). Furthermore, Main revealed that many foresters removed all lower branches close to the bole. In many cases this operation was carried out when the branches were large; their removal left pruning wound defects due to poor occlusion. Realising these mistakes, he came to the conclusion that tree pruning was not fully understood in all its aspects:

This idea induced many proprietors to become pruners who had done nothing of the kind before; but, fearing to injure the butt, by applying the saw too closely, they cut off the branches at the distance of two or three feet therefrom. This was called snagg-pruning, *and was done with the view of preserving the soundness of the trunk; for whether the snaggs lived or died the butt itself would still remain sound. In the expectation the inventors soon found their mistake; many of the unsightly stumps died back, and actually increased the injury to the butt which the pruner had laboured to avert. The snaggs* *which had living spray upon them, or produced shoots after they were amputated, continued to live; but whether dead or alive when the tree was felled, their presence still indicated either distortion or dead knots in the body of the tree, and therefore that it was almost useless for planking. An improved mode of snagg-pruning has been practised...called* foreshortening. *The object of the latter experienced forester was to prevent the lower branches of hedgerow trees spreading too far over the crops in their shade...The lower branches are cut back, but always reserving two or three secondary branchlets on their base, thus keeping the latter alive without the risk of their rotting back to injure the butt. Other foresters, seeing that a clear and handsome trunk was not obtained by snagg-pruning or foreshortening, concluded that to procure long and straight boles, all the lower branches, of whatever age, should be cut off close to the trunk; [*flush pruning*] they knowing that the wounds, however large, would be in time covered over with new wood and bark, the whole tree would be improved in appearance and much more attractive to the eye of the buyer. While prosecuting this plan of pruning – and in some woods it was done extensively and at great expense – the projector forgot that the new wood and bark which covers the scar can never unite with its face so as to produce perfect soundness; and that certainly, when the trees so operated on came to the sawpit, a defect would be visible at every place whence a branch of any large size had been cut: Experience has proved this fact; and dealers are alive to the circumstances, always cautious of buying out of woods, which have been close-pruned, however handsome the butts may appear...This is an instance that the pruning of forest trees is not yet well understood or practised; and the consequences is, that much timber is deteriorated for want of pruning, and great numbers of trees which are healthy are much impaired in quality by the injudicious manner in which it has been performed.*

Current practice is that disproportionately large branches should be removed at the earliest opportunity. (Disproportionately large branches have basal diameters at the main stem that are greater than half the diameter of the main stem at the same point.) A general rule of thumb is that such large branches should be removed before they achieve a diameter of 5 cm.

The season for pruning

Evelyn (1662) drew a distinction between old and young trees in relation to the proper time to prune, although his recommendations were not very convincing when he stated:

The proper Season for this Work, is for old Trees earlier, *for young* later, *as a little after the Change in* January *or* February, *some say in* December, *the* Wind *in a gentle Quarter....*Then shave their Locks and cut their branchy Tress, Severely now, luxuriant Boughs repress.

Pontey (1808) evidently carried out pruning in all seasons to determine the best time of the year to prune and to minimise damage to the stem of the tree. He discovered that summer was the preferred time to do this work:

In regard to the proper season for pruning, *there is only one difficulty; and that is discovering the* wrong one, *or the particular time when trees will bleed. Considerable pains have been taken to ascertain this point, by pruning all sorts at all seasons,*

> *repeatedly; and only two have been discovered which bleed uniformly, at certain seasons, namely, the Sycamore, and Firs, as soon as the sap begins to move. The best and safest way is, to notice, in spring-pruning, if the trees bleed, (for it never happens at other seasons;) if they do desist, till, upon trial, it be found to have ceased...As a general rule, we think* summer *is preferable to* winter-pruning*; because, in proportion as wounds are made early, they heal so much the more in the same season.*

Nicol (1820) recommend that pruning of forest plantations be carried out on all tree species during the month of January with the exception of the wild cherry (*Prunus avium*):

> *There is no kind of forest-tree but may with propriety be pruned at this time of the year, except the Gean.*

He stated that pruning might be carried out in February also, although this is not as a good time for a few species:

> *This work may be carried out during this month on every species of tree, excepting the Sycamore and the Birch. These, must not now receive a wound; because they bleed excessively, and sometimes die when pruned so late in the season.*

He continued that all pruning should cease at the end of February and not begin again until late summer:

> *The pruning of no kind of forest tree should be carried on beyond this month: because every one of them, at the rising of the juices, bleeds, less or more, at recent wounds. Hence the advantage of autumn pruning above that of any other season...Pruning ought therefore to be suspended, from the end of February till the middle or end of July.*

Main (1839) recommended that late spring or early summer was the most suitable time of the year to carry out pruning:

> *The months of April and May are the best seasons for pruning forest trees, because the wounds made by the removal of such small branches will be nearly healed over before the end of the summer, and of course no very visible knots or defects will remain in the bole when cut up for use.*

It is evident that, as the centuries passed, the consensus had changed in favour of summer shaping and pruning. Results from research at Kinsealy indicate that summer shaping is most effective, up until the tree reaches about 3 m height. Thereafter, summer shaping is more difficult due to the difficulty of reaching upper branches and because the foliage obscures the view of the stem.

Annual pruning

Most authors advocate annual or regular pruning (formative shaping). As previously alluded to, Pontey (1808) encouraged the early use of:

> *...a knife...to be repeated every second or third year, till the stem is cleared to the desired height.*

Evelyn (1662) had this to offer regarding the frequency and timing of pruning:

> *Young* Trees *may every Year be pruned, and as they grow older at longer Intervals, as at three, five, seven or sooner, that the* Wounds *may recover, and nothing be deformed.*

Nicol (1820) suggested that woodland owners should begin pruning (formative shaping) when the trees are young. This practice should be continued on an annual or regular basis in order to produce unblemished timber:

> *The same attention to these will be annually required, till they arrive at maturity...To secure these advantages, it is however necessary to prune betimes, or rather to commence pruning at the infancy of the trees, and thenceforward to continue it at intervals of one, or at most two years. If the pruning of young forest trees is performed only at intervals of eight or ten years, the growth is unnecessarily thrown away, and wounds are inflicted which will ever after remain blemishes in the timber; whereas if the superfluous or competing branches had been removed annually, and before they attained a large size, the places from which they issued would be imperceptible, or at least not hurtful to the timber, when it came to the hands of the artist.*

Main (1839) advised his readers to ensure, by annual inspection, that the leading shoot remains superior at all times. To achieve this objective, competing side shoots should be removed. Where multiple side shoots were present, he recommended removing some and partly removing others by "foreshortening" with a view to removing them at a later date. This practice is called 'tipping'. However we would recommend that, where there is any doubt about a second shaping, the whole branch should be removed.

> *He would by an annual examination see whether the leading shoot maintained a due superiority, and that no competitor threatened to attract an undue share of the sap. If any such appeared, he would instantly displace or shorten them; so that they might not attain to more than one* inch *in diameter. All other size branches of a less size he would leave, as whether they lived or died they would not prove defects in the wood...This method of pruning necessarily imposes on the forester the duty of annual review, as the branches will consecutively arrive at the size at which it is advised they should be taken off; but the only difficulty will be, when three or four of the laterals* [we believe this to refer to whorls] *arrive at the prescribed size at the same time. In this case, if the rule be observed, the whole of these three or four branches must be removed at once; which would be, perhaps, too severe a dismemberment of the head, and probably would give a check to the whole system and counteract the very purpose of the pruner. But in such cases, the operator should be content to remove only one or two of the number closely, and foreshorten the others, to prevent their swelling to a larger size than it would be judicious either to leave or take off. These foreshortened branches with their spray, would continue to act as necessary parts of the head, and at another pruning might be removed entirely when no longer useful to the system.*

Stumping-back

Stumping-back is the practice, referred to by Nicol (1820) as "heading down trees" but now commonly referred to as stumping-back (of young trees with poor stem form). This is a last-resort method to be used on trees of poor form. Its efficacy is questionable because the defect may be genetically determined. Nicol (1820) advised on the best method and recommended that the operation should be carried out in March:

> *It is now a proper time to examine all plantations which have been three or four years planted, to see if the* hard-wood *trees are in a thriving state, and such as have not begun to grow freely should be headed down to within three or four inches of the ground. The cut must be made with the pruning knife in a sloping direction, with one effort. Great care should be taken not to bend over the tree in the act of cutting. By so bending, the root may be split; a thing, which too often happens. The operation of cutting over young trees should not be performed at an earlier period of the season, because the wounded part might receive much injury from the severe weather in January and February, and the exposed shoot be thereby prevented from rising so strong and vigorous.*

He referred to work carried out on this subject in France by the celebrated M. de Buffon, of the Royal Academy of Paris, in his Memorial on the Culture of Woods to the French Government, in 1742, who stated:

> *I have repeated this experiment so often, that I can give it as a certain fact, and the most useful practice that I know in the culture of woods.*

Conclusions

It is clear from the literature reviewed that these authors and those they consulted (including professional foresters and sawmillers) had a depth of knowledge and expertise in the management of young plantations. The focus, particularly in the early period of the 19th century, was on producing high quality stems. It is possible that much of this expertise was lost at the time of the industrial revolution. The importance of growing high quality stems for industrial needs was less important because many wood products were replaced by steel. As a consequence of this technology-change, there was less emphasis on producing high quality trees so vital skills and knowledge of the techniques to manage young broadleaves was lost.

Teagasc began research on the formative shaping of young broadleaves in 1994, prompted largely by observations of the poor form of trees in a novel trial containing a mixture of ten broadleaved species. A visual ranking system, which concentrated on stem form was developed. An experiment was conducted to examine formative shaping as a means of improving stem form. Some trees were shaped regularly while others were left as untreated controls. Results to date have shown a significant increase in stem quality in the shaped trees compared with the unshaped controls (Bulfin and Radford 1998 a&b). Coincidentally, the type of stem defects identified and the remedial actions taken using formative shaping have remarkable similarities to the management techniques used by woodland managers in the early 19th century.

In the course of the research work it was speculated that the owners of the large estates must have used many skills and techniques in the past to manage young broadleaves. This inspired us - out of curiosity - to undertake this literature review, which confirmed our speculations. A review of recent scientific literature revealed very little new information about the topic (Bulfin and Radford 1998 a&b). The information from this older literature supported the approach taken in the research now underway in Teagasc. It seems that the 'wheel is being reinvented' albeit with a contemporary scientific and statistical twist.

John Main (1839), perhaps the most perceptive woodsman, foreshadowed Gifford Pinchot, father of American forestry, who defined the objective of the US Forest Service as "The greatest good for the greatest number for the longest period" (Pinchot 1910). Main wrote:

> *It is the knowledge of the foregoing descriptions of the growth, which directs and sanctions the operations of the pruner in the management of young trees. His especial aim is to obtain the greatest quantity and best quality of timber on the smallest space and in the shortest time. And when all the means of judicious planting and proper culture are followed by the necessary pruning, there need be no doubt of success.*

ACKNOWLEDGEMENTS

Many of the references are from rare and fragile documents. It was necessary, in some cases to travel to the library where the book was kept to consult it. We are deeply grateful to the librarians at the following institutions for assisting us in locating references: The University of Reading, The University of Liverpool, The University of Dublin, Trinity College, The Royal Dublin Society, and Teagasc.

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The impact of soil preparation method on water-table depth in Irish forest plantations on wet mineral soils

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Abstract

The impact of a range of soil preparation treatments on water-table depth in surface water gley soils was investigated. Although water-table levels were lowered for brief periods during the winter months, generally soil preparation did not have a big impact upon soil water levels in the types of wet mineral soils investigated at the study sites. Mound drains were found to lower the water-table during the winter for a distance of only 3 m from the drain. Mole drainage, however, when used on a suitable site, did lower the water-table uniformly. These results indicate that mole drainage may be more effective in lowering the water-table on these site types than mechanical mounding. However, continued evaluation of these experiments is required to assess the long-term effectiveness of the different soil preparation methods in lowering the water-table depth and improving tree stability.

Introduction

Roots are the below ground structures which supply water, minerals and support to the stem, leaves and flowers of a plant (Sutton 1969, Kozlowski 1971). Root growth is not completely random; each species possesses an internal mechanism to determine the structure of its root system. However, it is the external environment that creates the variability in rooting pattern (Henderson *et al.* 1983). Variations in water supply are frequently a cause of differences in the distribution of roots, particularly the depth they attain in the soil (Russell 1977). Gleys and peaty soils are particularly prone to waterlogging, as microaerophilic and anaerobic conditions can occur over prolonged periods (Smith 1976), inhibiting root growth (Sutton 1969).

Direct planting of trees into soils with a high water content and/or a high water-table has led to poor plant establishment in forest plantations in Ireland (Savill 1976). In addition, surviving trees usually experience check and poor early growth. Furthermore, stands of trees planted on such sites have frequently been found to have very shallow root systems (Horton 1958, Fayle 1965) and to lack stability (Ray and Nicoll 1998). The physical soil conditions necessary for tree survival, growth and stability can however be created on many poor sites by soil cultivation and drainage (Sanderson and Armstrong 1978). Establishment methods include deep drainage by ploughing or mounding, ripping or ploughing to disrupt iron pans, and moling to provide closed drainage systems (Ford and Deans 1977, Anon. 2000). Deep drainage has often been unsuccessful on fine textured soils, with the drainage effects restricted to areas immediately adjacent to drains (Armstrong *et al.* 1976). The ideal soil preparation technique should increase the degree of soil aeration by removing excess water, disrupt indurated soil layers/horizons (if present), provide an improved rooting medium for root proliferation, increase soil aeration and hence nutrient availability and reduce the impact of competing vegetation.

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Experimentation on soil preparation techniques for forest establishment has been carried out in Ireland for at least 70 years (OCarroll 1972). The most important techniques investigated and used, both in Ireland and abroad are spaced furrow ploughing (Savill 1976, Håkansson and Lindström 1994, Coutts and Philipson 1987), ripping (Chavasse 1978, Anon. 1980), mole drainage (Hendrick 1989) and mounding (Sutton 1993, Örlander *et al.* 1991). Most of the research work has been aimed at improving the establishment and early growth of tree crops planted on hard or wet soils. Assessments carried out in Ireland generally involved the measurement of survival and crop growth, with less attention given to the effect of soil preparation and drainage on water-table depth, root development or long-term crop stability. This article describes the impact of a range of soil cultivation practices upon water-table depth in surface water gley soils. The experiments and results presented here were part of a larger project examining the development of Sitka spruce crops on wet mineral soils (Wills 1999, Wills *et al.* 1999).

Materials and methods

Site description

Two experimental sites, located in the mid-west of the country, at Ballygar in Co Galway and at Strokestown in Co Roscommon, were selected for study. The soils at Ballygar and Strokestown were surface water gleys (Gardiner and Radford 1980) and best match the FAO-UNESCO (1971-81) types: Ballygar – Stagno-eutric Gleysol with incipient fragipan; Strokestown – Stagno-dystric Gleysol. Prior to the establishment of the field trials (Hendrick 1990) in 1990, the Ballygar site was neglected farmland consisting of small fields, some overgrown with furze (*Ulex* spp.) and whitethorn (*Crataegus monogyna*). The predominant vegetation was grass/rush (*Poa* spp/*Juncus* spp). The Strokestown site was in agricultural use before planting and had been cultivated. The predominant vegetation was

Table 1. *Location of and topography at the experiment sites.*

Experiment site	*Location*	*Elevation m*	*Aspect*	*Exposure*
Ballygar	53° 33' N; 08° 21' W	65	Flat, with slope generally of 1° or less.	Sheltered
Strokestown	53° 44' N; 08° 05' W	100	South-west, with slope of 2° - 3°.	Exposed

Table 2. *Site and crop descriptions including geology, soil type and vegetation.*

Site	*Geology*	*Soil*	*Vegetation*	*Crop*
Ballygar	Old red sandstone and some glacial drift of mixed origin.	Uppermost layer of shallow medium loam with an abrupt change to a sandy/stony, impervious gley.	*Poa and Juncus* spp.	Sitka spruce planted in 1990 at 2 x 2 m spacing.
Strokestown	Mixed sandstone/ limestone drift and glacial lake deposits.	Upper layer of medium loam changing to a sandy/stony, impervious gley.	*Poa and Juncus* spp. with some *Rubus* spp.	Sitka spruce planted in 1990 at 2 x 2 m spacing.

grass/rush (*Poa* spp/*Juncus* spp) and some briar (*Rubus* spp). Additional information on each of the sites is provided in Tables 1 and 2.

Experiment design

The experiments at Ballygar and Strokestown were established in 1990. The experimental design employed at both sites was a randomised block design, with three replications (Table 3). The experiments were blocked according to variations in soil type and/or the positions of the plots on the slope. There were four treatments at both Ballygar and Strokestown: mechanical mounding (the creation of mounds of soil to provide a raised planting position and drains for the removal rainfall and soil water); mole drainage (installed using a tine with a bullet shaped expander); mole drains combined with mounds; and a no soil preparation control.

Table 3. *Experiment design and soil preparation treatments at each site.*

Site	*Experiment design*	*Treatment*	*Distance between drains*	*Depth of drains*
			m	*m*
Ballygar	Randomised block design (3 blocks)	Machine mounding	16.0	0.45
		Mole-and-mound	2.0	0.35-0.40
		Mole	2.0	0.35-0.40
		Control, no soil preparation	---	---
Strokestown	Randomised block design (3 blocks)	Machine mounding	12.0	0.45
		Mole-and-mound	2.0	0.35-0.40
		Mole	2.0	0.35-0.40
		Control, no soil preparation	---	---

Water-table measurement

Water-table measurements were carried out at Ballygar and Strokestown from April 1995 to April 1996 and from October 1996 to April 1997. Slotted drainage pipes, 70 mm diameter were installed, using a soil auger to a depth of 0.6-0.9 m in the centre of each plot, and at 0.5, 1.0, 2.0, 3.0 and 8.0 m from the edge of the drains in the machine mounded mound plots at Ballygar (drains 16.0 m apart). At Strokestown wells were installed in the same treatment at 0.5, 1.0, 2.0, 3.0 and 6.0 m from the mound drains (drains 12.0 m apart). At both sites the mole-drained plots had wells installed at 0.2, 0.5, and 1.0 m from the mole drain centres (2.0 m apart). In the control plots, three wells were placed in the centre of each plot at 1.0 m apart. Approximately 5 cm of drainage pipe was left protruding above ground level at each location. Above-ground pipe slots were sealed with soil. Each pipe was covered with a plastic cap.

Water-table readings were taken from a graduated measuring rod with a float attached to the bottom. The rod was calibrated to allow for the part-immersion of the float. When inserted in the well, the rod floated on the water and a reading was taken to the top of the pipe. Readings were taken to the nearest 0.5 cm and were adjusted to ground level.

Readings were taken at monthly intervals from April 1995 to April 1996, and twice monthly from October 1996 to April 1997. During the months of May to September 1995 almost all of the wells were dry at both sites. Hence, in the second measuring period (1996/1997) measurements were not taken during those months but were increased to twice monthly readings for the remainder of the year. Water-table depths were measured from October 1996 to April 1997. Daily rainfall values were obtained from weather stations at Ballygar and Carrowclogher (both within 5 km of the experiment sites). The cumulative periodic rainfall from one measurement to the next is presented in the Results section, along with the water-table depths.

Data analysis

The data set from each site was analysed as a randomised block design, using the SAS (SAS 1990) General Linear Models (GLM) procedure. Water-table depth was treated as the dependent variable with experiment treatment (machine mounding, mole-and-mound, mole, and no soil preparation) and block as the independent variables. Within treatments, the impact of the distance from the drains on water-table depth was analysed. As the depth to the water-table was greater than the depth of the wells during the summer months, and therefore the true depth to the water-table was not known, the data from Ballygar for the months of May 1995 to September 1995 and the data from Strokestown for the months of May 1995 to October 1995 were omitted from the data sets used in the statistical analysis. These data sets are referred to as the 'complete data sets'. Data sets, using only readings taken on dates when the average depth to the water-table in the control plots was less than 25 cm, were also compiled. These data sets are referred to as the 'reduced data sets'.

Results

The effect of machine mounding on the depth of the water-table

The effect of the machine mounding treatment on the depth of the water-table was different at the two sites. At Ballygar, the depth to the water-table at any distance from the mound drain was similar to the water-table depth in the control plots (Figure 1). Analysis showed that the depth of the water-table did not change with increasing distance from the mound drain (Table 4).

Statistical analysis showed that the depths to the water-table in machine mounding plots did not differ significantly from those in the control, mole or mole-and-mound plots (Table 5).

At Strokestown, however, during periods of high rainfall the depth to the water-table was greater in wells within 3 m of the mound drain than those at greater distances from the drain (Figure 2). When the complete data set was analysed no significant differences were found between the wells with increasing distance from the mound drain (Table 6), nor were there significant differences among the average depths to the water-table in the different soil preparation treatments (Table 7). However, on dates when the average water-table depth in the control plots was less than 25 cm (using the reduced data set), depths were significantly lower at distances of less than 3 m from the mound drain compared to the depths at distances greater than 3 m from the drain (Table 6). In addition, when using the reduced data set, the average water-table depth level in the control plots was significantly less than in the plots with mole drains (Table 7).

Table 4. *The effect of distance from the machine mounding drain on the depth of the water-table at Ballygar from October 1995 to April 1997. (Results in the same column with different letters alongside indicate a significant difference at the $p \leq 0.05$ level.)*

Distance from mound drain	*Mean water-table depth and pairwise t-test*	
	Complete data set	*Reduced data set*
m	*cm*	
0.5	23.22 A	16.90 A
1.0	22.48 A	15.07 A
2.0	22.76 A	15.47 A
4.0	23.83 A	16.33 A
8.0	21.11 A	12.83 A
Standard error of difference between two means	5.076	6.007

Table 5. *The effect of soil preparation treatment on the water-table depth at Ballygar from October 1995 to April 1997. (Results in the same column with different letters alongside indicate a significant difference at the $p \leq 0.05$ level.)*

Treatment	*Mean water-table depth and pairwise t-test*	
	Complete data set	*Reduced data set*
	cm	
Machine mounding	23.69 A	15.32 AB
Mole-and-mound	23.18 A	12.80 A
Mole	31.32 A	23.13 B
Control	22.72 A	13.00 A
Standard error of difference between two means	4.602	4.244

Table 6. *The effect of distance from the machine mounding drain on water-table depth at Strokestown from November 1995 to April 1997. (Results in the same column with different letters alongside indicate a significant difference at the $p \leq 0.05$ level.)*

Distance from the mound drain	*Mean water-table depth and pairwise t-test*	
	Complete data set	*Reduced data set*
m	*cm*	
0.5	38.37 A	32.65 A
1.0	42.64 A	36.06 A
2.0	44.56 A	38.94 A
3.0	31.17 A B	25.04 AB
6.0	19.63 B	9.30 B
Standard error of difference between two means	6.687	9.036

Table 7. *The effect of soil preparation treatment on water-table depth at Strokestown. (Results in the same column with different letters alongside indicate a significant difference at the $p \leq 0.05$ level.)*

Treatment	*Mean water-table depth and pairwise t-test*	
	Complete data set	*Reduced data set*
	cm	
Machine mounding	36.59 A	29.99 AB
Mole-and-mound	40.26 A	34.51 B
Mole	39.89 A	34.75 B
Control	29.04 A	17.65 A
Standard error of difference between two means	7.072	7.072

The effect of moling and of moling combined with mounding on the depth to the water-table

In the mole treatment, the water-table depth at 0.2 m from the mole drain at Ballygar was deeper than the water level at 0.5 or 1.0 m from the mole (Table 8). This was especially the case during periods when the water-table was high. However, statistical analysis showed no significant differences ($p \leq 0.05$) in water-table depth with increasing distance from the mole, even when the reduced data set was used (i.e. only those readings when the depth to the water-table in the control plots was less than 25 cm). In contrast, in the mole-and-

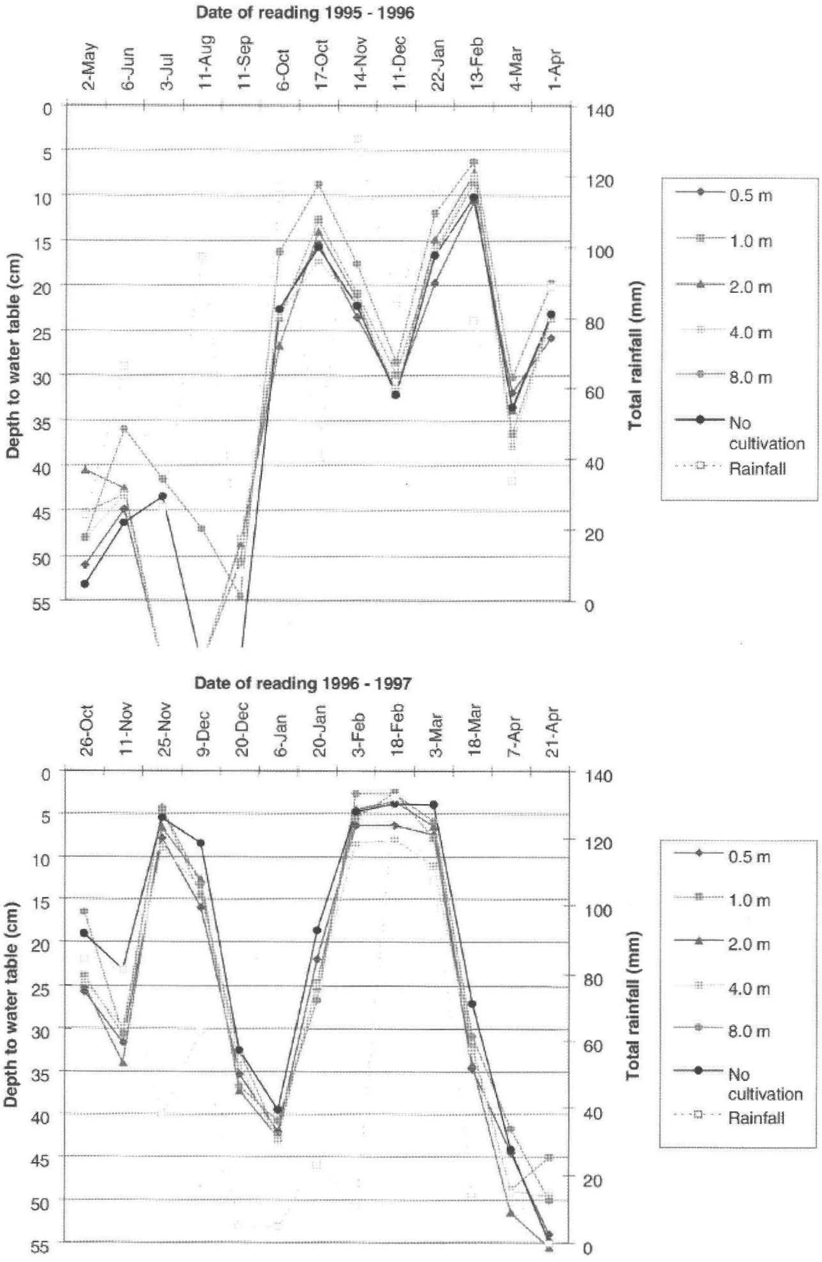

Figure 1. *Cumulative periodic rainfall and the fluctuation of water-table depth with respect to distance from the mound drains (16 m apart), from May 1995 to April 1997 in the machine mounding plots at Ballygar.*

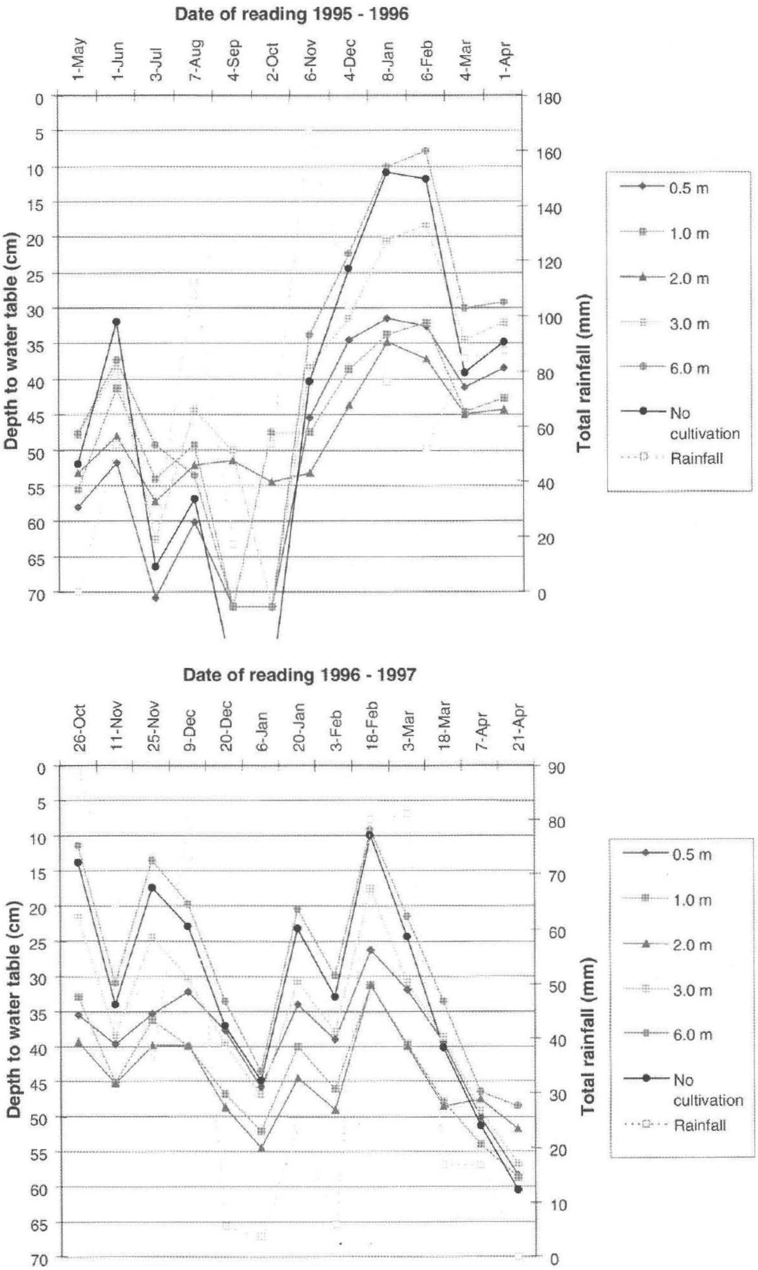

Figure 2. *Cumulative periodic rainfall and the fluctuation of water-table depth with respect to distance from the mound drains (12 m apart), from May 1995 to April 1997 in the machine mounding plots at Strokestown.*

mound treatment at Ballygar, there was very little difference between the water-table at distances of 0.2 and 0.5 m from the mole, and the water-table depth at 1.0 m from the mole was lower than in the two sets of wells nearer the mole (Table 8). However, no significant difference in water level was found between wells with increasing distance from the mole drain.

On average, the depth to the water-table in the mole plots at Ballygar was lower than that in the other soil preparation treatments or in the control (Table 5). The average water-table depth in the mole plots was 8.6 cm (complete data set), and 10.1 cm lower (reduced data set) than in the control plots. However, the water-table depth in the mole plots was only statistically different with the depth in the mole-and-mound and control plots, and only when the reduced data set was used. The mole-and-mound treatment had no effect on lowering the depth to the water-table, even during periods of high rainfall (Table 5).

Table 8. *The depth to the water-table at different distances from the drains in the mole and mole-and-mound plots at Ballygar. (Results in the same column with different letters alongside indicate a significant difference at the p ≤ 0.05 level.)*

Distance from the mole drain	*Mean water-table depth and pairwise t-test*			
	Mole		*Mole-and-mound*	
	Complete data set	*Reduced data set*	*Complete data set*	*Reduced data set*
m	*cm*			
0.2	33.12 A	28.97 A	18.57 A	10.07 A
0.5	29.12 A	20.77 A	19.44 A	11.50 A
1.0	27.95 A	19.53 A	23.58 A	16.83 A
Standard error of difference between two means	5.289	4.317	3.689	3.036

As at Ballygar, the water-table depth at 0.2 m from the mole drain as at Strokestown was slightly deeper at 0.5 or 1.0 m from the drain (Table 9). This was especially the case during periods when the water-table was high. However, as at Ballygar, the differences were not statistically significant (p ≤ 0.05), even for the reduced data set. In the mole-and-mound treatment there was very little difference in water-table depth at 0.2, 0.5 or 1.0 m from the mole (Table 9). In contrast to Ballygar however, the average water-table depth at Strokestown in both the mole and mole-and-mounded plots was deeper than in the control plots (by 10.9 and 11.2 cm respectively) when the complete data set was used (Table 7). These differences increased to 17.1 cm and 16.9 cm respectively when the reduced data set was used. Although these were not significant for the complete data set, the average water depth in the mole and mole-and-mound plots was significantly deeper when compared to the control plots in the reduced data set (Table 7).

Table 9. *The depth to the water-table at different distances from the drains in the mole and mole-and-mound plots at Strokestown. (Results in the same column with different letters alongside indicate a significant difference at the p ≤ 0.05 level.)*

Distance from the mole drain	*Mean water-table depth and pairwise t-test*			
	Mole		*Mole-and-mound*	
	Complete data set	*Reduced data set*	*Complete data set*	*Reduced data set*
m	*cm*			
0.2	46.15 A	40.70 A	40.55 A	33.93 A
0.5	36.35 A	31.63 A	42.86 A	38.37 A
1.0	38.52 A	33.77 A	40.00 A	34.70 A
Standard error of difference between two means	8.369	11.135	4.090	5.023

Discussion

The effect of soil preparation method

The impact of soil preparation method upon water-table depth was quite different at Ballygar and Strokestown. However, at both sites the positive soil drainage effects, if any, were restricted to the soil immediately adjacent to the drains. Similar results have been found in other drainage studies on gley and peat soils, such as by Savill (1976), Schaible and Dickson (1990) and Armstrong *et al.* (1976). At Ballygar machine mounding did not lower the water-table compared to the control treatment. At Strokestown however, machine mounding lowered the water-table during the winter period, by 12 cm on average, although the effect was only significant at distances within 3 m of the mound drains (Table 6). At both sites, mole draining showed a slight lowering of the water-table at 20 cm from the mole drain. This effect, however, was not statistically significant. A similar trend was not observed in mole-and-mound plots. At the Strokestown site, moling and mole and-mound lowered the water-table level by 17 cm on average during the winter months. At Ballygar, moling also lowered the level of the water-table (by 10 cm on average), although the effect was much less noticeable than at Strokestown. The mole-and-mound treatment at Ballygar had no effect on the depth of the soil water-table.

Water-table and rainfall

Generally an increase in cumulative rainfall was reflected in a decrease in water-table depth at Ballygar and Strokestown; likewise a decrease in cumulative rainfall led to an increase in water-table depth. Even where no soil preparation took place, the water-table level fell rapidly once heavy rain events were over. Thus, for example, while the water-table depth in the undrained plot at Strokestown in early 1997 came within 10 cm of the soil surface (Figure 2), this was maintained for one observation period only. Thereafter, the water-table fell rapidly in response to decreasing rainfall amounts. There were some occasions, however, when the cumulative rainfall amount increased but the depth to the water-table decreased, or vice versa. These anomalies may be explained by the distribution of the rainfall in the preceding month or fortnight, relative to the time of water-table measurement.

During the summer months, the water-table at both sites was deep; most of the time the wells (varying in depth between 50 and 80 cm) were dry. During the winter months, the drainage impact was most apparent when the water-table was at its highest, or at least not lower than 25 cm in the control plots. On average, in the control plots the winter water-table was at a depth of 13 and 17.7 cm at Ballygar and Strokestown respectively.

Rooting depth at Ballygar was not affected by the depth to the water-table, as maximum rooting depth had not yet reached the mean winter water-table in any of the soil preparation treatments (Wills 1999). At Strokestown, mean winter water-table depth did not appear to have a restricting effect on rooting depth of the trees, with roots found at a maximum depth of 50 cm. This was probably due to the rapid fluctuation of the water-table with changes in rainfall amounts (Wills 1999), leaving the top layer of the soil below the water-table sufficiently oxygenated (Nisbet *et al.* 1989).

Site differences

The soil preparation treatments were more effective at increasing water depth at Strokestown. This may have been due to a number of factors: slightly greater slope at Strokestown may have improved the effectiveness of the mole drains compared to Ballygar. At Ballygar, most of the site was flat, with only a very small slope in parts. In addition, the soil at Strokestown was slightly more clayey in texture. Mole drainage is generally more effective on clayey gleys, as moles tend to collapse if the proportion of sand in the soil is high (Savill 1976, Hendrick 1989).

Conclusion

Although water-table levels were lowered for brief periods during the winter months at Strokestown, soil preparation generally did not have a big impact on water-table depth in the types of soil found at Ballygar and Strokestown. At Strokestown mound drains were found to lower the water-table during the winter within a distance of 3 m from the drain. Mole drainage, when used on a suitable site (Strokestown), did lower the water-table during the winter months. These results indicate that mole drainage may be more effective in lowering the water-table on these site types than mechanical mounding. However, continued evaluation of these experiments is required to assess the long-term effectiveness of the different drainage and cultivation methods in lowering the water-table depth and improving stability.

Acknowledgements

The work reported here was co-funded by COFORD, Coillte and University College Dublin.

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Natural regeneration within the Coillte estate

I Occurrence and extent with respect to species and association with site factors

Dermot O'Leary[1], Áine Ní Dhubháin[2] and Michael Keane[3]

Abstract

A study was conducted in 1998 and 1999 on the occurrence and extent of natural regeneration within the Coillte estate. Natural regeneration was found on 0.4% (1,975 ha) of the estate. Three species: birch (*Betula* spp.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and lodgepole pine (south coastal) (*Pinus contorta* var. *contorta*) accounted for over 80% of this area. Natural regeneration occurred most frequently on brown earths and podsols. Sites of low fertility status had the highest occurrence of natural regeneration. It occurred most frequently at elevations below 100 m, on sheltered sites and on sites with good natural drainage.

Keywords: elevation, exposure, natural regeneration, soil type, species, site fertility.

Introduction

To date, the vast majority of forest stands in Ireland have been managed under a clearcutting silvicultural system; reforestation after felling uses nursery-grown planting stock. However, with forest owners aiming to achieve and retain forest certification, there is increasing interest in silvicultural systems other than clearcutting. These alternatives, in most instances, rely on natural regeneration for reforestation. While spontaneous natural regeneration occurs, especially of Sitka spruce (*Picea sitchensis* (Bong.) Carr.), mainly in the Wicklow area, and of lodgepole pine (*Pinus contorta* Dougl.) in many areas, it has, until recently, been considered more of a problem than an opportunity. The difficulty associated with predicting its density and speed (Harmer 1995) and its more demanding silvicultural requirements (Harmer *et al.* 1997) may account for this.

In response to the limited knowledge of natural regeneration in Ireland and of the potential for silvicultural systems other than clearcutting, a study was initiated in November 1998, which had as an objective an assessment of the extent of natural regeneration within the Coillte estate using existing inventory data. This paper reports the main findings.

Methods

All subcompartments within the Coillte estate containing natural regeneration were identified from the company's computerised inventory records. The presence of up to four separate tree species are recorded on any one subcompartment. The percentage of the total canopy cover of the subcompartment comprised of each species is also recorded. The minimum value that can be recorded for any one species is five percent of the total canopy cover. If one or more of the species arises from natural regeneration the subcompartment is

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tagged with the letter W on the database. All subcompartments thus tagged were selected and their inventory data copied to an Excel™ file. The database classified each subcompartment according to soil type, fertility class (OCarroll 1975), elevation, exposure and drainage. Data were not available for all of the factors in each subcompartment. In these instances the term 'unknown' was assigned to the missing datum. Using these data, an analysis of the occurrence and extent of natural regeneration within the Coillte estate was conducted (O'Leary 2000).

The area and number of naturally regenerated (NR) stands within the Coillte estate were categorised according to a number of factors, including the number of subcompartments found to contain naturally regenerated stands, their area and their regional distribution. The total area of the Coillte estate was also categorised according to these factors to indicate possible marginal effects. The species that were regenerating naturally were also identified.

Results

Of 121,767 subcompartments (SC) within the Coillte estate, 2,568 were identified as containing natural regeneration (as defined in Methods). These amounted to 1,975 ha of natural regeneration from a total Coillte forest area of 442,296 ha.

Species composition of natural regeneration

Twenty-one tree species were found to have regenerated naturally within the 2,568 subcompartments. Birch (*Betula spp.*) was found on the greatest number of subcompartments while Sitka spruce comprised the greatest area of regeneration (Table 1).

Table 1: *Occurrence and extent of natural regeneration within the Coillte estate.*

Species	*Area within the Coillte estate ha*	*Natural regeneration*	
		Number of subcompartments	*Area ha*
Sitka spruce (*Picea sitchensis* (Bong.) Carr.)	247,394	188	588
Birch (*Betula* spp.)	3,937	1,103	559
Lodgepole pine (south coastal) (*Pinus contorta* var. *contorta*)	51,221	748	473
Ash (*Fraxinus excelsior* L.)	3,106	300	102
Oak (*Quercus* spp.)	3,716	68	24
Other species	132,922	161	229

Five species (ash, birch, lodgepole pine, oak and Sitka spruce) occurred on 94% of those subcompartments with natural regeneration, and accounted for 88% of the total area of natural regeneration.

Association between location and site factors and the occurrence and extent of natural regeneration

Results are presented below for the association between a number of location and site factors and the occurrence of natural regeneration. No cause-effect is implied in the presentations. Furthermore, higher or lower occurrences may be an artefact of the extent of occurrence of a particular level of the variable in the Coillte estate. Marginal effects are not presented here but are explored in the Discussion.

Location – Coillte Regions

The Coillte estate is divided into six Regions. The Midlands Region was found to have the greatest number of subcompartments containing natural regeneration (Table 2). The North-Western and Western Regions contained the smallest number of subcompartments with natural regeneration. When examined on an area basis, the Eastern Region had the largest area of natural regeneration.

Table 2. *Regional distribution of the occurrence and extent of natural regeneration within the Coillte estate.*

Region	*Area*	*Natural regeneration*	
	ha	*Number of subcompartments*	*Area ha*
Eastern	44,903	434	656
Southern	93,186	501	310
Mid-Southern	99,001	537	229
Western	77,032	159	159
North-Western	76,327	148	88
Midlands	51,847	789	533

Natural regeneration and soil type

Natural regeneration occurred on thirteen different soil types[4], most commonly on brown earths and podsols (707 and 690 subcompartments respectively). It was more frequent on raised bog peats (298 subcompartments) than on blanket peats (121 subcompartments). Podsols had the highest area of natural regeneration, 743 ha, followed by brown earths (415 ha).

Table 3. *Soil type and the occurrence and extent of natural regeneration within the Coillte estate.*

Soil type	*Area within the Coillte estate*	*Natural regeneration*	
	ha	*Number of subcompartments*	*Area ha*
Brown earths	41,944	707	415
Podsols	99,937	690	743
Gleys	86,733	498	257
Raised peats	26,408	298	342
Blanket peats	167,397	121	79
Other	19,877	254	139

[4] Grouped into six categories for convenience (Table 3).

Site fertility

Subcompartments with natural regeneration were most commonly (33% or 857 subcompartments) found on sites of low fertility. These also had the greatest area (42%) of natural regeneration (Table 4).

Table 4. *Fertility class and the occurrence and extent of natural regeneration within the Coillte estate.*

Fertility class	*Area within the Coillte estate*	*Natural regeneration*	
	ha	*Number of subcompartments*	*Area ha*
High	26,430	174	70
Intermediate	89,608	664	603
Low	281,824	857	842
Varying	41,390	752	383
Unknown	3, 044	121	77

Elevation

Subcompartments containing natural regeneration were most commonly found at elevations above 100 m (Table 5).

Table 5. *Elevation and the occurrence and extent of natural regeneration within the Coillte estate.*

Elevation category	*Area within the Coillte estate*	*Natural regeneration*	
m	*ha*	*Number of subcompartments*	*Area ha*
<100	110,754	1,159	762
100-199	131,192	729	394
200-299	131,336	517	451
>299	65,923	163	367
Unknown	3,091	0	0

Exposure

Sheltered subcompartments or subcompartments that were moderately exposed contained natural regeneration more frequently than subcompartments with high or severe exposure (Table 6). This trend was true for the area of natural regeneration also.

Table 6. *Exposure and the occurrence and extent of natural regeneration within the Coillte estate.*

Exposure	*Area within the Coillte estate ha*	*Natural regeneration*	
		Number of subcompartments	*Area ha*
Severe	21,378	16	22
High	153,492	308	298
Moderate	207,817	1,247	1,056
Sheltered	56,507	876	510
Unknown	3,102	121	80

Drainage

Natural regeneration was most frequent on sites that were classified as having good drainage (Table 7). A sharp fall-off in the number of stands regenerating was noticeable as the quality of drainage decreased.

Table 7. *Drainage category and the occurrence and extent of natural regeneration within the Coillte estate.*

Drainage category	*Area within the Coillte estate ha*	*Natural regeneration*	
		Number of subcompartments	*Area ha*
Good	146,247	1,334	1,132
Moderate	159,345	786	478
Poor	124,103	284	272
Very poor	9, 493	33	14
Unknown	3, 108	121	79

Discussion

Just under 0.4% (or 1,975 ha) of the total area of the Coillte estate consists of natural regeneration. While this percentage is small, the relatively young age structure of the estate should be borne in mind. Also a limited amount of clearcutting has taken place to date. Furthermore, the majority, if not all of the existing areas of natural regeneration have occurred spontaneously, with no intervention used to favour their occurrence.

The range of coniferous and broadleaved tree species found in naturally regenerated areas was quite extensive. However, five species dominated: ash, birch, lodgepole pine, oak and Sitka spruce. These accounted for 88% of the total area of natural regeneration, while they also accounted for 70% of the total Coillte estate.

An examination of the species occurrence data (Table 1) suggests that lodgepole pine appears to regenerate naturally more readily than Sitka spruce. One percent of the total forest area of lodgepole pine was naturally regenerated, while only 0.2% of the total forest area of Sitka spruce comprised naturally regenerated stands. Natural regeneration of Sitka spruce is dependent upon good seed years (von Ow *et al.* 1996, Dagg 1998), the periodicity of which ranges from 3-5 years (Gordon and Faulkner 1992). Lodgepole pine, on the other hand, is a consistent seed producer, producing good quantities of seed cones annually (Fowells 1965), with the best seed crops occurring at 2-3 year intervals (*ibid.*). Another possible reason for the relatively greater area of natural regeneration of lodgepole pine is that many Sitka spruce stands are clearcut before they start to produce seed, which Savill (1991) indicated to be 30-40 years of age. In contrast, lodgepole pine starts to produce seed much earlier, with maximum seed production occurring after 30 years of age (Savill 1991). Unlike Sitka spruce, the majority of lodgepole pine stands in the Coillte estate are planted on blanket peat. Competing vegetation on these soils may be more limited following clearcutting than in the case of soils, such as gleys, that are carrying Sitka spruce crops, making it more likely that lodgepole pine would regenerate naturally.

Of the broadleaves, birch showed the greatest capacity to regenerate naturally (Table 1). Of the total area of birch 3,937 ha, 559 ha were identified as arising from natural regeneration, in 1,103 subcompartments. Ash also showed a strong capacity to regenerate naturally, with 3% of the total area of ash arising from natural regeneration. Both ash and birch are pioneer species (Evans 1984) with prolific seed production (Savill 1991) and with a high capacity to regenerate naturally. The other main broadleaved species, beech and oak, which account for 53% of Coillte's broadleaved forests, have distinctive fruiting patterns, with heavy mast years for both species usually occurring in Britain every 10 years (Savill 1991).

Characteristics of sites on which naturally regenerated stands were found

The majority of naturally regenerated stands were located on brown earths and podsols (Table 3). These soils comprise 9% and 22% of the Coillte estate, respectively. It may appear surprising that brown earths were the soil type that most commonly supported natural regeneration. The normally high fertility status of these soils would make colonisation with vegetation very likely shortly after clearcutting. There is also evidence from the work reported here (Table 4) and from Britain (Brown and Neustein 1974) that natural regeneration tends to be more commonly associated with low fertility sites and poor quality soils such as podsols and peats, probably because of the slower rate of vegetation colonisation of these soils following clearcutting. However, one possible explanation for this result is that many of the oldest stands in the Coillte estate are found on brown earths. Many of the earliest state forests were the woodland areas of estates which were acquired by the Land Commission in the early part of the 20th century. In addition, during the 1930s the Forestry Division acquired better quality lands than in subsequent decades, as many farms were sold off because of the depressed state of agriculture during the Economic War. As a result, many of the forests within the Coillte estate that have reached seed-bearing-age are more likely to be located on brown-earths and podsols. Thus, the observation of high natural regeneration occurrence and extent on better quality soils may be confounded with stand age. It may also be the case that old woodland sites have seed reserves already present, or they may be located nearer to tree-seed banks than upland, formerly unenclosed, mountain sites that have been afforested.

A quarter of the total area of natural regeneration was at elevations less than 100 m (while only 13% of the entire Coillte estate was located at these elevations) (Table 5). Furthermore, over two thirds of the area of natural regeneration was on sites classified as sheltered or moderately exposed, while 60% of the Coillte estate was thus classified (Table 6). These findings are not surprising, given that the majority of natural regeneration was found on brown earths and podsols which tend to occur at lower elevations (as opposed to peats and peaty podsols at higher elevations).

Sixty-nine percent of the Coillte estate is located on sites classified as moderately or well drained (Table 7). Of the sites on which natural regeneration occurred and where drainage conditions were known, 81% were classified as being moderately or well drained. This finding would suggest a greater tendency for stands to regenerate naturally on sites where drainage is good rather than on poorly drained sites. However, all seed requires moisture to germinate. Nixon and Worrell (1999) indicate that optimum conditions are provided by a moist substrate with a high relative humidity. However, even on well drained sites lack of moisture is unlikely to limit germination in the wet, maritime climate of Ireland. Similarly, on poorly drained sites, there is a greater likelihood that the litter layer will take longer to decompose following clearcutting than on more freely draining soils, thereby making it more difficult for the radicle of the germinating seed to reach soil and for the seedling to survive. Site drainage may also influence the survival of newly germinated seedlings. For example, Vickers and Palmer (2000) found that the survival of germinants was negatively affected by excessive moisture in the seed bed. The reason is believed to be the restricted availability of soil nutrients for the growth and development of seedlings on poorly drained soils (Carlisle and Brown 1968).

Conclusion

The increased emphasis on examining silvicultural systems other than clearcutting has resulted in an increased interest in natural regeneration. However, the successful use of natural regeneration is a challenging task. A necessary prerequisite for successful implementation and management is the identification of sites where regeneration is likely to occur. The findings presented in this paper provide some information to help to identify such sites.

Acknowledgements

This study was co-funded by COFORD, University College Dublin and Coillte. The assistance of the Coillte inventory and GIS staff in Newtownmountkennedy is acknowledged.

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Trees, Woods and Literature – 25

A thin, blue haze hung in the valley, but as they began to climb up among the bracken, the sun struck through, revealing behind them the lake where the cattle stood meditating and swinging their tails gently in the shade of overhanging branches. It promised fierce heat later in the morning, by the still air and the unruffled surface of the water. The sun beat hotly on the bracken, raising its sharp scent as it dried, and encouraging the swarm of flies which followed them, buzzing and hovering about their heads. They skirted a plantation of firs, set among the rocks.

'How discouraged they look, don't they Mick?' said the girl.

'No wonder,' he said, with a glance at the poor, thin trees, huddled miserably together. 'They're only grown to make into pit-props.'

'Pit-props!' she exclaimed. 'How awful.' No wonder, indeed. After the sky and the sun, to be condemned to the darkness for ever.

From the short story 'Ill Wind' by John Ward, published in *The Penguin New Writing 29*, (1947) edited by John Lehmann. The Penguin Group (UK) has disavowed rights on the text and it has not been possible to find out anything about the author.

John Lehmann (1907-1989), editor, set up as a publisher in 1946 having learned the trade at the Woolfs' Hogarth Press in London. He published three volumes of autobiography in one of which he recounts an anecdote about the Irish architectural historian Maurice Craig, who, when asked to provide details of Irish wartime naval defence capability 'proudly declared: " There's that gunboat we bought from Britain the other day, a ship to strike terror into the enemy's breast when manned by Irish boys"'.

The voracious demand for pit-props, to support the roofs and walls of coalmines, was probably the main outlet for forest thinnings from the heyday of the British mining industry in the later part of the nineteenth century, until the more recent development of particle-board manufacturing facilities, and round pit-props were exported from Ireland until the 1960s. They are now sawn to precise size specifications. With the continuing decline of coal-mining in Britain pit-props represent a diminishing market

(Selection and note by Wood Kerne)

Society of Irish Foresters 58th Annual Study Tour Hungary 2001

Forty-eight Society members assembled at Dublin Airport on Saturday the 1 September 2001 to begin the 58th study tour and the Society's first visit to Hungary. A notable absentee was the late Charlie Farmer, formerly of the Northern Ireland Forest Service and a regular study tour participant over the years. A minute's silence was observed in his memory.

The group was met at Budapest Airport by Professor Janos Gál, who was our tour leader for the week. Janos gave us a snapshot of Hungarian forestry during our bus ride from the airport to the hotel. Hungary has a total land area of 9.3 million ha, which is about 10% larger than the land area of the island of Ireland. Its population of 10.5 million is about twice Ireland's. Forests cover 1.7 million ha, about 19% of the land area. The state owns 61% of the forest area, while 25% is in private hands. Ownership of the remaining 14% has yet to be decided. The species mix is 85% deciduous/15% coniferous. About 57% of the forest comprises native species – mainly beech, sessile and Turkey oak (*Quercus cerris*) and hornbeam – while the main exotic species are black locust (*Robinia pseudoacacia*), pines and poplar.

After uncertain beginnings following the change to a market economy in 1990, Hungary now has an annual growth rate of 4% in gross domestic product – well above the EU average – an inflation rate of 6% (down from 31% in the mid 1990s) and is well on its way to EU membership by 2004.

Janos was the perfect host and guide for the week; he worked tirelessly in looking after the needs of the group. The Society is deeply indebted to him.

John Mc Loughlin, Convenor

Saturday, 1 September

After lunch the group departed on a guided tour of the city taking in many of the sights that make Budapest such a beautiful city. We started in Pest, on the eastern bank of the Danube, and visited the state Opera House, the parliament building and Heroes' Square before crossing over the Chain Bridge to Buda. Later we travelled up to the limestone plateau of Castle Hill, 170 m above the Danube, in a funicular railway and explored the Castle district and Margaret Island.

Donal Magner

Sunday, 2 September

We set off to the north-east, to the city of Eger, in the heart of the Northern Uplands. On the way we travelled through flat countryside running parallel to the Matra Hills before reaching Eger, which is flanked by the Matra and Bukk Hills. Fields of ripened maize and sunflowers gave way to vineyards as we approached the Matra foothills.

Smoke from lignite-fired power stations was an intrusion in this generally unspoiled landscape; apart from the extraction of low grade coal there is little mining in Hungary. This marks the country apart from other former Eastern Bloc countries. As a result Hungary is fortunate in not having air pollution (apart from a few belching Trabants!) of the scale witnessed on previous Society study tours in parts of Poland in 1995 and in the Krusne Hory region of the Czech Republic in 1997.

We visited Eger Castle which overlooks the city. Eger is a favoured destination for Hungarians because it was here that 2,000 of their forebears defended the castle against 100,000 Turks during the famous siege of 1552. Our guide told us how the women of Eger played a crucial role in its victory, pouring boiling water, oil, pitch, and even porkolt (soup) down on the attackers. However, the Turks recaptured Eger 40 years later, and they held the city until finally driven out at the end of the 17th century. Apart from some descendants of the Turkish community – like our tour guide – there is little of the Turkish occupation evident today, as their domestic and religious architecture has been destroyed. After the castle tour, the group visited Eger Cathedral, a neoclassical edifice and were fortunate to hear the massive baroque organ playing at evening Mass.

Later in the evening, we had a presentation from Laszlo Jung, General Director, Eger Forestry Company (Egererdö Rt.) and Urban Pal, Leader of the Department of Production. Egererdö Rt. is a state company that manages 70,000 ha of forest in three regions in the northern uplands. In addition the company owns and operates the Matra parquet factory, a nursery with 22 million seedlings and the Matra Railway with its three narrow-gauge tracks. The annual production potential of Egererdö forests is 328,000 m3 (underbark), with an annual harvest of 220,000 m3. Beech (30%), sessile (25%) and Turkey (25%) oak (25%) are the main species harvested with the balance comprised of range of species. Laszlo congratulated Ireland on its World Cup success and wished the group well in their visit to the Bukk Hills, which take their name from the beech forests which predominate in that region. After a question and answer session, the President of the Society, Trevor Wilson thanked both foresters for their welcome and presentation. He presented them both with copies of *Fr. Browne's Woodland Images* before they joined the group for a hearty evening meal. We overnighted at Taltos.

Donal Magner

Monday, 3 September

On Monday morning we arrived at the Eger Forest Company and were greeted by District Manager Karroly Nemeth and Forest Manager Jozsef Abtal. We boarded the Matra forest railway, now used for tourists but which had once been used for wood haulage, and were brought high into the Bukk Hills.

The Eger Forest Company (Egererdö Rt.) manages 74,700 ha of forest in three regions, which comprise the largest contiguous area of forest in Hungary, covering the mountains and hill land of northern Hungary. The forests cover the whole of the Matra Hills, the western Bukk Hills and the Heves Hills. They have been managed for over 400 years and during the industrial revolution they provided large volumes of coppice for the charcoal industry.

The forest is comprised of natural and naturalised tree species, predominantly broadleaves:

Species	*Forest cover* %
Sessile oak	35
Beech	30
Turkey oak	18
Hornbeam	7
Conifers	7
Others	3

After the introduction we continued uphill to a mature oak stand which was at the initial regeneration stage, with some few good quality stems remaining. The hill slopes had been terraced by hand to prevent acorns from rolling downhill. We made our way to the open-air museum which showed traditional machinery and equipment that was used to remove wood from the forest; these varied from human sledges to oxen carts. We also saw the reconstruction of forest workers' homes which were made of slabs of wood or poles where they would spend a number of weeks before returning to their home down the valley. We also stopped off at the forest museum, a converted District Forester's house, which was in stark contrast to the slab huts in the wood. It was pointed out that the District Forester was a powerful man in former times, with 500 workers under his direct control.

The Hungarian state forest is comprised of 22 regions each 75,000 ha in extent (19 general forest management and three military). Each region is divided into forest districts of about 8,000 ha. The district manager has two professional foresters working in support - these usually specialise on either harvesting or establishment and general management. Each forest district is sub-divided into ten forest units (800 ha), each with its own forest technician, who supervises all field operations in the unit. All work is carried out on contract (mostly by forest workers who were formerly employed by state forest organisation).

A ten-year management plan is agreed with the Forest Service. This determines the areas to be cut, the annual harvest volume and the composition of reforestation programmes. Some of the areas in the region are part of Hungary's extensive National Parks where consultation must also take place with the Environment Department (equivalent to Dúchas) when compiling the plan.

The annual allowable cut for the region is 330,000 m3, of which 220,000m3 was harvested in 2000. About 60% of the harvest is suitable for industrial use (veneer, sawlog and pulpwood) with the other 40% being used as firewood. The product assortments sold in the region in 1998 were as follows:

Wood product	*Removals by volume %*
Veneer logs	1.5
Sawlogs	23.5
Other sawmilling products	5.4
Pit props	0.6
Pulpwood logs	8.9
Panelboard logs	13.1
Other industrial uses	4.8
Total industrial wood	57.8
Firewood	42.2

Hunting of red, roe and fallow deer, wild boar and moufflon is managed on 55,000 ha (70%) of the forest. It yields little revenue however. In the Bukk forest district, revenue from hunting represented less than 5% of income. Three thousand ha lots were leased annually at about €19,000 upon which the allowable cull was 100 animals. Prices for red deer stags varied between €190 to €1,900 (for good quality stags) and €63 for females. Prices for roe deer stags varied between €190 to €1,300 and €63 for females. Germans and Austrians as well as Hungarians are the main users of the hunting facilities.

In the afternoon Turkey oak silviculture was dealt with in greater depth, stops included mature Turkey oak where the majority of the harvest goes to firewood. Reforestation of such sites favours a shift to sessile oak which has a higher end-use value. We overnighted at Sarospatak

Richard Lowe

Tuesday, 4 September

The Hedaoya area, located in northern Hungary, in the forested hill country of Bukk was our destination for the day. We were welcomed to the Zemplen district, by the district manager, Szaniselo Gabor, who manages a forest area of about 10,000 ha of state land, for the Egererdö company. The company harvests about 300,000 m3 annually. Some of the harvest is processed in the company's mills; part is sold for logging. Felling volumes conform to a forest plan, with felling licences being granted by the state forest service.

The first stop was at a 6.4 ha stand of mature (111 year-old) Douglas fir, which was being conserved for seed production. The largest trees were up to 10 m3. Originally Norway spruce grew alongside the Douglas, but it had died out due to the dry climate and the high incidence of *Fomes*.

This was followed by a very impressive stand of 90-year-old beech, of exceptional quality. (Beech is native to Hungary, comprising 6.3% of the forest area.) The stand will be due for clearfelling after a further ten years, and was being opened-up to encourage natural regeneration - when a certain proportion of beech seedlings are present, mature trees are felled to let in light. Beech is slow growing and shade tolerant so the process of opening-up a stand to encourage natural regeneration can take up to six years, sometimes longer, to minimise the risk of frost damage to seedlings. After regenerating naturally beech seedlings can grow very densely, necessitating a reduction in the numbers of stems, also aggressive species such as hornbeam need to be controlled. It is necessary at an early stage to establish the proper ratio between selected species and to control invasive species. Beech seedlings are tended for up to 10 years, gradually reducing the number of stems. The stocking rate for beech here is 6000 to 8000/ha at 10 years, falling to 2500/ha stems at 40 years.

The next phase can last for up to 40 years, with some pruning and a further reduction in density. It can take up to 60 years before any profit arises from thinning. At this stage management is aimed at encouraging diameter increment as opposed to height growth. Felling of mature beech trees takes place in winter, when the ground is snow-covered, to facilitate log sliding during extraction. It is restricted to areas less than 5 ha. Unfelled areas must be left alongside regenerated/clearfelled areas.

At the next stop a 15-year-old stand of beech, in mixture with hornbeam and oak, was seen. It has been the experience that mixtures increase the wind-stability of stands. In this particular area, mixtures comprised of beech and European larch have been found to be very wind resistant.

In some areas fencing is used to exclude deer; a chemical is also applied to stems to discourage them.

After an interesting day in the field we made for the city of for our overnight stay.

Pat Berkery

Wednesday, 5 September

Following a pleasant overnight stay at Debrecen we departed from our hotel to visit the Great Forest of Debrecen. On route we were joined by Mr Tibor Olah, a representative of the Nyirerdo Forestry Corporation, our hosts for the morning.

Mr Olah gave an excellent presentation on the city's past and present state. Debrecen is situated in the Eastern Great Plains of Hungary and has been a place of importance since the Middle Ages. It has a population of over two hundred and fifty thousand inhabitants and is the second largest city in Hungary. Its inhabitants have survived multiple invasions by Mongols and Tatars, and the later Turkish and Hapsburg occupations. The Reformation brought Calvin Protestation to Debrecen, and during the Thirty Years War (1618-1648) Debrecen proved to be a fortress of Protestantism and has since been referred to as the "Hungarian Geneva" and the "Calvinist Rome".

Today, Debrecen is better known as a place of leisure and tourism. Its main attraction is the Great Forest, where a large recreational centre has been created with botanical and zoological gardens, health spas, camping areas and a large sports arena. It hosted the 2001 World Youths' Athletics Championships.

After a short bus journey we arrived at Nyirerdo Corporation's Forest Cultural Centre in the village of Bank. We were met by Mr Pal Csoke (District Director), Lajos Erdos (Recreational Forester) Miklos Szemeredy (State Forest Service) and Ms Miklosne Elek (Forester). The District Director, Mr Pal Csoke outlined the structure of the Debrecen Forestry District. The forest is situated at the southern point of the Vyirseg on marshy ground. The typical soils found here are wind-blown humic sands with various layers of humus.

The total forest area is 9,400 ha, of which 8,700 ha are under forest. Of this 8,500 ha are located around the city of Debrecen, the remainder is scattered throughout other nearby settlements. One third of the forest is oak, other common species include acacia, poplar and pine. The annual planting target is 140 ha. Wood production runs at 48,000m^3 annually, mostly (65%) black locust and comprises a number of assortments: sawlog (acacia and oak), mining timbers and pit props, vine poles for the wine industry, aspen and pine wood panels and pulpwood.

The company operates a forest culture centre, an exhibition hall and arboretum, where foresters teach the public how to conserve and value nature. The 9,400 ha district is staffed by sixteen forest workers and twenty-five technical and administrative staff (including fifteen foresters and three forest engineers). Timber revenue covers expenses whereas silvicultural operations receive state support.

Mr Lajos Erdos gave us an insight into the recreational aspects of the district forest. Work began in 1975 when the museum was founded. Its primary function is to display the flora and fauna found in the district and to house and display a pictorial record of how the inhabitants of the forest lived in former times. It also has rooms for guests and scientists who wish to experience and study the surrounding forest habitat. Recreational activities are segregated in the forest, noisy spots are confined to the northern section of the forest away from the more valuable habitats, scientific studies take place in the middle section of the forest, whereas boating, water sports and horse riding take place in the southern portion.

At this point the tour moved outdoors where our hosts led us to our first stop of the morning, a black locust stand. Black locust is native to south-western US. It first appeared in Europe in the 1600s. Samuel Tessedick, an Evangelical priest is believed to have brought the first specimens to Hungary in 1710. The role of the black locust in Hungarian forestry is extraordinary. Hungary has more of these trees than the rest of the European continent put together. The area of black locust forest is 318,620 ha, or 19% of the total forest area of Hungary. It was originally planted to stabilize sandy soils and prevent erosion, and has the ability to thrive in the dry sandy soils of the plains.

In the Debrecen forest, black locust grows to 25-30 m and yields a significant amount of wood in a relatively short time (its yield is normally twice the average of other broadleaved species). Young plants, growing from seed, grow as tall as 1 m within the first year. Its rate of growth is rapid until it reaches 20 years of age. It falls off thereafter to become insignificant after 35 years. In Debrecen it is usually clearfelled at 40 years of age, with a final volume of 400 m^3/ha (volume to a top diameter of 5 cm). The assortment breakdown is: 30% sawlog, 20% vine poles and props, 50% firewood (much sought after by locals). Near a mature stand we were shown regeneration using root suckering and natural seeding (this accounts for 40% of regeneration with the balance is by artificial regeneration).

Black locust is extraordinarily durable, even without chemical treatment. Experience locally indicates that the wood lasts 20-25 years in soil contact, and 60-100 years out of contact. Sawn goods are used in the furniture and carpentry trades, for chairs, tables, parquet, stairs, banisters and railing supports. It is an ideal tree for bee keeping; the honey produced from the flowers is a golden yellow.

We next visited a beautiful, mature oak (*Q. robur*) forest on the outskirts of Debrecen. This 200 ha of old woodland was declared a nature reserve in 1992; all fellings are prohibited, mainly due to public pressure. This has resulted in invasive species such as black locust increasing to the detriment of oak regeneration – another situation where rigid preservation is counterproductive to conserving the original habitat type.

The next stop included a selection of young oak plantations where discussion took place on establishment methods. Here the first step is to burn lop-and-top on the ground. After cultivation 600 kg/ha of oak seed is sown. In the first year growth of 8-12 cm is common, while competing vegetation is controlled chemically. Crops are usually free growing at 6 years of age with a stocking of 30-40,000/ha. Shaping and selection of final crop trees begins at 10 years of age.

On leaving the Great Forest of Debrecen, we journeyed west on Route 33. After about 25 miles we entered Hungary's first national park, the Hortobagy National Park, which includes wetlands, marshes and grasslands. We were met at the famous nine span bridge by the National Parks Cultural Affairs manager Mr Gensi Zoltan. The tour was treated to demonstrations of ox driving and horse riding by the parks herdsmen and shepherds.

Hortobagy is a salifereous, grassy desert of 115 km^2; its landscape was primarily shaped by the waters and floods of the river Tisza. The park consists of 80,000 ha of open country in the great Hungarian plains, its flatlands have an average altitude of 5-10 m above sea level.

The main sources of income in the area are from livestock breeding and tourism. It is home to the nonius – a Hungarian horse breed, Hungarian grey cattle, black and white racka sheep, and buffalo. It is also home to the great bustard, one of the world's largest birds, which stands a metre high and weighs in at 20 kg (unfortunately not seen during our visit). However, we were fortunate to see many marsh harriers hunting over the great reed beds. After a lunch of local goulash soup (Gulyasleves) we boarded our coach for a four-hour journey to the overnight stop at the town of Bujac, ending a most enjoyable day.

Gerry Murphy (Limerick)

Thursday, 6 September

On a very wet morning the tour bus departed in the direction of the Kiskunsag National Park and drove through the great Puszta plain.

Our first stop was the Puszta Museum where the District Forester gave an overview of his district and the museum. The museum contains information and displays of the life and cultural habits of the people who lived and worked in this area. The Puszta plain was traditionally grazed and managed by shepherds. The Puszta is the largest lowland plain in Central Europe and traditionally was used for extensive animal grazing. The Forest District consists of 11,200 ha and is situated on very sandy soils. The origin of these soils is the result of the sea receding and the river Danube changing direction over 4 million years ago, resulting in large deposits of sand which can reach 1,000 m in depth. The sand is alkaline in nature. Planted coniferous species account for 65% of the total area, principally Scots and black pine. In 1945, a large afforestation programme established over 10,000 ha on the plains. Skills in the afforestation of sandy soils were developed. The district's annual cut is about 33,000 m^3, on rotation lengths that vary between 40 and 50 years. Wood quality is generally poor with fuelwood and pulpwood accounting the main products. Hunting accounts for 2 % of the income.

After leaving the museum we travelled to our next stop, an area where a grey poplar stand had been windthrown in 1996. The forester explained that following the windthrow the site was cleared to regenerate from cut stumps. Results were poor following a dry summer after harvesting. As a result all of the stumps were removed and windrowed. Poplar cuttings were planted 2.5 x 0.9 m apart. In the first year competing vegetation between the rows is mechanically cut back up to three times. The plantation is usually fully established by the end of the second year. Natural regeneration of species such as black locust is acceptable between the rows.

The bus departed south-westwards towards Baja where our hosts laid on another great lunch, which consisted of local venison and other Hungarian delicacies. The local Forest District manager gave an overview of the Gemenc Forest and Game Company. Almost two-thirds (17,000 ha) lies in the flood plain of the river Danube, making it the largest flood plain forest in Europe. Humic, alluvial soils and humic sands predominate. The climate of the region is continental with a sub–Mediterranean microclimate in parts. Species planted include black locust, oak and white poplar. The company also manages large hunting fields, which are internationally renowned. A number of record sized red deer have been shot, with one red deer measuring 271 C.I.C.[1] points in 1986. A large population of wild boar was also present. A single shooting party can take up to 30–50 wild boar in a day. There are a number of hunting lodges throughout the area which are rented by hunting parties. A large number of hunters come from Austria, Germany and Italy.

We were next treated to a railway trip that took us through the Gemenc forest where excellent stands of oak and black walnut were seen. The importance of the region's hunting was confirmed as numerous wild boar and some red deer were seen. The railway is 30 km long; roundwood from the forest is transported by rail to the workshop at Porboly where it is either processed or further transhipped along the Danube. Passenger use of the railway is significant and can exceed 40,000 people yearly. The line operates a scheduled service from 1 May to the 31 October between the stations of Porboly and Malomteto. The station at Malomteto is adjacent to nature trails and a bird observatory that allows

1 International Council for Game and Wildlife Management.

the public to observe the rich and varied flora and fauna of the forest and lakes within the flood plain.

Before dinner at the forestry station at Lake Balaton, a representative of the Forest Service gave the group a comprehensive overview of its organisation and structure and on Hungarian forestry in general. The Forest Service has a staff of about 500 who are responsible for forest policy and the compilation and monitoring of forest people. They carry out an inventory of one tenth of the growing stock each year, in order to calculate the allowable annual cut and the volume of the national growing stock. Recreation and conservation are also important functions of the forest and this is reflected in the nine National Parks that exist.

We overnighted at the Forest Service Education Centre at Lake Balaton.

Fergus Moore

Friday, 7 September

Lake Balaton lies at the foot of the Balkony Mountains and is situated 175 km south-west of Budapest. It is the largest inland lake in Europe and contributes significantly to the environmental, economic and social value of the Balaton Uplands. The lake area is renowned for its geological, botanical, zoological, landscape and scenic values, its historic relics and association with political figures and events of the past.

Against this background, the day was spent in the Balaton Uplands National Park. The tour leaders for the morning were Drs Peti Miklos and Sonnevad Imbre, both of whom are attached to the Balaton Uplands National Park Directorate at Veszprem.

We were met at the steps of a complex of buildings that make up the Benedictine Monastery by Dr Miklos who has special responsibility for forest management and planning. Dr Imbre has special responsibility for conservation and protection in the Balaton Uplands National Park.

Following a brief introduction, the tour began with a visit to one of the oldest religious sites in Hungary - the Benedictine Monastery at Tihany, whose buildings occupy the most prominent point on the peninsula. The monastery was founded by King Andrew I in 1055 and is dedicated to St Anianus. King Andrew was buried here in the vaults in the year 1060. In the course of time most of the original church and monastic buildings were modified as a result of fire and war.

In the 16th and 17th centuries drawings were discovered which highlighted the fundamental changes in the building's history because of Ottoman attack. It was at this point in the monastery's history that the Benedictine Order left for the first time. When Hungary was liberated from the Turks with the assistance of the Habsburgs, the lands and estates were returned to their former owners by the royal court in exchange for money. However, in the case of Tihany, the Hungarian Benedictines were too poor to pay for the return of their estates and asked their Benedictine brethren in Altenberg, Austria for assistance. So it was that in 1702 the church and lands became the property of the Austrian monks and title was later transferred to the Hungarian Benedictines in 1716.

During the period 1716-1786 three successive abbots concentrated on re-establishing the monastic life and stabilising its estates and finances. Reconstruction on the present church and monastery began in 1720 and was completed in 1754.

In 1786 the Benedictine Order was dissolved by decree issued by the Habsburg Emperor Joseph II, the monks had to leave the abbey for the second time. In 1802 the monks were allowed to return to the abbey. By 1880 the condition of the monastery buildings was very poor. Restoration and renovation were carried out in 1889–1890.

In 1950, during the Communist regime, the monks again had to leave the monastery. They returned in 1990 but it was only in 1994 that the Order regained ownership from the state. Renovation of the interior began in 1992 with the restoration of altars and the wall paintings. This was followed by overall restoration of the monastery in 1996. Renovations to the exterior are still in progress.

The Balaton Uplands National Park stretches from the northern shore of Lake Balaton to the plains of the Raba river, from the valley of the Marcal river to the Teo plateau, and from the valley of the Murca River to the Kio Balaton basin. It extends over 56,000 ha, containing over 36,000 ha of protected areas, within which there are about 800 ha of original forest.

The Balaton Upland National Park Directorate is administered from the offices of the state Forest Service located at Veszprem, with a staff of 80 who have responsibility for 22 nature conservation areas. In 1952 Tihany was the first protected landscape area created in Hungary. It covers 1,562 ha, of which 195 ha are strictly protected.

The varied landscape of the peninsula is an attraction to visitors throughout the year. The unique geological value of the Tihany peninsula (which is valued on a world scale) is its complete Upper Pannonian (Middle Miocene) sequence which is rich in fossils. Its most famous fossil is the 'goat hoof', a petrified Congeria shell. Various stages of the erosion of basaltic tuff can be studied on the Kiserdo Peak.

Rare fauna and flora occur as a result of the mild, Mediterranean climate. The arid forests of ash, oak and sumac are especially picturesque especially in autumn. One of the rare birds of the peninsula is the horned sparrow owl – on summer evenings the loud call of the cicada and the balm-cricket living can be heard.

Several rare, protected sub-Mediterranean plants (*Sternbergia colchiciflora* and *Scilla autumnalis*) occur on the grassy steppes of Tihany. Forest developments have been created on these ancient Pannon grasslands, which prior to planting were extensively used for sheep grazing. The Directorate actively encourages sheep grazing within the protected zones in order to help conservationists restore the pastures that had been neglected for so long. As part of this work, the Directorate construct sheep pens in order to encourage farmers into the area.

The Tihany area is especially rich in insects that thrive in the warm climate: over 1,000 species have been identified in the area. A wide variety of butterflies occur, some of which are extremely rare such as ruly tiger, red underwing and looper. An interesting fauna of bees and wasps occupy the steep sand clay slopes descending towards the lake, such as the turret wasp, *Plopeus destillatorium* and *Podolinus parietinus*.

The historic relics of the peninsula are also the responsibility of the Directorate, such as the Benedictine abbey and grounds, the former Orthodox Church cave dwellings, which were restored in 1993 and the village heritage museum.

In 18th and 19th centuries the population in the Tihany peninsula was much greater, sheep grazing on upland pastures was extensively practised, leading to erosion on these light sandy soils. In the early 1900s, to counteract the effects of erosion, the hillsides above Tihany were planted with pure crops of maritime pine (*Pinus pinaster*), at a stocking density of 13,000 stems/ha. At time of establishment, humus had to be imported onto the site and applied to each individual plant. It was envisaged that the pine would act as a pioneer species, create its own humus, thus stabilising the soil and creating a good medium for the second rotation. The silvicultural treatment consisted of a reduction in stem numbers at years 10-12, followed by further thinning which was carried out at intervals until 70-80 years of age,when pre-commercial fellings were completed. From year 80 onwards it was noticed that the rate of canopy closure in the pine decreased, creating open pockets ideal for natural regeneration to occur. Surprisingly, assisted by prevailing winds and birds, the area regenerated with a mixture of a wide range of broadleaved species including ash (*Fraxinus ornus*), Turkey and downy oak (*Q. pubescens*), sumac (*Rhus typhinus*) and elder, forming the upper and middle storeys with *Cotina* and *Cornus* spp forming the ground/lower storey. At year 90, a manual stem reduction, removing whips and wolves was carried out in the broadleaves with the best stems being retained and pruned. Currently, the plantation consists of pine, which forms the upper canopy, the oak and ash forming the middle to lower canopy layers. From a visual perspective, the plantation has a very attractive appearance. However the broadleaves will have a poor commercial value due to the high percentage of poor quality stems and the very high cost of manual improvement treatments. It has now been recognised that the visual value of the plantations, on this prominent elevated landscape, far outweighs the commercial value of the remaining pine crop. As a result, and in response to strong public demand, the Directorate have decided to maintain the pine indefinitely, and that future management of the crop should favour the production of the broadleaves, albeit with no economic return.

Dr Miklos, in his role as Deputy President of the Association of Hungarian Professional Foresters was pleased that the Society choose Hungary for its study tour in 2001, stating that it was a pity that the tour party had so little time – just seven days to view the variety of forest types and landscapes throughout Hungary. He was very pleased that his colleagues had arranged a tour that was both interesting and varied sufficiently in order to provide a good flavour of Hungarian forestry.

The Association of Hungarian Professional Foresters was established in 1987. At that time it had 5,000 members representing both private and professional foresters. Professional foresters have a degree in forest engineering. During the Russian administration period, the Association comprised professional foresters only – as land and estates were confiscated by the State. That situation prevailed until the early 1990s when 700,000 ha of land was repatriated to the former owners. As a result, there is increased contact today with members operating in the private sector. As in the case of Society of Irish Foresters, the Association represents the professional well being of all its members. For administration purposes the membership is divided into regional groups. The Association has one president and three deputy presidents to cater to the technical and private membership.

In conclusion, Dr Miklos stated that the Society and its members were always welcome to visit Hungary, that his Association members would welcome opportunities to demonstrate management and silvicultural achievements, and offered his Association's best wishes to the Society of Irish Foresters both here in Hungary and those at home in Ireland.

The Society's Vice-President, Aeneas Higgins paid tribute to Dr Miklos for his Association's warm welcome and good wishes, to his members' contribution to the success of the Society's tour, and his members' success in preserving the heritage, cultural and landscape values of forestry in Hungary.

The tour party enjoyed a most informative visit to the Tihany peninsula and were most appreciative both to Dr Miklos and Dr Imbre for helping us to understand the natural and cultural values of the Lake Balaton Uplands, for their depth of knowledge and patience in coping with such a large group, and to all of the Directorate staff who gave of their time to ensure the success of our tour of the Balaton Uplands National Park. Following a show of appreciation and exchange of gifts with the staff, the society bid farewell to the Directorate staff to begin our journey along the M7 motorway eastwards through Budapest, over the river Danube, bound for the airport to begin our return journey to Dublin.

Tour Convenor, John Mc Loughlin and the Society President, Trevor Wilson, paid tribute to Professor Janos Gál, who through his dedication and attention to detail, worked extremely hard throughout the week in order to ensure that the tour operated smoothly. He left us very conversant with the current issues and values in Hungarian forestry. We were extremely honoured and fortunate that Janos accepted the task of organising and leading the tour group, and bade him farewell in our customary manner. Finally and by no means least, special tribute was paid to Thomas, our driver, for the courteous, helpful and agreeable manner in which we reached our daily destinations.

Eamon Larkin

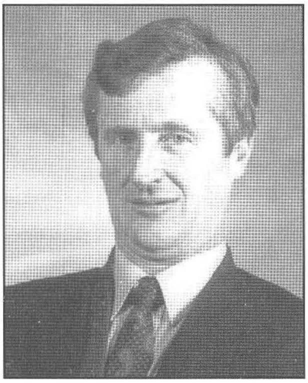
Participants

Marie Aherne, Pat Berkery, John Brosnan, Richard Clear, Tadhg Collins, Jim Crowley, Jim Dooley, Frank Drea, Ken Ellis, Jerry Flemming, Matt Fogarty, Brigid Flynn, Gerhardt Gallagher, Tony Gallinagh, Sean Galvin, Christy Hanley, Aeneas Higgins, George Hipwell, Eamon Larkin, Richard Lowe, Donal Magner, Brian Mahony, Fergus Moore, Tony Mannion, PJ Morrissey, Gerry Murphy, Liam Murphy, Ted McCarthy, Pat McCluskey, Kevin McDonald, John McLoughlin, (Convenor), Jim Neilan, Nuala Ni Fhlaithbheartaigh, Frank Nugent, Michael O'Brien, Pat O'Callaghan, Con O'Driscoll, Liam O'Flanagan, Derry O'Hegarty, Tim O'Regan, Denis O'Sullivan, Pat O'Sullivan, Padraig O Tuama, Tom Purcell, Mary Ryan, Joe Treacy, Trevor Wilson (President).

Acknowledgement

The Society of Irish Foresters acknowledges the generous sponsorship for the study tour from the Forest Service of the Department of the Marine and Natural Resources under the National Development Plan 2000- 2006.

Patrick F. Berkery
1947-2002



Pat Berkery died suddenly on February 9, 2002, aged 54 while hill walking with work colleagues in the Galtee Mountains. Hill walking provided Pat with an opportunity to maintain fitness after he reluctantly hung up his hurley, but more importantly, it provided him with a regular opportunity to connect with nature. It also allowed him to trek through forests and woodlands and to keep in touch with his forestry past. He was proud of the role forestry played in the changing landscape and proud too of his own contribution to the development of forestry although his career had taken on a new direction a number of years previously. He was well informed on all forestry matters and in recent years attended Society study tours and contributed to journal reports. Before his untimely death he was carrying out research for a M.Sc., specialising in forestry and planning.

Pat was a native of Rearcross, Co Tipperary and was the eldest in a family of three girls and four boys, one of whom, Billy, followed him into forestry in 1969. He began his forestry studies in Kinnitty Castle, in 1967 where he was a bright and diligent student. After qualifying as a forester he spent four years in Glenealy forest and nursery. He relished the challenge of working in an environment that covered the forest cycle from seed to sawlog. He would carry this enthusiasm to other forest centres he worked in, such as Kilworth and Ballymahon.

He was an excellent hurler and won three Tipperary divisional senior hurling medals for the Sean Treacy club. He also made a major contribution to Wicklow hurling and won an All-Ireland Junior Hurling medal with the county in 1971. What was remarkable about Pat was his insatiable appetite for education in forestry and a range of other subjects. During his hectic work and sports lifestyle he completed – in his own unassuming style – an honours B. Comm. degree in 1974 at University College Dublin.

Unfortunately, during this period there were few promotional outlets in forestry and in addition foresters were subject to transfer, usually without redress. Pat wanted to put down roots in Wicklow and felt that a transfer would be unfair to his family. With some regret he left the Forest Service to pursue a career in the Valuation Office. Here, he worked with distinction achieving promotion to the senior management position of team leader during the restructuring of the agency.

While Pat excelled in his career and sport, he maintained a balance in his life that put these in perspective. He would freely admit his life only took on a true meaning when he met and married Margaret and a sense of purpose with the arrival of his son John and twin daughters Mairead and Mary. His love of family and nature were based on a deep spirituality which only became apparent after years of knowing him. This was the private side to Pat, not the subject of easy banter. The other side to him was that of a cultured man, at ease with life. He had an encyclopaedic knowledge of sport and he had a deep interest in a broad range of subjects especially politics and literature. His education in the classics was a reminder of an era when things were learned 'by heart' and he used this to good effect in conversation.

His loyalty to his friends and colleagues was a feature of his life. This was reflected in the attendance at his funeral as mourners gathered from all over Ireland to pay their respects to a friend whose death was all too soon. And it is the suddenness of his departure that is so difficult to comprehend because Pat was a man with such boundless energy, with so much still to give. Those of us who were privileged to know him, can but imagine his thoughts in the Galtees on that fateful February day. Family and friends would no doubt have featured in Pat's thoughts as he told his companions to walk on without him for a while as he savoured the panoramic splendour of south Tipperary: a landscape that would evoke the clash of ash and perhaps a few verses from his favourite poems. Sadly, this time, it would be the stark finality of Keats that would intrude in this idyllic setting:

Stop and consider! Life is but a day;
A fragile dew-drop on it perilous way
From a tree's summit.

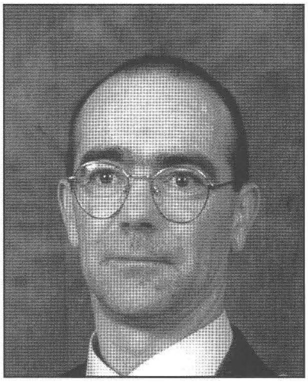
One thing we can know for sure about Pat: there would be no malice, no recriminations in his thoughts. He brought a strong sense of fair play from the hurling field to all aspects of his life. He epitomised all that is best in a good public servant: honest, hard-working and loyal. Pat possessed these qualities in abundance along with integrity and a sense of humour. It is the memory of these qualities that will surely help his family and friends to come to terms with his untimely death and face the future with hope and confidence.

We offer our sincere sympathies to Pat's wife Margaret, children John, Mary and Mairead and his brothers and sisters. They can justly remember him with pride and affection.

Go ndéanfaid Dia trócaire ar a anam.

Donal Magner

Pat Carroll
1957-2002



The recent death of Pat Carroll, Dundrum, Co Tipperary, after a brave battle against illness was a shock to us all, especially when the good Lord called him ashore at such an early age.

I first met Pat in 1978 when four Tipperary men, three Cork men and a Kerryman were taken on to train as foresters by the Forest and Wildlife Service of the Department of Fisheries and Forestry. With Pat's late father also a forester and his own involvement in forestry work, we looked up to him as a leader. Pat was always full of energy and ideas; he had an opinion on everything and would debate issues to the last, whether he turned out to be right or wrong. But once a decision was taken Pat would row in with the majority and give it his all.

His interest in forestry was total no matter what area he was in - be it nursery production, forest management or training and safety. His last post was as Coillte internal auditor for Forest Stewardship Council certification.

Throughout his career Pat was a loyal member of the Society of Irish Foresters. He served as Technical Councillor for a period from

A few years ago Pat took up golf at his local club. Within a few weeks he could compete with the best of them. His golfing comrades would tell you about many a shot that had been debated with Pat.

The great memory of Pat was of his helpfulness. Any favour or help one asked for was no problem to him. If Pat had to do a job for you, you knew it would be done without asking a second time. During our early days in forestry college we had only two means of transport, Pat's mini and a motorbike. Often times Pat made two or three journeys to get us to our destination and back.

Pat was extremely positive in everything he did. The way he bore his illness over the last year was a testament to that, as he tried everything to make himself well again. His courage was evident to all as he was still entertaining people up to his last days.

His popularity was shown by the many who attended his funeral, and by the guard of honour provided by his forestry and golfing comrades.

Pat was also a great family man; to his wife Mary Alice, daughter Marian, son Sean, mother Joan and brothers Noel and John we extend our sincere sympathy.

Thanks for the memories Pat

John Moore

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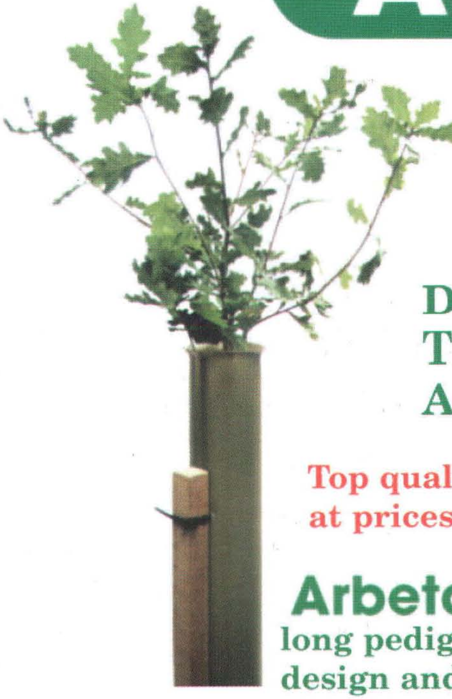

IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

Volume 58, Nos. 1 & 2, 2001

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