IRISH FORESTRY

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FORESTERS

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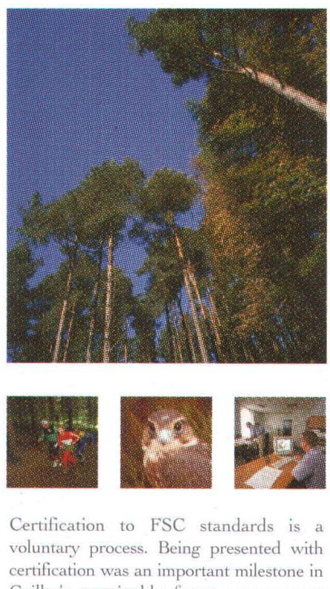
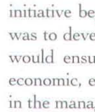
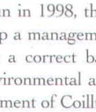
ONLY THE BEST FORESTS IN THE WORLD MAKE THE GRADE

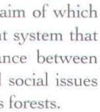
The awarding of a five-star grade in any industry is recognition that a list of criteria and guidelines laid down have been met, maintained and in some cases surpassed.

In the summer of 2001 Coillte received Forest Stewardship Council (FSC) certification. This was recognition from the FSC, a non-governmental organisation dedicated to responsible forest management on a global basis, that our forests are well managed in accordance with strict environmental, social and economic criteria. In short, our forests were given a five-star rating.





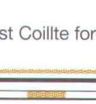


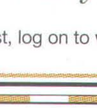


Certification to FSC standards is a voluntary process. Being presented with certification was an important milestone in Coillte's sustainable forest management initiative begun in 1998, the aim of which was to develop a management system that would ensure a correct balance between economic, environmental and social issues in the management of Coillte's forests.

This award doesn't come easy and the achievement of certification is not an end in itself. FSC certification commits Coillte to a process of continuous improvement, independently monitored and assessed on an ongoing basis. We are committed to maintaining the highest standards in the management of our forests, through the implementation of strategies including nature conservation, species diversity, forest design and archaeology.

In the meantime, you can enjoy the treasures of Ireland's best kept secret - 1.1 million acres of forest land, all open to the public to enjoy. We've dedicated recreational areas, picnic sites, guided trails, even children's playgrounds. Witness wildlife in its natural habitat, discover an abundance of flora and fauna, and scenery that will take your breath away. Coillte forests are now a unique five-star experience... and that's official.





coillte

The Forestry People

FSC accredited certification means that the forest is managed according to strict environmental, social and economic standards.
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IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

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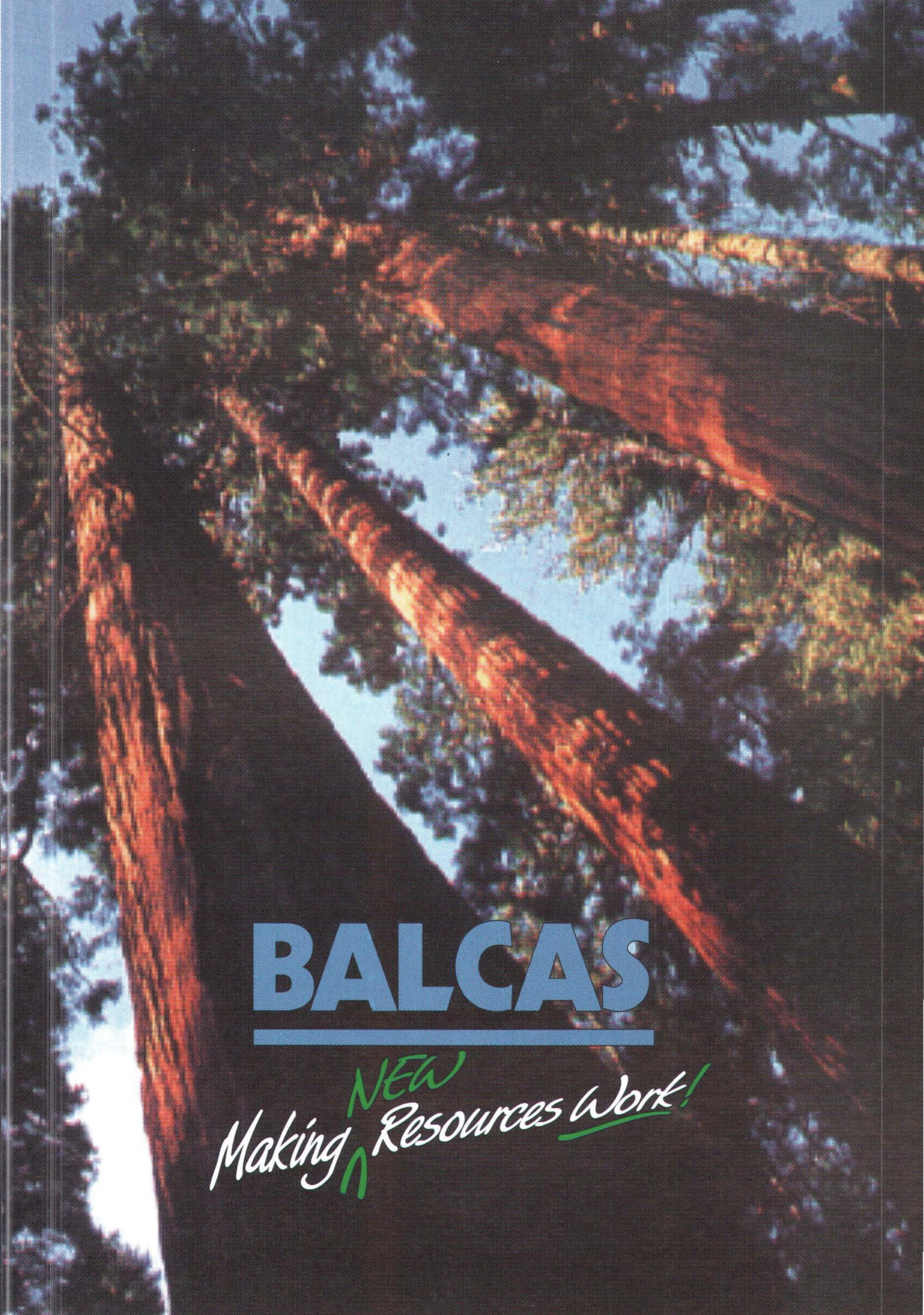
Contents

Cover: Scots pine at St. Anne's School, Killaloe, Co Clare, measured as 4.46 m in girth in 2001. One of many specimen trees now recorded in the Tree Register of Ireland (see article in this issue).


BALCAS
Making NEW Resources Work!

The Society of Irish Foresters

The Society of Irish Foresters, founded in 1942, is the representative body for the forestry profession in Ireland. Its aims are *to advance and spread the knowledge of forestry in all its aspects, and to promote professional standards of practice in forestry and the public benefits arising from forestry.*

The main activities of the Society include the organisation of symposia, field meetings and study tours on forestry topics, and the publication of *Irish Forestry*, the Society's journal, and *The Irish Forester*, its quarterly newsletter. The Society also organises forestry shows and exhibitions, and has published *The Forests of Ireland* and *Forest Images – Father Browne's Woodland Photographs*.

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- Technical (MSIF): Persons who wish to promote the objectives of the Society and who, at the time of election, hold a degree or diploma in forestry from a recognised university, or who have successfully completed a full-time course at a forestry school recognised by the Society, or who hold the Foresters Certificate of the Society. Annual subscription €120.
- Associate: Persons not qualified for technical membership but who wish to promote the objectives of the Society. Annual subscription €60.
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1. Only original material, unpublished elsewhere, will be considered for publication in *Irish Forestry*. Authors must indicate if the material has been submitted for publication elsewhere in the past.
2. Two complete hard copies of the paper, double spaced with numbered lines should be submitted to the Editor, *Irish Forestry*, together with an electronic version, in Microsoft Word. Electronic submission is also acceptable to sif@eircom.net.
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.
4. Subject to editorial decision submitted papers will be peer reviewed. Papers must include an abstract (maximum 250 words) and a list of up to six key words before the main body of text. Authors are advised to keep papers as concise as possible and no more than 25 pages long (double-spaced, including tables and figures).
5. Where Figures are embedded in an article the originals should always be included, along with information regarding software used to create them. Figures should preferably be saved as graphic files (.eps, .wmf where possible). Avoid .tif, .bmp files and Word picture format. Word Excel formats, embedded in documents, are acceptable for Figures. However, an original hard copy of the Figure must also be submitted.
6. Figure and table captions and general style should follow recent editions of *Irish Forestry*.
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   Lavender, D.P. 1984. Plant physiology and the nursery environment: interactions affecting seedling growth. In *Forest nursery manual: production of bareroot seedlings*. Eds. Duryea, M.L. and Landis, T.D., Martinus Nijhoff/Dr W Junk Publ., The Hague/Boston/Lancaster, pp 133-141.
9. Journal titles may be abbreviated in conformity with Biological Abstracts.
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The above guidelines are designed to facilitate the speedy processing of material submitted for publication in *Irish Forestry*. Inadequate adherence to these guidelines may result in material being returned to the author for redrafting.

EDITORIAL

Seeing the wood and the trees

Ireland's afforestation programme and national investment in forestry have been mainly predicated on the basis that the primary objective is the production of roundwood for industrial-scale processing. By and large this objective has been achieved in the period up to the present day.

Naturally the mix of wood products produced by sawmills and board mills reflects the raw material base – largely lodgepole pine and Sitka spruce. The product mix has, with some notable exceptions, remained fairly constant over the past twenty years and more. The building boom of the past decade has created robust demand for traditional carcassing timbers, such as floor joists. But times are changing and the use of systems approaches to domestic construction is beginning to take hold, and not just in the timber frame area. Engineered wood products such as I beams are impacting on the traditional building market in the UK. It is only a matter of time before this and similar systems begin to make inroads in Ireland.

Opportunities to diversify the product mix and to respond more fully to market trends do exist. For example the work reported in this issue relating to wood treatment shows that Irish wood can be modified to improve not only decay resistance but also overall dimensional performance. This offers the possibility of making inroads in markets such as cladding, which have traditionally been the preserve of the more durable species. In other areas such as structural applications Irish wood can be graded to higher strength classes to penetrate markets such as truss rafters.

As well as diversifying the product range at the higher end there is huge potential for wood energy. Many wood-using sectors face difficulties in disposing of waste wood or co-products such as sawdust. Forest operations such as clearfelling generate considerable quantities of residues that are mostly pushed into windrows and left to decay on the site. These materials can provide a ready source of biomass to fuel heat-only or combined heat and power installations. Ireland is almost alone in the developed countries in not exploiting these resources. Instead of being perceived as problem they should be regarded as a positive asset that can make a significant contribution to green energy and security of supply.

Present government supports and incentives for wood energy are clearly not sufficient to encourage new projects. A concerted programme is necessary at all levels to put such a package in place. The time is ripe for such as programme in view of the increasing importance of energy and climate change issues.

Submissions to *Irish Forestry* are welcomed and will be considered for publication.
The attention of contributors is drawn to "Guidelines for Authors".

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Effect of root wrenching in the nursery on the quality of Japanese larch transplants

Ned Morrissey[1] and Conor O'Reilly[2]

Abstract

The influence of root undercutting and wrenching in the nursery on the quality of two-year-old Japanese larch (*Larix kaempferi*) seedlings was investigated. Seedlings were undercut in June and then subjected to a factorial combination of wrenching in July, August and October. All treated stock plus one set of controls (not undercut or wrenched) received additional fertiliser. The effect of these treatments on the phenology of height growth and bud flushing the following spring, end-of-season morphology and root growth potential (RGP) was evaluated. Undercutting (June) had the largest effect on the rate of shoot growth. Wrenching in July reduced the rate of shoot elongation further, wrenching in August had a smaller effect, while wrenching in October had no effect. Treatments had little effect on the date of growth cessation in the year of treatment or date of bud flushing the following spring. Wrenching had little effect on root collar diameter, but improved (reduced) sturdiness (height/diameter), especially if carried out late in the season and/or more than once. Wrenching also increased RGP, decreased height and improved (decreased) the shoot:root ratio, but had a small or non-consistent effect on shoot and root dry weights. Except for final height, the time of wrenching had a small effect on this outcome. The results of this study suggest that larch transplants should be undercut in June and wrenched early if height control is required, but more than one wrenching may be necessary to improve RGP.

Keywords

Root wrenching, undercutting, root growth potential, plant morphology.

Introduction

The Forest Service requirement (Department of Agriculture Food and Forestry 1996) for species diversity in new plantations has encouraged the planting of larch (*Larix* spp.) in Ireland. The number of larch seedlings[3] planted increased from 0.8 million trees in 1995 to 6.75 million in 1999, mostly composed of Japanese larch (*L. kaempferi* (Lamb.) Carr.) and hybrid larch (*L.* x *eurolepis* Henry) (Anon. 2000). Although larch is adaptable to a wide range of site types (Macdonald et al. 1957), plant failure rates during the early establishment phase are at least twice those of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) on the same sites in Ireland (Carey 2001). Losses of up to 50% have been reported for larch in Britain (McKay and Howes 1994). The survival and early growth of planted trees depends largely on their readiness to rapidly produce new roots and thereby re-establish intimate contact with the soil after planting (Ritchie 1985). The poor root regeneration capacity of larch after planting may be the main cause of mortality after planting (McKay 1998, McKay and Morgan 2001). The morphological quality of the shoot system also may contribute to this problem.

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

Most bare-root planting stock used for forest establishment in Ireland is produced as transplants. In addition to providing extra growing space, transplanting usually also stimulates root development (Mason 1994a). However, transplanting alone does not appear to be fully effective in stimulating the development of a fibrous root system in larch. The quality of the root system of transplants can also be further improved by using undercutting and wrenching treatments (Duryea 1984). This treatment is more commonly used to improve the quality of stock that has not been transplanted (e.g. 1u1 stock). Undercut and wrenched (non-transplanted) seedlings generally perform better than transplanted stock, mainly owing to the better quality of the root system (McKay and Howes 1994, McKay and Morgan 2001). Undercutting involves horizontally drawing a sharpened, thin blade through the nursery bed, severing roots at a desired depth. Wrenching differs from undercutting by using a thicker blade, angled at 25-30° downwards, and drawn through soil at a depth below the undercutting level. Wrenching loosens and aerates the soil around the root ball and breaks off smaller roots. This action usually stimulates root regeneration (Benson and Shepherd 1977). The severing of the root system causes water stress in the plants, and is best carried out in moist, humid weather conditions. Irrigation should be available after treatment because of the risk of drought stress during dry weather (Duryea 1984, Mason 1994b).

There is little published information available concerning the benefits of using wrenching treatments to improve the quality of transplanted stock in Ireland. In one study, Sitka spruce was wrenched late in the season (September) in an attempt to induce early dormancy in transplanted stock to facilitate early lifting, but the treatment was found to have the opposite effect (O'Reilly and Keane 1996).

The objectives of this study were to examine the effect of root wrenching treatments on:

1. the phenology of shoot growth in the year of wrenching and the date of bud flushing in the following spring and;
2. the morphological characteristics and root growth potential (RGP) of Japanese larch transplants.

Materials and methods

Plant material, nursery and general cultural care

Japanese larch transplants (1+1) (British seed source: 96(3015); exact origin unknown), from the Coillte nursery at Ballintemple, Co Carlow (52° 44' N, 6° 42' W, 100 m elevation) were used in the experiment. The soil is a sandy loam, with a pH 4.8-5.7, 6-10% organic matter and sand, silt and clay fractions of 66%, 19% and 15%, respectively. The seed was broadcast sown in May 1998.

Prior to transplanting, 50 m^3 of waste mushroom compost, 500 kg of 0-16-0, and 250 kg of kieserite (15% Mg) fertilisers/ha were applied to the soil. These amendments were made soon after ploughing and were incorporated in the top 15 cm of soil. The seedlings were transplanted (25 September, 1998) using a *Super Prefer* five-row machine, with rows 25 cm apart, achieving an average seedling density of 18/linear metre. After transplanting, 100 kg/ha of calcium ammonium nitrate (27% N) was applied once per month in April, May, June and July 1999. Sulphate of potash (42% K) was applied in the first week of July at 100 kg/ha. All other aspects of cultural care were similar to those described by Mason (1994a).

Wrenching treatments

Seedlings were subjected to a factorial combination of early-season (E) (23 July), mid-season (M) (19 August), and late-season (L) (5 October) wrenching treatments in 1999 (Table 1). The late season wrenching was carried out approximately two weeks later than scheduled, because of heavy rainfall. The plants were wrenched at 15-20 cm depth (approximate depth of upper and lower sides of blade, respectively). Wrenching is normally carried out after the roots of the plants have already been undercut (Hobbs et al. 1987, Sharpe et al. 1988). For this reason, the roots of the seedlings destined for wrenching were first undercut at 13 cm on 28 June. Because root wrenching reduces the ability of plants to absorb nutrients (Landis 1985), additional fertiliser was applied to the plots that contained wrenched seedlings. However, two sets of controls were used. Seedlings in one set received additional fertiliser while those in the other did not. The seedlings in the control plots were not undercut or wrenched. Calcium ammonium nitrate, at 75 kg/ha (27% N), was applied to all plots containing wrenched seedlings, plus one set of controls. The fertilisers were applied on 28 June, 23 July and 19 August, just before the undercutting/ wrenching treatment. Fertiliser was not applied before the last wrenching (October) because sufficient fertiliser had been applied earlier in season. There were a total of nine treatment combinations (including two controls).

Table 1. *Description of the wrenching treatments applied to Japanese larch transplants in 1999.*

	Wrenching treatments[1]		
Treatment number	*Fertiliser treatment*	*Description*	*Number of wrenchings*
1	No	No wrenching	0
2	Yes	No wrenching	0
3	Yes	Wrenched early (E) in growing season	1
4	Yes	Wrenched in mid (M) growing season	1
5	Yes	Wrenched late (L) in growing season	1
6	Yes	E x M	2
7	Yes	E x L	2
8	Yes	M x L	2
9	Yes	E x M x L	3

[1] All wrenched seedlings were undercut 28 June.

Experiment design

The experiment was laid down as a randomised block design. Each of the nine treatment combinations (Table 1) was replicated once in each of the three blocks. Each bed was approximately 215 m long and was divided into three blocks of equal length. Each block was further sub-divided into nine 5.5 m treatment plots. Plots were separated from each other by a buffer zone (2 m) containing untreated plants. A larger buffer of 5.5 m was allowed at the top and bottom of each bed.

Phenology of shoot growth and date of flushing

The effect of the wrenching treatments on shoot elongation was evaluated using 10 permanent sample trees per plot. These 10 seedlings were in the centre transplant line in each plot. Height measurements commenced on 25 June 1999, just before the date of undercutting. Subsequent measurements were made just before each wrenching and the scheduled (September) wrenching date and in mid October (after all elongation had ceased).

The same sample trees were used to evaluate treatment effects on the date of flushing in the following spring. The number of seedlings per plot that had flushed dwarf-shoot buds was recorded during February and March 2000. The date of flushing of the long-shoot buds of the branches and leader of each plant was not determined. The long-shoot buds usually flush in about April or May (personal observations), but the transplants were scheduled for lifting for field planting before this time.

Morphology

In mid February 2000, 15 plants from near the centre of each plot (excluding the permanent sample trees) were carefully lifted by hand. The soil was gently washed from the roots of the seedlings to minimise root loss. The plants were stored in co-extruded polyurethane plastic bags at 2°C until all measurements were completed (over 10 day period following lifting).

The root collar diameter (RCD), seedling height and height increment in 1999 was recorded for each plant. After this, the shoot was excised from the root at the root collar. The shoot and root of each plant was dried separately at 75°C for 24 h and then weighed. The sturdiness (shoot length (cm):RCD (mm)) and shoot/root ratios (shoot weight (g): root weight (g)) of each plant were calculated from these values.

Root growth potential and number of days to bud break

In a similar manner to that described for the morphology assessment, a further six plants were carefully lifted in mid February from near the centre of each plot and placed in plastic bags. The plants were immediately stored at 2°C at the nursery and then dispatched in early March to University College Dublin (UCD) for testing. Six pots (replications), containing three seedlings each, represented each treatment combination (total of 18 plants/treatment combination). The three seedlings (one from each nursery plot) were placed in 3.5 l pots containing a 3:1 (vol:vol) mixture of peat-perlite. The pots were placed in a heated (17-23°C day/15-17°C night) greenhouse at UCD. The positions of the pots were randomised. The photoperiod was extended to 16 h using high-pressure sodium vapour lights. Relative humidity was maintained above 50% by using time-controlled fine mist nozzles. Just after potting, the medium was watered to field capacity and at 2-3 day intervals thereafter.

The plants were monitored at 2-5 day intervals and the dates at which the first flushing of the lateral and terminal bud of each plant occurred were recorded. At the end of the test, after 28 days, the plants were removed from the pots and the roots washed carefully in tap water. The number of new white roots (>1 cm) per plant was recorded (Ritchie 1985).

Meteorological data and irrigation

Since undercutting/ wrenching may induce drought stress in seedlings (Duryea 1984, Mason 1994b), rainfall data for the June to October 1999 period were obtained for a weather station at Oakpark, Co Carlow, approximately 18 km from Ballintemple Nursery.

The summer and autumn of 1999 was much wetter than normal (Table 2). Nevertheless, there was no rainfall for 10 days after wrenching in July, but it rained shortly after treatment on all other occasions. The transplant beds were irrigated during dry periods. About 3 mm h^{-1} of water was applied on 13 (2 h), 22 (4 h), 24 (1 h) 27 (2 h), 30 July (4 h) and 3 August (2 h).

Table 2. *Daily accumulated rainfall (mm) during the June – October period in 1999 for Oakpark, Co. Carlow (18 km from nursery).*

			Month		
Day	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*
1	0.0	30.2	0.0	0.0	n/a
2	1.8	3.0	1.4	0.2	n/a
3	31.8	0.6	9.4	0.0	n/a
4	4.6	0.4	0.0	0.0	n/a
5	8.4	0.0	57.6	0.0	18.4
6	4.0	0.0	9.0	0.0	0.2
7	1.4	0.2	14.8	63.8	0.0
8	0.0	0.0	0.2	0.0	0.4
9	0.0	0.2	1.8	14.8	0.0
10	0.6	0.0	0.0	0.2	0.2
11	0.0	0.0	0.0	57.2	0.8
12	0.0	0.0	0.0	9.4	0.0
13	0.2	3.8	1.8	22.4	0.2
14	2.8	0.6	0.8[1]	0.6	0.0
15	0.0	0.0	1.0	0.0	1.8
16	0.2	0.0	0.6	25.4	7.8
17	0.0	0.2	12.0	0.0	0.0
18	0.0	9.2	1.4	16.2	0.0
19	0.0	6.6	17.2	23.4	0.0
20	5.6	9.6	0.0	8.6	0.0
21	1.6	0.2	0.0	58.8	3.2
22	0.0	4.0	0.0	0.4	10.8
23	1.8	0.0	5.6	8.8	19.0
24	0.0	0.0	0.4	0.0	11.4
25	0.0	0.0	8.6	48.6	0.0
26	0.0	0.0	2.0	14.8	0.0
27	5.6	0.0	0.0	18.0	0.0
28	1.8	0.0	0.0	12.8	0.2
29	0.6	0.0	0.0	2.0	0.6
30	0.4	0.0	1.4	1.6	2.4
31	—	0.0	0.0	—	9.8
Mean	73.2	68.8	147.0	408.0	87.2
Long term average	53	49	67	71	81

[1] not available.

Data analyses

All data except the root growth potential data were analysed according to a factorial randomised block design, using the GLM procedure in SAS (SAS 1989). Plot means were used in all analyses. The effects of block, fertiliser, and the factorial combinations of early, mid and late season wrenching on the responses were evaluated. The mean for the standard (operational practice) treatment (control without fertiliser) was compared with the means for all other treatment combinations using Dunnett's test. The data also were analysed according to a second model to determine the effect of the number (0, 1, or ≥2) of wrenchings on parameter responses, followed by less square means tests. The RGP data were analysed in a similar manner, but there were no block effects for this parameter. The RGP data were transformed to ranks to standardise variation, but this transformation and others did not correct this problem for some parameters. In such cases, the data were analysed using non-parametric tests. However, the results from these tests were similar to those obtained using parametric procedures, so only the results of the latter tests are presented.

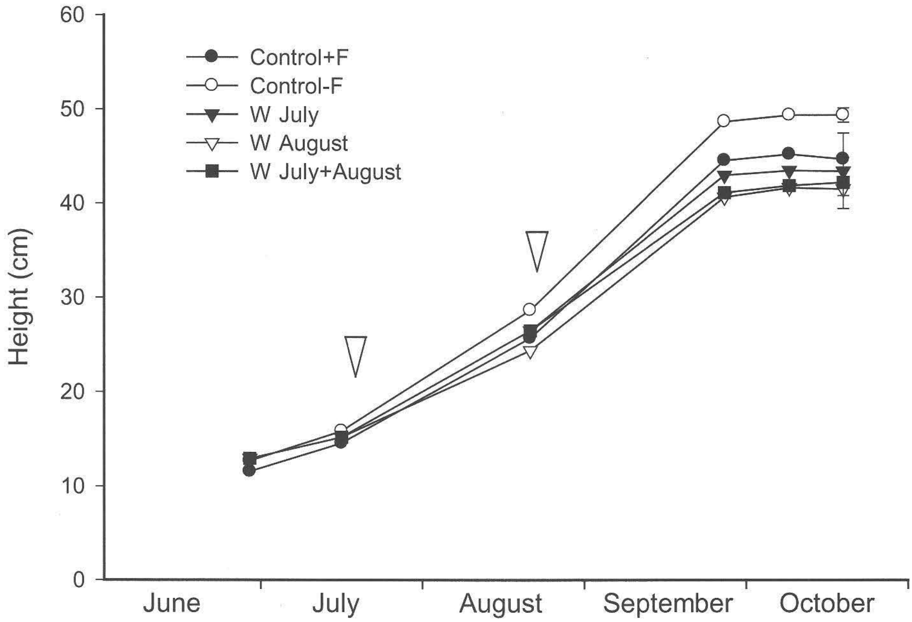

Figure 1. *Height growth of Japanese larch seedlings transplanted in the autumn or spring and then subjected to combinations of early (E) or mid (M) season wrenching or no wrenching (control, C). All seedlings except one set of the controls (C-F; standard treatment) received additional fertiliser. The date of each wrenching is indicated (arrows). Means are based on three replications of each treatment combination, each replicate containing 10 seedlings.*

Results

Shoot elongation and flushing

Early wrenching significantly reduced the height growth that occurred over the period between the first and the second wrenching ($p \leq 0.05$). However, wrenching treatments did not significantly influence height growth after each of the two subsequent wrenchings. Although mid or late season wrenching had no significant effect on height growth, treatment effects were apparent for mid season wrenching due to the effect of undercutting in June. For this reason, only the effect of early (July) and mid (August) season wrenching (and combinations of these treatments) on height growth is shown (Figure 1). The effect of wrenching treatments on end-of-season plant height is described in detail below (based upon a separate sample of plants).

The seasonal pattern of height growth was similar regardless of wrenching treatment (Figure 1). Height growth was slow in June and early July, and then increased rapidly during late July and early August. Height growth was most rapid from late August until mid to late September. Thereafter, height growth was slow and ceased in about early October. The control seedlings (no fertiliser) were the tallest at the end of the growing season.

Root wrenching in the 1999 growing season had no significant effect on the date of lateral bud flushing in the following spring (mean, 8 March).

Morphology

Final plant height was significantly reduced by mid or late season wrenching (Table 3). In addition, the number of wrenchings received (regardless of application date) significantly affected plant height. Mean height ranged from 39–46 cm for wrenched seedlings, smaller than the 49 cm for both controls (Figure 2). Compared with the standard treatment (control minus fertiliser), a single wrenching reduced height increment by about 7%, while more than one wrenching reduced it by about 15%.

Table 3. *Significance of effect of fertiliser and wrenching treatments on morphological characteristics and root growth potential in Japanese larch transplants. Abbreviations: Root collar diameter (RCD); shoot (SDW) and root (RDW) dry weights; root growth potential (RGP), not significant (ns).*

Source of variation	*Height*	*RCD*	*Sturdiness*	*SDW*	*RDW*	*SDW/ RDW*	*RGP*
Fertiliser	ns	ns	ns	ns	ns	ns	ns
Early season wrenching (E)	ns	ns	0.0043	ns	ns	0.0004	ns
Mid-season (M) wrenching	0.0029	ns	0.0036	ns	0.0248	0.0013	0.0417
Late season (L) wrenching	0.0062	ns	ns	ns	ns	0.0129	ns
E x M	ns	ns	ns	ns	ns	ns	ns
E x L	ns	ns	0.0279	ns	ns	ns	ns
M x L	ns	ns	ns	ns	ns	ns	ns
E x M x L	ns	ns	ns	ns	ns	ns	ns
Number of wrenchings	0.0029	ns	<0.0001	ns	ns	<0.0001	0.0162

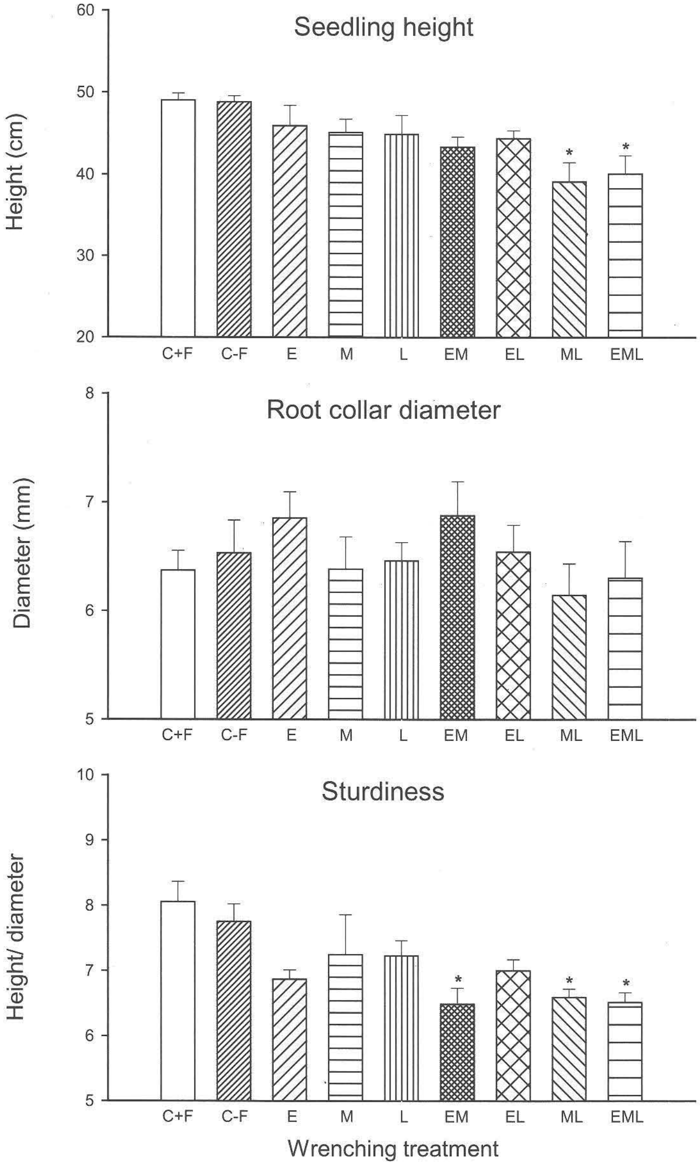

Figure 2. *Mean total height, root collar diameter and sturdiness of Japanese larch seedlings lined-out in autumn or spring and then subjected to combinations of early (E), mid (M), and late (L) season wrenching or no wrenching (control, C). All seedlings except one set of controls (C-F) received additional fertiliser. Means significantly (p<0.05) different from the standard (operational practice) treatment (C-F) are indicated (*). Means are based on three replications of each treatment combination, each replicate containing 15 seedlings. Vertical lines are standard errors.*

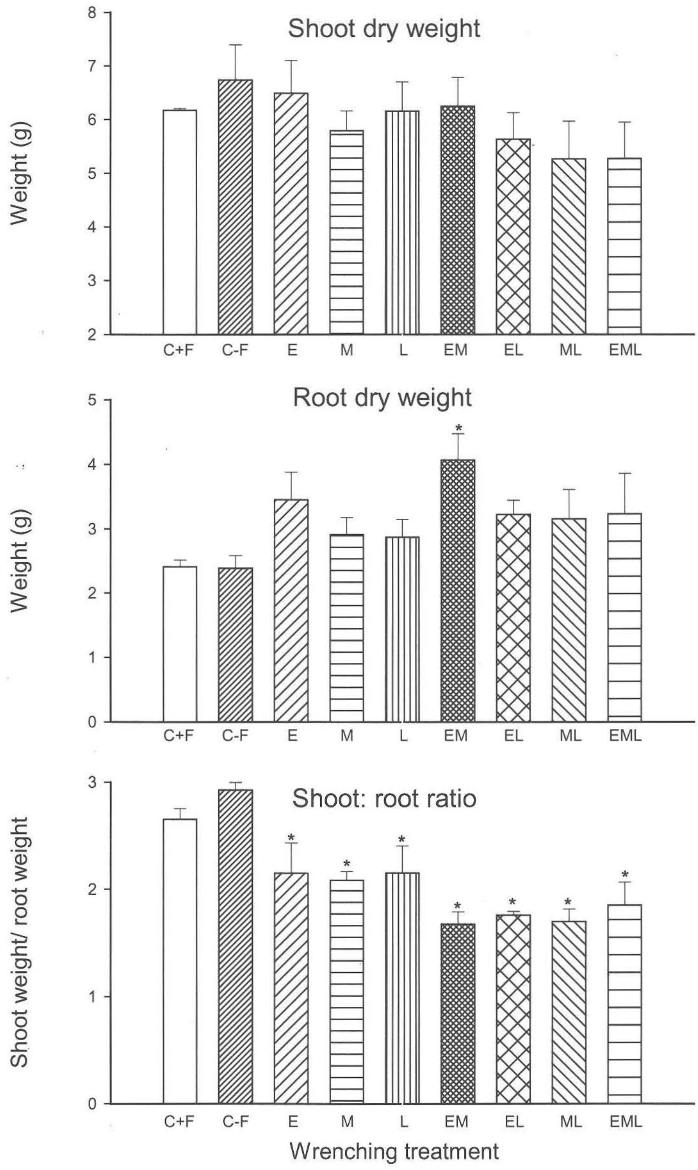

Figure 3. *Mean shoot and root dry weights and shoot to root ration of Japanese larch seedlings lined-out in autumn or spring and then subjected to combinations of early (E), mid (M), and late (L) season wrenching or no wrenching (control, C). All seedlings except one set of controls (C-F) received additional fertiliser. Means significantly (p<0.05) different from the standard (operational) treatment (C-F) are indicated (*). Means are based on three replications of each treatment combination, each replicate containing 15 seedlings. Vertical lines are standard errors.*

The date of wrenching or the number of wrenchings applied did not significantly affect root collar diameter of the seedlings (Table 2). The mean RCD ranged from 6.1–6.9 mm (Figure 2).

The sturdiness (height/root collar diameter) of seedlings was significantly affected by early or mid season and the combination of early with late season wrenching (Table 3). The number of wrenchings received by the seedlings also significantly affected sturdiness. Low values indicate sturdier, better-balanced plants. For autumn lined out stock, mean sturdiness ranged from 6.5–7.2 for wrenched plants, compared with 8.1 (+fertiliser) and 7.8 (-fertiliser) for the controls (Figure 2). The mean sturdiness values were 7.9, 7.1 and 6.7 for seedlings that received 0, 1 or ≥ 2 wrenchings, respectively

The date of wrenching or number of wrenchings had no significant effect on shoot dry weight (SDW) (Table 3). The mean SDW ranged from 5.3–6.7 g (Figure 3). Early wrenching significantly influenced root dry weight (RDW), but the number of wrenchings used had no significant effect (Table 3). The mean RDW ranged from 2.9 to 3.5 g for wrenched seedlings compared with 2.4 g for both controls (Figure 3).

The shoot: root (S:R) ratio was significantly affected by early, mid or late season wrenching (Table 3). The S:R ratio was also significantly influenced by the number of wrenchings applied. A low S:R ratio indicates a better balance between the shoot and the root mass. The S:R ranged from 1.7–2.2 for wrenched plants, smaller than the 2.7 (+ fertiliser) and 2.9 (-fertiliser) for the controls (Figure 3).

Root growth potential

RGP was significantly increased by mid season wrenching only (Table 3). However, the number of wrenchings applied had a large effect on RGP. Seedlings wrenched two or three times had significantly higher RGP than those that received a single wrenching ($p \leq 0.05$) or no wrenching ($p \leq 0.01$). However, the RGP of seedlings wrenched once did not differ from the RGP of the controls. The mean RGP of seedlings wrenched two or more times ranged from 87–92, compared with 74–77 for those wrenched once, and 73 (- fertiliser) and 75 (+ fertiliser) for the controls (Figure 4).

Discussion

The results showed that root undercutting/ wrenching improved the quality of Japanese larch transplants (Figures 1-3). These treatments improved sturdiness and RGP, decreased height and the shoot: root ratio, but the effect on shoot and root dry weights was small and non consistent. Wrenching had no effect on the date of height growth cessation and date of bud break the following spring. Therefore, root wrenching may be a viable cultural practice for operational use for larch in Irish nurseries. There is no published information of this kind for transplanted stock of larch, although there is considerable information available from other countries on the use of wrenching for non-transplanted (often called "undercut") stock (Rook 1969 & 1971, Benson and Shepherd 1977, Duryea 1984, Mason 1986).

Fertiliser was applied to all plots except one set of controls. Undercutting and wrenching may induce nutrient deficiency so extra nutrients are usually supplied to treated seedlings (Sharpe et al. 1988, Mason 1994b). The shoot elongation data indicated that the control seedlings that received no fertiliser were taller at the end of the season than the controls that received no additional fertiliser, whereas the end-of-season morphology data showed no difference between these treatments. Since the morphology data were based upon larger sample sizes than the shoot elongation data (used to study phenology of growth only), the former are probably more accurate than the latter. The effect on growth was small, perhaps because there was an adequate store of nutrients already in the soil. However, the nutrient status of the seedlings was not determined in this study. The intention of the study was to examine the effect of wrenching treatments on seedling growth responses under non-limiting nutrient conditions. Further research is needed to determine the nutrient requirements of wrenched Japanese larch transplants.

Bud flushing, phenology of shoot growth and final height

Wrenching treatments had no effect on the date of growth cessation (leader growth ceased in early October) or the date of flushing of buds in the following spring, but affected the rate of height growth. In contrast, a single late (September) wrenching delayed bud flushing the following spring in Sitka spruce sampled from Ballintemple Nursery (O'Reilly and Keane 1996). Most shoot growth in mature larch trees is predetermined (i.e. from a bud), although some additional free (or neoform) growth usually occurs in the same growing season (Owens and Molder 1979). Therefore, shoot elongation ceases much earlier in mature trees (probably June or July), but growth ceases much later in seedlings because they undergo considerable free growth (Colombo et al. 2001).

Undercutting in June followed by wrenching in mid July reduced the rate of height growth of seedlings in this study, but undercutting followed by wrenching later in season had a small or negligible effect on height growth. However, the height growth of stock that was wrenched late was reduced due to the effect of the undercutting in June. Undercutting/wrenching reduced height growth probably because the uptake of moisture and nutrients were restricted (Rook 1969& 1971). Rook (1971) also reported that the initial undercutting treatment had a greater effect on height growth than the subsequent wrenching. Undercutting/wrenching reduces height growth probably because photosynthate is re-allocated from the shoot to the root (Rook 1971, Mason 1994b). Although treatments had no effect on date of height growth cessation in this study, wrenching induced slightly earlier bud set in slash pine (*Pinus elliottii*) seedlings growing in Florida, suggesting that height growth also ceased earlier (Kainer et al. 1991). Wrenching delayed bud set in Douglas fir seedlings during drought conditions in NW America (Duryea and Lavender 1982). The generally mild, moist climate that prevails in Ireland probably induced much less moisture stress in the seedlings in this study than occurred in the countries in which the other studies were carried out. Furthermore, the 1999 growing season was wetter than normal, although there was no rain for 10 days (Table 1) after wrenching in July. Irrigation was used to minimise the effect of drought stress during dry periods.

Similar to the results of this study, undercutting and wrenching treatments reduced height growth in Douglas fir seedlings (Duryea and Lavender 1982; Hobbs et al. 1987). Van den Driessche (1983) also found that early (May/June) wrenching reduced height growth in Douglas fir seedlings, but wrenching later in the season (July/August) had no effect on this parameter. Undercutting and wrenching significantly reduced height growth of Monterey pine (Rook 1971, Benson and Shepherd 1977), Caribbean pine (*Pinus caribaea* Mor. var. *hondurensis* B. & G.) (Bacon and Bachelard 1978) and slash pine (Kainer and Duryea 1990) seedlings. The time of wrenching application had a relatively small effect on shoot growth in this study, but this may be more important in other species than in larch (Aldhous 1972).

Root collar diameter, sturdiness, shoot and root dry weights, and shoot:root ratio
Wrenching had no significant effect on root collar diameter of the seedlings in this study. Wrenching might be expected to increase root collar diameter if photosynthate is reallocated from the shoot to the cambium and the roots at the expense of the shoots (Ritchie and Dunlap 1980). In contrast, the height:RCD ratio (sturdiness) was affected greatly by wrenching, probably mainly caused by the decrease in height since diameter growth was affected little by the treatments. Wrenched seedlings, especially those treated late in the season and/or more than once, were sturdier than the unwrenched controls. In other similar studies, undercutting and wrenching of Monterey pine reduced height growth relative to RCD, thus improving sturdiness (van Dorsser 1981, Rook 1971). However, wrenching reduced root collar diameter in loblolly pine (*Pinus taeda* L.) seedlings (Tanaka et al. 1976). A similar response was reported for Douglas fir in one study (Duryea and Lavender 1982), but it had virtually no effect in another (Tanaka et al. 1976). Sturdy (low sturdiness values) plants are generally considered to be of better quality (Thompson 1985). However, it is difficult to compare results because of differences among studies in the number of wrenchings used, depth of wrenching, weather conditions after wrenching, nursery soil type, and study location etc.

Early wrenching significantly reduced the shoot dry weight of seedlings. This result is not surprising since this treatment also influenced plant height. However, treatment effects on plant height were not always reflected in shoot dry weight differences, perhaps because most height differences were relatively small and much of this extra shoot tissue was probably non-woody. Shoot dry weight of Douglas fir seedlings was virtually unaffected by root wrenching in one study (Tanaka et al. 1976), but was reduced in another (Duryea and Lavender 1982). Wrenching was found to have reduced the shoot dry weight of slash pine seedlings (Kainer and Duryea 1990).

Wrenching early slightly increased the root dry weight of seedlings in this study. Similar to the effect on the shoots, wrenching probably increased fine (non-woody) root mass, without having a large effect on total root dry weight. In Monterey pine, wrenching had little effect on root volume (weight not determined), but it increased the number of fine roots (Rook 1971). While wrenching may stimulate root growth, an increase in root mass may not be detected since roots are also excised during the undercutting/wrenching operation. For example, wrenching reduced taproot dry weight in Douglas fir (Duryea and Lavender 1982). Wrenching did not affect root dry weight in slash pine seedlings (Kainer and Duryea 1990), increased it in Douglas fir in some studies (van den Driessche 1983, Tanaka et al. 1976), but had no effect in another study (Duryea and Lavender 1982).

Wrenching improved (reduced) the shoot: root ratio of larch seedlings in this study, although the effect on the parameter components of ratio was less clear. Seedlings that have low shoot: root ratio are likely to perform better in the field than those having a high ratio (Aldhous 1994, Tanaka et al. 1976). Nevertheless, the shoot: root ratio of seedlings, regardless of the wrenching treatment used, did not exceed the recommended maximum value of 3.0 (Aldhous 1994). Similar to the findings of this study, wrenching reduced the shoot:root ratio in Douglas fir (van den Driessche 1982, Duryea and Lavender 1982, Tanaka et al. 1976) and in Monterey pine (Rook 1971) seedlings. Wrenching also reduced the S:R ratio in Caribbean pine seedlings (Bacon and Bachelard 1978). The reduction in the S:R ratio may be a response of the plant to drought stress induced by wrenching (Bacon and Bachelard 1978).

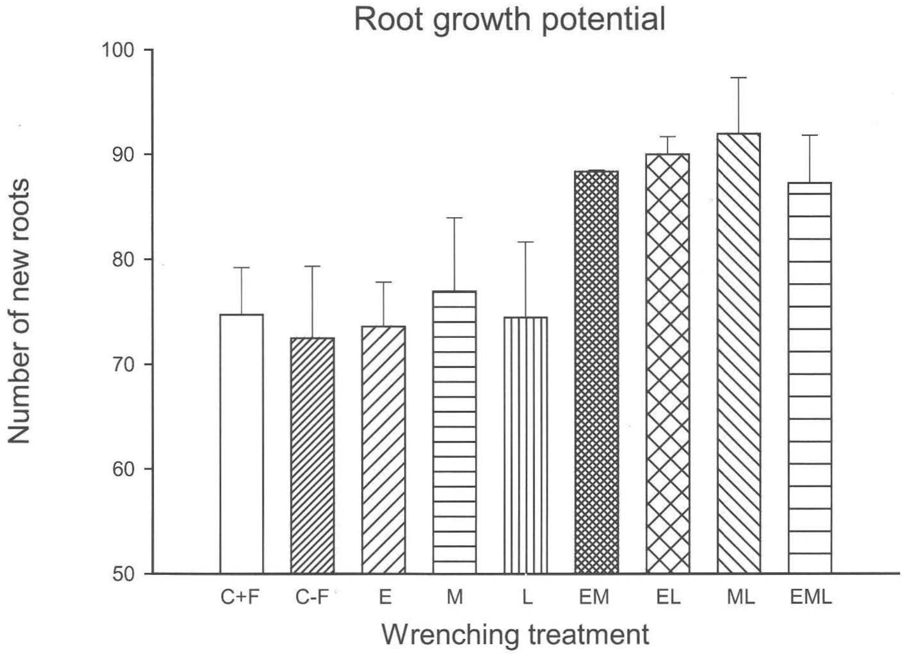

Figure 4. *Root growth potential of autumn lined-out Japanese larch seedlings subjected to combinations of early (E), mid (M) and late (L) season wrenching or no wrenching (control, C). All seedlings except one set of controls (C-F) received additional fertiliser. Vertical lines are standard errors.*

Root growth potential

Seedlings wrenched two or three times had significantly higher root growth potential than those that received one wrenching or no wrenching (Figure 4). This increase probably resulted from an increase in root fibrosity (mainly fine, non-woody roots) due to wrenching (Rook 1971, van den Driessche 1983, Tanaka et al. 1976), although this was not detected in the root dry weight values (Figure 3). RGP tends to be strongly associated with root fibrosity (Deans et al. 1990). Undercutting and wrenching sever many roots and disturb the intimate contact between the roots and the soil, thus leading to moisture stress and a reduction in nutrient availability (Mason 1994b). In response to this, root activity is stimulated and there is usually an increase in the amount of photosynthate allocated to the roots (Rook 1971). Wrenched and undercut seedlings ('undercut' non-transplanted stock) of Sitka spruce and Douglas fir had higher RGP than (unwrenched) transplants in one British study (McKay and Mason 1991).

Root regeneration after undercutting/wrenching is dependent on soil temperature, with rates of regeneration being faster at higher temperatures (Mason 1994b). For this reason, these operations are usually carried out in the warmer months of June to September. In addition, root growth varies seasonally and is influenced by shoot growth (Kramer and Kozlowski 1979), perhaps suggesting that the response of the seedlings to wrenching might vary seasonally. However, the date of wrenching did not have a large impact on RGP in larch in this study.

Operational implications

The relatively heavy nature of nursery soils in Ireland may preclude the widespread use of wrenching, although the method may be more useful for larch than other species since it appears to respond well to treatment over a wide range of wrenching dates. However, further research is needed to assess the effect of undercutting alone (without subsequent wrenching) and its timing on plant quality. Furthermore, the effect of year-to-year variation in climate (especially since 1999 was much wetter than normal), the time and number of wrenching treatments applied, soil type and nursery location on plant quality need to be evaluated. In addition, field trials are required to confirm that the superior quality of wrenched seedlings is reflected in better field performance. Nevertheless, the results of many studies have shown that wrenching improved post-planting survival and/or growth of several conifer species (van den Driessche 1983, Sharpe et al. 1990), including larch (McKay and Howes 1994), especially for cold stored stock (McKay and Morgan 2001).

Conclusions and recommendations

Undercutting (carried out in June only) followed by early wrenching reduced the rate of shoot elongation, with mid season wrenching having a smaller effect on growth. Undercutting followed by late season wrenching had little effect on height growth. However, the rate of height growth was reduced in stock that was wrenched late because of undercutting earlier in season. Wrenching treatments had little effect on the date of growth cessation in the current season or bud flushing the following spring. Undercutting and wrenching improved sturdiness, shoot: root ratio and root growth potential, but had little effect on shoot and root dry weights. Except for final height, the time of wrenching had no consistent effect on this outcome. The results of this study suggest that larch transplants should be undercut and wrenched early in season if height control is required, but more than one wrenching may be necessary to improve RGP.

Acknowledgements

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The Dehesas: a study of a Mediterranean silvopastoral system. Implications for temperate silvopastoral systems in Northern Ireland

Peter McEvoy[1] and James McAdam[2]

Abstract

There has been a resurgence of interest in silvopastoral systems (widely spaced trees growing on grazed pasture) in the United Kingdom and Ireland in recent years. Potential benefits of these combined land-use systems over simple pasture or woodland can include an increase in diversity of flora and fauna, increased financial returns and more efficient nutrient cycling amongst others.

The tradition of these systems in other parts of Europe has been particularly strong and much can be gained from studying the ecological interactions within these established systems. The Dehesas of Spain and Portugal are perhaps the best-known example of an established silvopastoral system in Europe.

Both market and non-market advantages of temperate agroforestry are discussed based on results from a continuing National Network Experiment (NNE) in Great Britain and Northern Ireland and findings from the dehesa system of western Spain.

Keywords

Dehesas, agroforestry, silvopastoral systems, woodland grazing.

Introduction

The dehesas are an example of a silvopastoral system (widely spaced trees on grazed pasture) with extensive (both diverse and low intensity) utilisation. They occur in semi-arid, Mediterranean regions of Spain and Portugal with a seasonal climate on poor acid soils.

They present a unique example of nature conservation combined with optimal land use and as such are considered one of the best examples of environmentally sound traditional agricultural practices in Europe. They also offer a unique habitat for protected plants and animals (Ruiz 2000). The survival of the Dehesas depends on a delicate balance between grazing pressure, pasture quality and tree growth (Gómez-Gutiérrez et al. 1998).

There is little tradition of silvopastoral systems in the United Kingdom or Ireland (Sibbald et al. 2001). However, a resurgence of interest in agroforestry became evident in the mid 1980s as a result of pressures to:

1. reduce agricultural production following changes in the Common Agricultural Policy (CAP),
2. increase diversity of rural production,

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3. maintain rural employment and infrastructure,
4. reduce imports of wood products and
5. enhance the rural environment.

Silvopastoral systems are capable of satisfying these multiple objectives (McAdam et al. 1999a) and are suited to implementation on small livestock farms in Northern Ireland (Crowe and McAdam 1998). Although, as experience of practical and experimental systems is limited, there is merit in learning from longer established systems elsewhere.

The aim of this paper is to outline how the Dehesas, as a silvopastoral system, are more beneficial environmentally and has more efficient production than more recent land use practices adopted in Mediterranean areas and to apply relevant findings to assist silvopastoral research in Northern Ireland, both in an agroforestry and woodland grazing context.

Background

Pasture woodlands were once common throughout Europe and they may well have dominated the landscape for over 1000 years (Rackham 1998). Today in north-western Europe, only a few remnants remain. However, with recent EU policy developments there is a renewed interest in silvopastoral systems. Yet, at present, few examples of such systems exist. But in the Mediterranean area large pasture-woodlands still exist. One of the richest systems is the Dehesas of central and southern Spain (Ruiz and Ruiz 1986).

Dehesas are normally privately-owned farms ranging from 300 to 2000 ha (Pulido et al. 2001). They form an important land-use alternative to more complex and dense forests and contain more annual plant species. The wide spacing of the trees and reduction of scrub through grazing decreases the risk of wildfires.

Ancient in origin (a relict of Roman land management), they were developed by progressive selection of the best acorn producing trees, which are used to feed livestock. They have a particular value in making meat production compatible with the maintenance of a high quality landscape and biodiversity (Pineda et al. 1981). High value food products such as *Jamón serrano*, the typical cured legs of ham seen hanging in restaurants and bars in Spain, are a product of acorn-fattened Iberian pigs raised on the Dehesas.

The fragile ecological balance provided by the Dehesas is under threat from modern intensive agricultural systems, partly encouraged by CAP reforms and the intensification of agriculture since World War II. Over the last three decades, 2 m ha of the Dehesas has been significantly altered or destroyed (Gómez-Gutiérrez and Pérez-Fernández 1996), with estimates of the remaining area varying between 2.5 and 8 m ha (Gómez-Gutiérrez and Pérez-Fernández 1996, Goncalves 2000, Diaz et al. 1997). Many of the areas lost have been converted from their system of optimum production of livestock and wood products to intensively managed crops such as sunflower and cereals. These result in soil erosion and require irrigation and fertilisation, resulting in lowered water tables and ground water contamination (Gómez-Gutiérrez and Pérez-Fernández 1996).

Livestock raising up until the age of industrialisation/emigration in the 1950s and 60s, was highly diversified, incorporating *bravo* (fighting bulls), *retinta* and *morucho* cattle, sheep, goats, pigs and horses (Gómez-Gutiérrez et al. 1998). Recent trends have seen a change from the more traditional breeds towards animals with more efficient milk and meat production. These animals are not compatible with the dehesa system, requiring more attention, supplementary feed and being more susceptible to heat stress, disease and injury. The traditional breeds of the Dehesas have been selected over many hundreds of years, in some cases through natural selection due to the vast areas they can range over and the little contact they have with man. This also allows the animals to become semi-feral, and consequently they are harder to handle than more conventional breeds. As these rural areas depopulate, the number of people with the specific animal handling and husbandry skills required are also lost, thus preventing the return of the indigenous livestock breeds.

In Northern Ireland, farms are small (average 32 ha), family-owned and there is a predominance of livestock farming with the emphasis on grazed pasture and conserved forage. Tree cover is low (approximately 6%) and there is a heavy reliance on imported wood products (only 13% self-sufficiency). Current agricultural policy is strongly influenced by the Common Agricultural Policy (CAP) where the emphasis is on reduction in agricultural production and the encouragement of systems which encourage biodiversity, enhancement of the landscape, embrace high animal welfare values, yet remain economically viable. It was felt that silvopastoral systems could combine these objectives and align with recent agri-environment support measures, which encourage wildlife conservation through structural heterogeneity of habitat.

Trials were established in 1989 at a lowland site at Loughgall, Co Armagh (Sibbald et al. 2001), and in 1991 at an upland site at Broughshane, Co Antrim (McAdam and Mulholland 1990). These trials were part of a National Network Experiment (NNE), where a common set of treatments was used to investigate all aspects of the output of the system and some of the ecological interactions which occurred within the system (Sibbald et al. 2001).

It is clear from the two trial sites in Northern Ireland that up to 9 years after planting of the trees, livestock production and quality (carcass composition) of output are unaffected by the presence of trees at spacings of up to 400 trees ha^{-1} (McAdam and Hoppé 1997). Clear environmental benefits have been shown (McAdam 2000) and the economic predictions for the system have been favourable (McAdam et al. 1999b). However, experience of the long-term implications of the systems on livestock farms and their incorporation in the conventionally farmed landscape and the economy of Northern Ireland is almost non-existent.

Conservation

The Dehesas form an important habitat for many rare or endangered species. There are 40 important bird areas (IBAS) in Extremedura province alone (Sears 1991). Two threatened endemic Iberian species, the Imperial eagle *Aquila heliaca adalberti* and the Iberian lynx *Linx pardina* inhabit the dehesa regions almost exclusively, thus demonstrating the close link with the natural climax flora and fauna that the Dehesas must have to support these large, native predator species. The European Habitats Directive affords designated areas of dehesa special protection from damage or intensification (Pulido et al. 2001), thus helping to safeguard the future of many of the species reliant on the unique habitat.

Plant diversity is amongst the highest in the world, the average pasture was found to contain about 150 higher plant species in a survey in 1993 (Baldock and Beaufoy 1993). This diversity is intimately linked with the traditional grazing regimes (González-Bernáldez 1991, Pineda and Montalvo 1995).

Soils

In Mediterranean regions with a highly seasonal semi-arid climate, soil organic matter rarely exceeds 1% (Garcia-Rodriguez et al. 1979). The tree component of the system can enhance the organic content, and thus fertility of the soil by cycling nutrients from the lower soil horizons and enriching the surface layers via leaf litter and other residues from the woodland system (Escudero-Berian et al. 1985).

Traditionally, this system of enrichment is exploited by obtaining one or two crops of cereal. The soil is then returned to pasture before it becomes too impoverished (Gómez-Gutiérrez and Pérez-Fernández 1996).

Weeds and shrubs are also controlled by this periodic ploughing and by sowing with cereals or foliage such as clover.

Tree species

The most commonly encountered tree species in the dehesa system are two evergreen oaks: holm oak (*Quercus ilex*) in the north (the more common) and cork oak (*Q. suber*) in the more southerly, drier areas (Blanco et al. 1997). In the north *Q. pyrenaica* forms the natural climax vegetation with holm oak but the latter is more resistant to grazing pressure and is the dominant species.

Forest products

The trees serve multiple purposes: shade in summer, shelter in winter, fuel and forage for livestock thorough leaf-litter, pruned branches and high-energy feed from acorns (Gómez-Gutiérrez et al. 1998). They are not normally managed for timber as growth is too slow to be economically viable (Rupérez 1957), although small craft items such as furniture may be manufactured (Gómez-Gutiérrez and Pérez-Fernández 1996).

The shredding and pollarding carried out to increase leaf and acorn production also make the trees unsuitable for timber, but tend to prolong their lives, giving rise to the occurrence of ancient trees (Rackham 1976).

Cork oak is highly valued in the wine industry for producing bottle corks. Cork can be harvested by stripping the bark from the tree every 9-11 years. It is the only species that can so regenerate its cambium. However, the value of natural cork has decreased significantly over the last 5 years due to the increased use of plastic corks and screw-top bottles, thus reducing the profitability and as a consequence, viability of large areas of dehesa (Goncalves 2000). Some extra income can be gained by charcoaling pruned branches (Gómez-Gutiérrez et al. 1998, Pulido et al. 2001).

Beneficial microclimatic effects

Trees have an important role in buffering climatic limitations and are an integral feature of many rural Spanish areas (Gómez-Sal 2000). Provision of shade is the most beneficial physical aspect of trees on both the associated flora and fauna of the Dehesas.

In Mediterranean silvopastoral systems a certain amount of tree cover can enhance sward production, especially with leguminous trees e.g. *Acacia* spp, with approximately 40 trees ha^{-1} being considered the optimum density to ensure maximum returns on pasture and cereal production (Pulido et al. 2001).

Holm oak has been shown to prolong the growing period of the sward by 15-20 days (Puerto et al. 1994). Presence of trees also delays the effects of drought on pasture species, which can extend the period of available green forage by 10-15 days (Acciaresi et al. 1993).

Excessive heat is one of the main constraints to animal production, particularly to lamb growth and milk production (Ani et al. 1985), shade in summer can also ameliorate heat stress.

In Northern Ireland silvopastoral systems, canopy cover is unlikely to enhance sward growth due to the more overcast conditions resulting in reduced light intensities compared to Mediterranean areas. However, in the National Network Experiment (NNE) sward production was maintained for 12 years following planting before yields started to decline (McAdam and Sibbald 2000). Although having a tree component introduced in the conventional pasture system does not enhance sward production, sheep production has benefited from the shade and shelter cast by the trees (McArthur 1991, Hoppé et al. 1997).

Management and regeneration

In some areas of Spain the dehesas may be seen as an example of a forage dominant production system in which tree management aims exclusively at producing as much forage as possible when the herb layer is dry. This has also been defined as pastoral silviculture (Etienne 1996). The trees of the Dehesas are more drought resistant, and have good leaf and acorn production in the dry months contributing significantly to the forage production of the system.

Normally canopy cover does not exceed 65% (Figure 1). Five types of pruning are carried out to ensure this:

1. form pruning which facilitates cork production and acorn harvesting (Figure 2),
2. maintenance pruning: which ensures steady acorn production,
3. production pruning for firewood and browse during hard years (Figure 3),
4. renewal pruning which restores foliage production and tree vitality and
5. lopping, a more drastic pruning leaving only 4-6 thick branches per tree (Figure 4).

Pruning is generally carried out every 7-10 years, with lopping every 15-20 years (Gómez-Gutiérrez and Pérez-Fernández 1996). Skilled workers are usually hired to carry out these operations.

Regeneration is difficult, if not almost impossible, in some instances due to the presence of large domestic herbivores. They browse leaves and shoots and break the young trees (Pérez-Fernández and Gómez-Gutiérrez 1995). However regeneration usually occurs without artificial planting. It is normally encouraged by one of three methods:

1. low animal stocking densities, which allow the regeneration of new seedlings, browsing will delay growth without significantly affecting mortality,
2. pruning to accelerate development by encouraging greater terminal shoot growth than lateral growth, thus ensuring trees grow as tall as possible as quickly as possible. This reduces the risk of terminal leader browsing by livestock.
3. seasonal exclosure to allow regeneration if livestock numbers are not reduced, this can be carried out on a rotational system ensuring that stock carrying capacity is kept constant.

Recent research has however, suggested that the only long-term sustainable management of the dehesas may be to exclude livestock for 20 years or more, either continually, or rotationally to ensure regeneration (Pulido et al. 2001).

Figure 1. *Normal canopy cover does not exceed 65% in the Dehesas.*

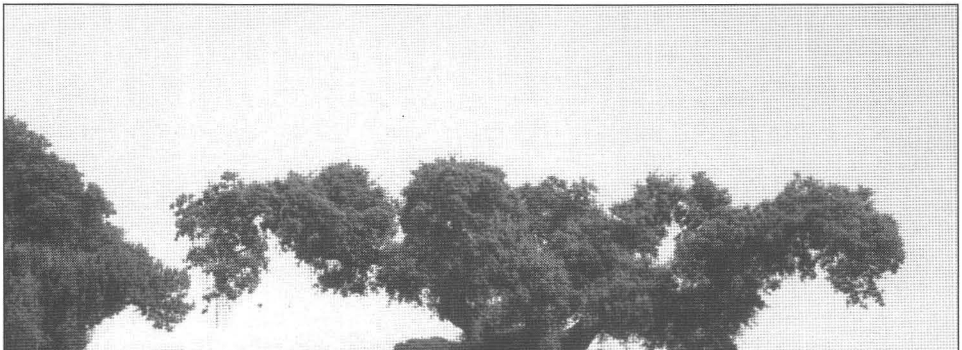

Figure 2. *Form pruning facilitates cork production and acorn harvesting.*

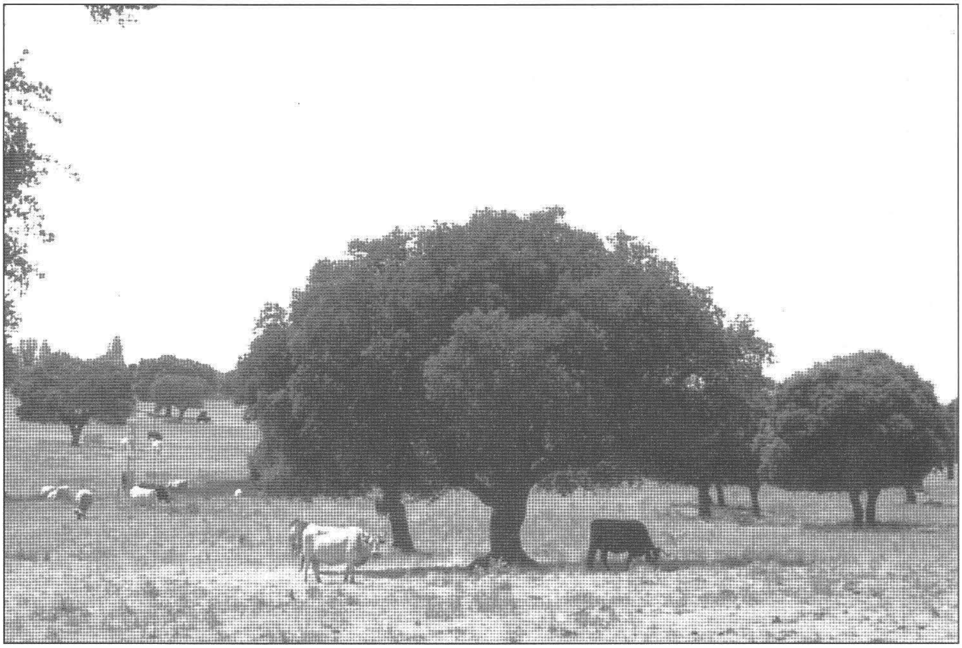

Figure 3. *Dehesa tree with full crown, trees are ready for production pruning.*

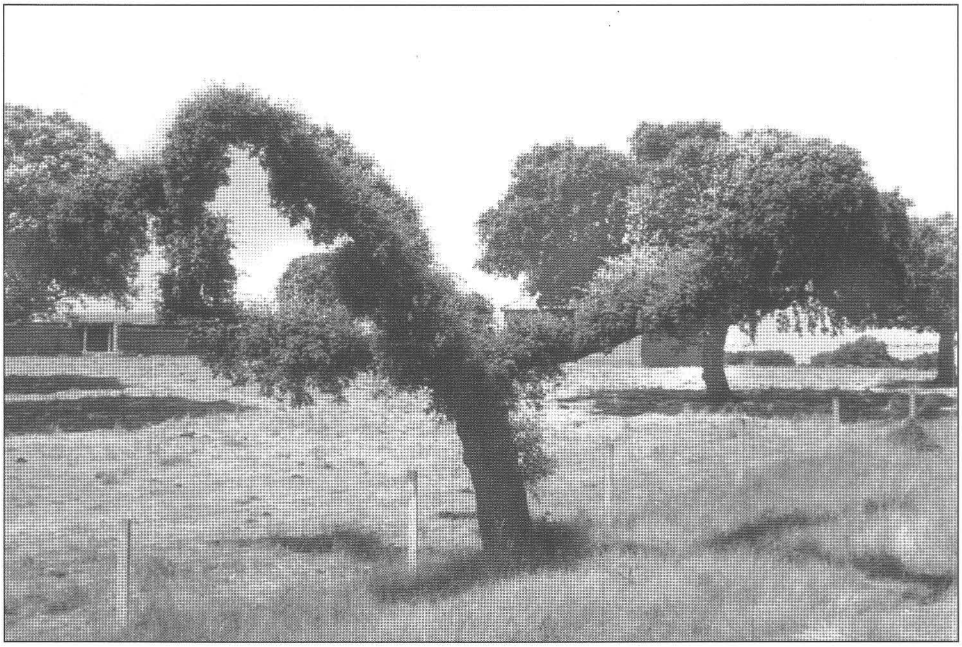

Figure 4. *Lopping; a more drastic pruning, leaving only 4-6 thick branches per tree.*

In Britain in similar cases regeneration can be sporadic, rather than continuous (Rackham 1998), especially when periods of browsing fall below critical limits. (Work carried out by Tubbs (1986) in the New Forest, England has shown such an effect.) Due to the long-lived nature of trees in silvopastoral systems, sporadic periods of regeneration can be sufficient to ensure continuity of tree cover.

Holm oak is resistant to high herbivore grazing pressure (Gómez-Gutiérrez and Pérez-Fernández 1996) but the trees remain dwarfed under heavy browsing. However, while the outer leaves are consumed, the terminal shoots become more lignified, dense and dry. These form spike-like barriers, which defend the innermost leaves. The tree does not increase in height but it builds up reserves for future growth and will increase in height when grazing pressure is reduced. It is only when herbivore pressure is very high and persistent that it eventually dies.

Regeneration has suffered in the last few decades due to higher livestock densities, increased mechanisation and abandonment of traditional forestry practices (Diaz et al. 1997).

Tree density is controlled to ensure optimum returns on pasture and cereal production; it is usually around 40 trees ha^{-1} (Pulido et al. 2001).

Implications for silvopastoral systems in NI

Agroforestry systems

There is a need for integrated management, with early and multiple returns to make agro-forestry systems economically viable. Timber trees could be planted with inter-spaced fruit and nut producing bushes to encourage both biodiversity and generate some early income. Non-timber crops have the added advantage of requiring less protection from livestock as tree form and leader damage are not as important as for trees grown for timber, reducing one of the main costs of agroforestry.

Pruning is important at all stages for optimum output from tree and pasture systems. The specialised pruning used in the dehesa system requires skilled workers. Pruning is especially important in silvopastoral systems when timber is an end product as the wide-spacing of trees results in the formation of heavy lateral branching (Figure 5). Branches from pruning and early thinnings could be used for firewood/charcoal and fodder for livestock.

Although weather conditions are less extreme than the dehesa region, animal welfare also benefits from the shade and shelter provided by the tree canopy, through reduction in wind-speed, precipitation and irradiance.

While soil conservation and nutrient cycling are of obvious benefit in the dehesa system, in the past these issues have never been of great importance in Northern Ireland. However, recent policies relating to sustainable land management have encouraged greater awareness of soil conservation and the excessive use of both organic and inorganic fertilisers. Agri-environment schemes pay subsidies for reduction in fertiliser applications. Planting of agroforestry systems can increase the natural fertility of pasture through efficient nutrient cycling, ameliorate the problems of erosion caused by livestock and water and decrease the amount of fertiliser runoff into water courses.

The value of the livestock could be increased through eco-labelling it as a product from a silvopastoral system, much like the labels carried by organic and regional food products.

Figure 5. *Form pruned ash* (fraxinus excelsior) *trees in the national network Experiment, Loughgoll, Co Antrim.*

Woodland grazing management

The Dehesas provides examples of how, on the one hand, natural regeneration can be achieved in a semi-natural silvopastoral system, and, on the other, of the problems associated with achieving it.

Recent concerns of both over and under-grazing of semi-natural woods have created interest in understanding the effects of large herbivores on natural regeneration (Mitchell and Kirby 1990, Kirby et al. 1994). While the full range of effects is unclear, some conjectures can be made based on observations of the dehesa system:

1. trees can regenerate under low grazing pressures, but the species assemblage may be altered depending on species browse tolerance, in extreme cases this can lead to a mono-specific stand of climax trees,
2. tree regeneration in the dehesas is also encouraged by exclosing stock from areas of land for a number of years to allow regeneration to occur, this will allow some browse-sensitive species to regenerate from seed and permit the leaders of the more browse-resistant species that have survived as shrubs to grow above browsing height[3],

[3] Research is currently underway at The Queen's University of Belfast, in conjunction with the agri-environment section of the Department of Agriculture and Rural Development, to ascertain the approximate age of some common woodland tree species that this critical height occurs at. This estimation is critical as many tree species will not survive prolonged periods of leader browsing and defoliation

3. natural regeneration without the direct influence of man may rely on natural catastrophes, such as disease outbreak (e.g. Foot and Mouth Disease, or bovine tuberculosis) or drought in order to reduce herbivore levels sufficiently to allow sporadic episodes of tree regeneration,
4. the dehesa system, as a converted woodland system, has more floral and faunal diversity than either woodland or pasture systems alone.

It would seem that it is more feasible to graze woods on a rotational basis, rather than continuously at low densities, to ensure sufficient tree regeneration. This would also allow graze-sensitive species (both trees and forbs) to regenerate, given the longer periods of exclusion (approximately 10 years for temperate systems). The problems associated with ensuring correct animal stocking densities and grazing pressure are not as important in a rotational system as the tree regeneration occurs in the absence of livestock. Post and wire fencing is used to fence woodlands in existing agri-environment schemes in Northern Ireland.

Conclusion

These observations suggest that a system of woodland grazing, or agroforestry is potentially more beneficial than either a woodland, or system of pasture alone, much in keeping with the historical practices of pannage and wood-pasture in historic parkland-type environments in northern Europe.

These findings however, must be applied with caution due to the climatic differences between the Mediterranean dehesa system and the temperate Atlantic climate of Britain and Ireland. Environmental benefits of a relatively young silvopastoral system have already been shown, but more needs to be known about the long-term effects.

In the Mediterranean systems, the tree component can ameliorate problems associated with nutrient cycling, heat stress, evaporation and scorching of grass, but in temperate systems, light will eventually become the limiting factor for herbage production under a silvopastoral system, even with a regime of pruning and thinning. Thus the number of useful applications of the tree component of the system would be reduced, consequently reducing the viability and profitability of the system.

There are however enough non-market advantages of temperate agroforestry to sustain interest in its use, such as biodiversity (McAdam 2000), carbon fixation and increasing tree cover in areas of low cover. These can also be financially compensated through agri-environment schemes and woodland planting grants making the system more financially viable for the landowner (Thomas and Willis 2000). Any future increases in timber values relative to livestock, no matter how small, could make agroforestry a much more attractive option to farmers. The current uncertainties in the meat market with BSE, Foot and Mouth disease and the continuing EU policies towards extensification and biodiversity in farming may further enhance the attractiveness of agroforestry (Thomas and Willis 2000).

Currently, experimental, temperate silvopastoral systems are under investigation, in addition to on-farm trials (Hoppé et al. 1996). Silvopastoral systems could become a more familiar part of the landscape in the future, just as they were in the past. Lessons can be learnt from other countries, which have managed to preserve their traditional silvopastoral systems despite modernisation and intensification of farming practices.

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Natural regeneration within the Coillte estate

II The occurrence of natural regeneration of lodgepole pine on clearfelled areas

Áine Ní Dhubháin[1] and Dermot O'Leary[2]

Abstract
The factors that influence the probability of lodgepole pine (*Pinus contorta* Dougl. var. *contorta*) regenerating naturally were examined in a field survey of clearfelled lodgepole pine sites in the Coillte (Irish Forestry Board) estate. Sixty-six sites with naturally regenerated lodgepole pine and 41 sites without were selected. Logistic regression was used to model the relationship between its occurrence and site and stand factors. Of twenty-five factors examined, four were shown to significantly influence the probability of natural regeneration occurring: site exposure, site drainage status, the percentage of the clearfelled crop comprising lodgepole pine and whether the antecedent stand had been thinned. Lodgepole pine natural regeneration was reduced at increased exposure, whereas improved site drainage increased it. The greater the percentage of lodgepole pine in the antecedent crop, the greater the probability of lodgepole pine regeneration occurring. Thinning also increased the probability of natural regeneration occurring.

Keywords: seed germination, seedling survival, logistic regression, probability model

Introduction
The majority of forests in Ireland consist of even-aged monocultures of exotic species, managed under a clear cutting system. At final harvest the entire crop is felled, followed (usually) by artificial regeneration with nursery-produced plants, often of the same species as the antecedent crop. There is however, increasing national and international pressure to examine and introduce alternatives to the clear cutting system. These alternatives rely largely on natural regeneration as a means of reforestation.

As a result of increased clear cutting levels in Irish forests, spontaneous natural regeneration of a number of species, including lodgepole pine, is occurring more frequently. Lodgepole pine is the second most widely planted coniferous species in the Coillte estate, comprising 15 % of the company's forest area. It is most commonly found on poor sites with low fertility and productivity, where the financial justification of forestry is often questionable (Carey and Hendrick 1986). However, adequately stocked crops arising from natural regeneration could prove to be economically viable, as they avoid the costs associated with planting. In addition, basal sweep, a common defect in planted lodgepole pine, is generally not found in naturally seeded trees (Pfeifer 1982).

A range of factors is known to influence the occurrence of lodgepole pine natural regeneration. Lotan and Critchfield (1990) found the highest germination rates in full sunlight and on bare mineral soil or disturbed duff, free of competing vegetation. Minore (1972) found that the germination rates of lodgepole pine under field conditions ranged from 30 to 88%, depending on the nature of the seedbed and amount of shading. Moderate and heavy shade reduced germination by up to 20%. Another factor influencing natural

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regeneration is the seedbed moisture level. Lotan (1964) found drought the most common cause of mortality among first-year lodgepole pine seedlings. In its natural range, the greatest losses of lodgepole pine seedlings occur on soils with low water-holding capacity, and on seedbeds of duff and litter, with losses declining after the first growing season (Lotan and Critchfield 1990).

Objective

The objective of the work described was to determine the stand and site factors associated with the occurrence of natural regeneration of south coastal lodgepole pine on clearfelled sites in Ireland.

Materials and methods

The later stages of the natural regeneration process, seed germination and survival, were considered and the factors influencing these two stages identified. Stands (subcompartments in the Coillte estate) with natural regeneration of lodgepole pine (referred to hereafter as 'regeneration sites') were examined, as well as sites where it was assumed seed of lodgepole pine was available, but had not germinated ('non-regeneration sites').

Sites were selected using the following criteria:

1. a second rotation crop was present and the antecedent crop had been clearfelled,
2. sites on which crops were clearfelled prior to January 1986 were excluded because data were not available.

Regeneration sites were selected from Coillte's subcompartment database. Up to four tree species were recorded in the database for each subcompartment together with their relative canopy composition (if above 5%). The database also recorded which species were naturally regenerated. Subcompartments in the database which had naturally regenerated stands of lodgepole pine were listed in descending order, according to the percentage of the canopy composed of natural regeneration. The first 66 sites on this list were chosen.

Forty-one non-regeneration sites were identified using GIS, inventory data, and information from Coillte personnel. These were sites which had no evidence of naturally regenerated lodgepole pine but

1. contained lodgepole pine in the antecedent crop or
2. contained no lodgepole pine, but at the time of harvest had at least one adjacent subcompartment containing mature (at potential seed-bearing age) lodgepole pine.

It was assumed therefore that seeding but not germination had occurred at these sites. In order to ensure that the process that was being examined was germination and survival, rather than seed production *per se*, non-regeneration sites were selected close to those where regeneration had occurred. This approach had the added advantage of ensuring that environmental influences on seed production and its rate would be similar on both site types. Thus, if seed were produced in one stand of lodgepole pine, it was likely that seed was also produced in the neighbouring stand, provided it had reached seed production stage (about 20 years) as both would have been subject to similar (seed producing) climatic conditions. Selecting crops in the manner described did not fully ensure that they had produced seed and it did not germinate. However, it was the only available means to identify non-regeneration sites.

Data collection

Site (Table 1) and crop (Table 2) data were recorded for each subcompartment. Sites which were clearfelled some time before they were visited contained little evidence of the understorey vegetation type and weight that was present under the antecedent crop. In those instances the vegetation type and weight of similar clearfelled sites were used. The antecedent crop history was obtained from local forest records. Some historical data proved difficult to obtain due to lack of long-term records.

Table 1. *Site variables recorded.*

Variable	*Category*	*Source*
Aspect	N, NE, E, SE. S, SW, W NW, flat	Survey
Slope	Gentle (0-5°), moderate (6-11°), steep (12-17°)	Survey
Elevation category	1 (<100 m), 2 (100-199 m), 3 (200-300 m), 4 (>300 m)	Ordnance Survey
Exposure	Sheltered, moderate, high	Coillte records[1]
Soil type	Brown earth, blanket peat, etc.	Coillte records[1]
Drainage status	Good, moderate, poor, very poor	Coillte records[1]
Germination surface	Organic, mineral	Survey
Site fertility	High, intermediate, low, variable	Coillte records
Animal trespass?	Yes, no	Survey

[1] Updated during field survey if necessary

Table 2. *Antecedent crop variables recorded.*

Variable	*Category*
Proportion of antecedent crop comprised of lodgepole pine (%)	0, 1-50, > 50
Stocking at clearfell	
level (%)	0-32, 33-66, > 66
volume	m^3ha^{-1}
Initial crop spacing (m)	≤ 2, > 2
Crop thinned?	Yes, no
Yield class ($m^3ha^{-1}an^{-1}$)	< 10, 12-14, > 14
Windthrow	
presence	Yes, no
% of crop area affected	0-32, 33-66, > 66
Age of antecedent crop at time of clearfell	Years
Year of clearfell	
Time of clearfell	1 (February-April), 2 (May-July), 3 (August-October), 4 (November-January)
Harvesting method	Harvester, motor-manual, combination

Table 2. *continued*

Variable	*Category*
Time interval between harvesting and reforestation	1 (< 5 months), 2 (5-8 months) 3 (> 8 months)
Reforestation site preparation used?	Yes, no
Vegetation at clearfell	
volume	Heavy, moderate, light, none
type	Predominant plant species
Brash	
mats	Yes, no
windrowed	Yes, no
volume	Heavy, moderate, light

The presence and location (compass bearing) of adjacent, mature lodgepole pine was recorded at each site. Of the sites visited, the crop age at the time of clearfell ranged from 20 to 51 years, yield class ranged from 6 $m^3 ha^{-1} an^{-1}$ to 16 $m^3 ha^{-1} an^{-1}$. The mean time period between clearfelling and reforestation was 12 months (Table 3).

Table 3. *Current and antecedent crop, and site characteristics at the study sites.*

Variable	*Minimum*	*Maximum*	*Mean*
Area of lodgepole pine regeneration (ha)	0.3	13.9	2.2
Age of antecedent crop at time of clearfell (years)	20.0	51.0	31.5
Yield class of antecedent crop ($m^3 ha^{-1} an^{-1}$)	6	16	12
Time interval between harvesting and reforestation (months)	2.0	24.0	12.1
Proportion of antecedent crop comprising lodgepole pine (%)	0	100	95
% of productive stand area stocked	70	100	90
Initial spacing of antecedent crop (m)	1.5	3.0	1.8
Extent of antecedent crop affected by windthrow (% of area)	0.0	50.0	7.1

Data analysis

Stepwise logistic regression (using GENSTAT™) was used to model the probability of lodgepole pine regenerating naturally (the dependent variable) based on the antecedent crop and site (including treatment) factors (independent variables). Each level of the categorical variables, for example exposure, was represented by a score.

The first step identified individual variables which significantly ($p \leq 0.05$) influenced lodgepole pine natural regeneration. A second logistic model was then fitted to a subset of these factors, arrived at by deleting them one by one until only significant factors were included in the overall model. The final model had the form:

$$p_i = \frac{e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_n x_n}}{1 + e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_n x_n}}$$

where:

p_i: probability of lodgepole pine regenerating naturally in subcompartment i,
$\beta^{0}_{,1\ldots n}$: parameters fitted by regression,
$x_1, x_2, \ldots x_n$: level of independent variable x_n in subcompartment i.

Results

The second regression model included four factors and an intercept (Table 4). The four factors were: site exposure, drainage status, the percentage of the antecedent crop comprising lodgepole pine and whether or not the antecedent crop had been thinned (Table 5). The residual element of the model was not significant, indicating no significant lack of fit.

Table 4. *Analysis of variance of fitted logistic regression model.*

Dependent variable	*Probability of natural regeneration occurrence*			
Fitted terms	*Constant, exposure, drainage, % of antecedent crop comprising lodgepole pine and whether or antecedent crop thinned*			
Summary of analysis				
	Degrees of freedom	*deviance*	*mean deviance*	*deviance ratio*
Regression	8	76.26	9.5321	9.53
Residual	96	63.29	0.6593	
Total	104	139.55	1.3418	

Table 5. *Parameter estimates for the variables in the natural regeneration probability model.*

Variable	*Parameter estimate*	*Standard error*	*t-value*	*Probability > t*
Intercept	3.43	1.71	2.00	0.045
Exposure				
1. Sheltered	0.00			
2. Moderately exposed	-2.97	1.18	-2.51	0.012
3. Highly exposed	-3.03	1.32	-2.30	0.022
Drainage				
1. Good	0.00			
2. Moderate	-3.14	0.92	-3.43	≤0.001
3. Poor	-5.32	1.20	-4.43	≤0.001
4. Very poor	-4.64	1.36	-3.42	≤0.001

Table 5. continued

Variable	*Parameter estimate*	*Standard error*	*t-value*	*Probability > t*
Proportion of lodgepole pine in antecedent crop				
1. None	0.00			
2. < 50%	1.22	1.66	0.74	0.461
3. > 50%	2.46	1.29	1.91	0.056
Thinned				
1. No	0.00			
2. Yes	1.73	1.05	1.65	0.099

The model showed that thinning increased the probability of natural regeneration after clearfelling (Figure 1). Thinning the antecedent crop almost doubled the probability of natural regeneration occurring on both highly and moderately exposed sites, with moderate drainage and an antecedent crop of 100% lodgepole pine. On sheltered sites with similar

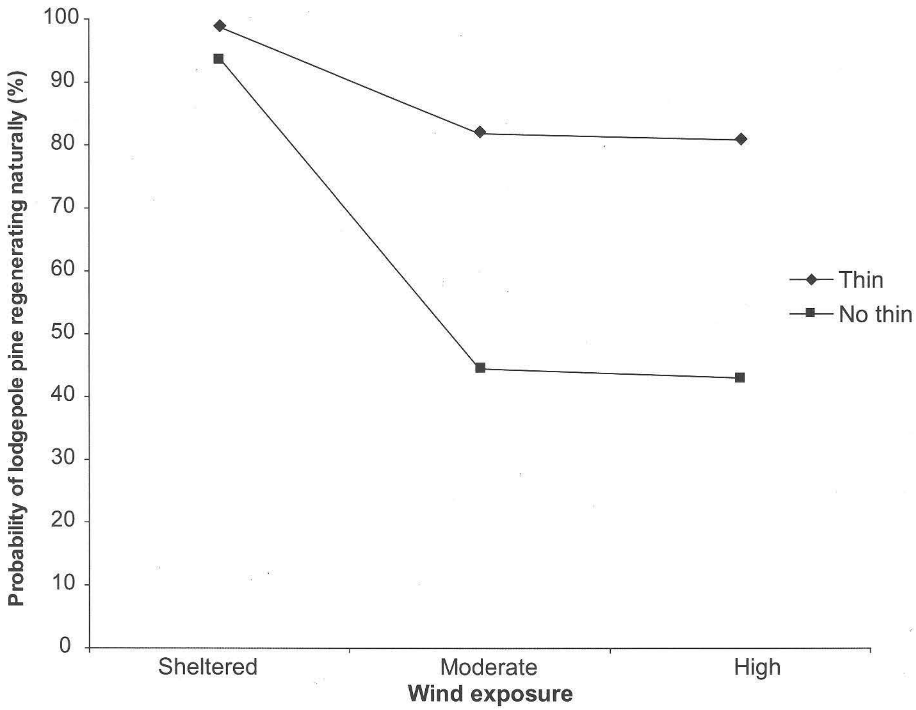

Figure 1. *Combined effect of thinning and wind exposure on the probability of lodgepole pine regenerating naturally (assumes site is moderately drained and antecedent crop comprised 100% lodgepole pine).*

drainage and composition of the antecedent crop, thinning increased the probability of natural regeneration to 99% (with a standard error of ±2%). If the antecedent crop had not been thinned the probability dropped to 93% (with a standard error of ±6%).

In general, better site drainage substantially increased the probability of lodgepole pine regenerating naturally (Figure 2). On well-drained sites the probability of lodgepole pine regenerating naturally was high, irrespective of site exposure.

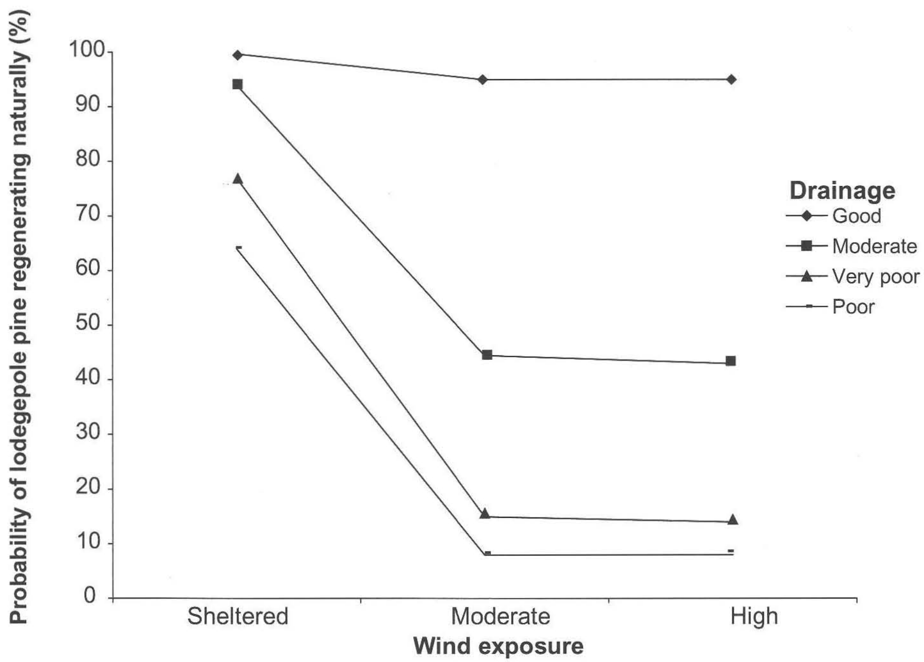

Figure 2. *Combined effects of drainage and wind exposure on the probability of lodgepole pine regenerating naturally (assumes antecedent crop unthinned and comprised 100% lodgepole pine).*

Discussion

Selection of variables in the model

Lodgepole pine was significantly less likely to regenerate on sites that were moderately or highly exposed than on sheltered sites. Stuart et al. (1989) also found that harsh microclimatic conditions were responsible for limiting the natural regeneration of lodgepole pine. Similarly, Dagg (1998) found that exposure negatively influenced natural regeneration of Sitka spruce. Exposure to wind affects seed germination by influencing both the temperature at the soil surface and the moisture content of the soil. Indeed, Lotan and Perry (1983) found that germination of lodgepole pine seed was significantly affected by climatic conditions. For example, temperature fluctuations between 8°C to 26°C favoured germination. However, greater extremes of temperature are likely on exposed sites. Seedling survival is also influenced by exposure. For example, heat girdling, freezing, frost heaving and moisture deficits all negatively affect survival (Aldhous and Mason 1994) and all are influenced by exposure. Indeed, one advantage of retaining a light slash cover on a clearfelled site is that exposure is reduced. Consequently, environmental conditions for seed germination and seedling survival are likely to be more favourable, with less variation in temperature and soil moisture (Lotan and Perry 1983).

There was little difference in the probability of regeneration occurring between moderately and highly exposed sites. Thus, high exposure did not reduce the probability of natural regeneration occurring below that for moderately exposed sites. This finding would suggest that a moderate exposure is the critical level for natural regeneration to occur. However the assessment of exposure was subjective, and it may be that that the exposure classes were not sufficiently differentiated.

Site drainage status was a significant factor in explaining the occurrence of natural regeneration of lodgepole pine. The probability of lodgepole pine regenerating naturally was significantly greater on well-drained sites as opposed to less well-drained sites. Drainage status is indicative of the condition of the germination surface. On well-drained sites the litter layer would not be expected to accumulate to the same extent as on wetter sites. A thinner litter layer would increase the chance of the roots of germinating seedlings reaching the soil surface. Furthermore seed can lose viability before germination if subjected to prolonged waterlogging, particularly when anaerobic conditions persist (Nixon and Worrell 1999). On poorly-drained sites newly emerging seedlings would be at greater risk of attack from damping-off fungi (Leiffers and Rothwell 1986). There may also be a greater diurnal temperature range on poorly-drained sites (Garman 1955). However, very poorly-drained sites were more likely than poorly-drained sites to support natural regeneration. While this contradicts the overall trend, it may be explained by the fact that most very poorly-drained sites were peat sites. Peat sites readily support natural regeneration, because of the relatively slow rate at which competing vegetation recolonises them (Brown and Neustein 1974).

Thinning prior to harvest also significantly influenced the likelihood of natural regeneration of lodgepole pine occurring after the stand was clearfelled. There is strong evidence that the development of large tree crowns following thinning promotes seed production (Wenger 1954, Allen and Trousdell 1961). Thinning also increases the amount of light reaching the forest floor, which increases soil temperature, which in turn increases the rate of germination (Nixon and Worrell 1999).

Natural regeneration of lodgepole pine was also significantly affected by the proportion of lodgepole pine in the antecedent crop. Where lodgepole pine comprised at least 50 % of the antecedent crop, natural regeneration was more likely to occur than on sites with less than 50 % lodgepole pine. This is most likely attributable to a higher overall lodgepole pine seed production rate in antecedent crops with higher proportions of the species.

A number of site factors which were hypothesised to influence the occurrence of natural regeneration of lodgepole pine were not significant. Soil type was one. It is likely that the effects of soil type were masked by the other factors such as exposure and drainage. Soil type is closely associated with both of these factors. Crop age does determine the occurrence of seed production. However, as this study focused on seed germination and survival, only those clearfelled crops which had reached the age of seed production were included. Thus it may be that once seed production had begun in these crops there was little further increase with age.

Application and limitations of the model

The model answers some questions about spontaneous natural regeneration of lodgepole pine. Combined with local knowledge it should allow forest managers to predict with greater certainty the occurrence of natural regeneration following the clearfelling of lodgepole pine crops. For example, on poorly-drained (non peat), highly-exposed sites, natural regeneration of lodgepole pine has only a 10% chance of occurring (even if seed were available). On the other hand, natural regeneration is highly likely on sheltered and well-drained sites (assuming that seed is available). The model also provides information as to how to increase the likelihood of lodgepole pine regenerating naturally. For example, thinning not only increases the probability of seed production but also the probability of successful germination and survival. Improving drainage will also increase the chance of natural regeneration occurring.

The model is based on a limited number of sites. The standard error of prediction for some categories of the variables reflect this. It is also important to note that a limited number of silvicultural activities were recorded, and some of these, such as the level of brash remaining on the site, were shown in other studies to significantly influence the occurrence of natural regeneration of lodgepole pine (Cochran 1973). No long-term record of silvicultural or harvesting activities, such as the method and time of harvesting had been maintained for the sites in the study. Similarly, the treatment of slash was not recorded. Thus, it was necessary to rely on records that some foresters retained or on their recollection of these activities. As a result, in some instances information on these site activities was not available.

Conclusions

The increased emphasis on alternative silvicultural systems to clear cutting has increased interest in reforestation using natural regeneration. Recent studies have increased the available information on factors which influence its occurrence (Nixon and Worrell 1999, O'Leary 2000). Increased knowledge and the ability to more accurately predict the occurrence of natural regeneration should encourage foresters to seriously consider using natural regeneration as an alternative to planting on certain sites. Further study is required however, to more fully understand the factors favouring the occurrence of natural regeneration.

Acknowledgements

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The Tree Register of Ireland

Mark Twomey[1], Aubrey Fennell[2] and Frances McHugh[3]

Abstract

The Tree Council of Ireland and The Irish Tree Society initiated the Tree Register of Ireland (TROI) project in 1999 with the aim of compiling a database of trees in Ireland. Five thousand two hundred trees were measured and recorded over the period 1999 to 2001. Of these some 3000 had previously been recorded by Alan Mitchell on behalf of the Tree Register of the British Isles (TROBI).

Mitchell covered many of the large estates, public parks and gardens throughout Ireland. Many of Ireland's finest trees however, are found on private farmland and in gardens. TROI endeavoured to both update the tree measurements taken by Mitchell, and to locate and record new trees which were growing in less conspicuous locations.

The tallest tree measured was a Douglas fir at Powerscourt, Co Wicklow standing at 57.5 m. The largest girth tree was a Monterey cypress at Killyleigh, Co Down, measuring 12.09 m. The oldest tree recorded was a yew in Co Wexford, which was estimated to be between 800 and 1200 years old.

Differential Global Positioning System (DGPS) technology was used to accurately determine tree location and to facilitate subsequent relocation.

The Tree Register can be viewed at the National Botanic Gardens at Glasnevin, Dublin and provides the most comprehensive database of outstanding tree specimens in Ireland.

Keywords

Differential global positioning system, champion trees, Tree Register of Ireland, TROI, Tree Register of the British Isles, TROBI.

Tree recording in Ireland

The Dublin Society, founded in 1732, began, in the mid eighteenth century, to encourage the creation of woodlands and forests by awarding premiums (grants) to landowners who planted trees. This led to several landowners writing about their tree-planting endeavours. As a result five books on arboriculture were published in the last half of the eighteenth century; one such was on methods of raising Scotch Fir (sic), written by the Earl of Clanbrassil, James Hamilton and published at Newry in 1783 (Hamilton 1783). These books advised fellow landowners on growing trees and were based on the authors' own personal experiences. Hayes (1794) commented on fine, mature exotic trees, some of which must have been planted in the preceding century.

However, the history of the early planting of exotic trees in Ireland can principally be derived from Loudon's writings of 1838 in which 18 Irish estates and their trees were described.

Notwithstanding this earlier work, it was Elwes and Henry who laid the foundation for modern tree measurement in Ireland. In the introduction to their seven-volume *The Trees of Great Britain and Ireland* (Elwes and Henry 1906), they state that although the historic trees of parts England and Scotland had been described in various publications, those in

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Ireland were in need of more detailed study. They go on to say that Henry paid special attention to many interesting tree locations in Ireland. Throughout the seven volumes, the authors refer to both native and exotic trees, measured in Ireland, from Fota in Co Cork in the south, to Castlewellan in Co Down in the north.

Lowe (1897) focused on yew, and published a comprehensive listing of outstanding trees of the species in Great Britain and Ireland. He gives measurements at 20 locations in Ireland, including the famous Silken Thomas yew at Maynooth and the yew-lined avenues at Strokestown, Co Roscommon, Glencormac, Co Wicklow and Gormanstown, Co Meath (subsequently re-measured by the Tree Register of Ireland (TROI)).

Fitzpatrick (1933) continued the work of Elwes and Henry by recording native and introduced trees in Ireland at 72 estates in Ireland.

Alan Mitchell, a dendrologist from Essex, followed on from the work of Fitzpatrick. Having read forestry at Dublin, he was appointed dendrologist with the Forestry Commission in 1970. This allowed him to travel Britain and Ireland, collecting measurements of outstanding trees. He located and re-measured trees recorded by Loudon in the 1820s and 30s, Elwes and Henry in the period 1906-1913 and those included in the 1890 and 1930 Conifer Conference reports by the Royal Horticultural Society. He was himself closely involved in the work of the 1970 Conifer Conference. Much of his data was included in the publication *Conifers in the British Isles, A Descriptive Handbook* (Mitchell 1972). He also made an important contribution to W.J. Bean's *Trees and Shrubs Hardy in the British Isles* (Bean 1976).

In 1988 Mitchell and Victoria Schilling founded the Tree Register of the British Isles (TROBI). The aim of TROBI was to protect Mitchell's register of trees and ensure its future updating.

Mitchell's continuing search for rare and exceptional trees enabled the Forestry Commission to publish the first comprehensive list of champion trees in *Champion Trees in the British Isles* (Mitchell 1985). This publication continued to be updated until 1994 (Mitchell et al. 1994). It set out the location and dimensions of trees of outstanding size, vigour, and quality in Britain and Ireland. The 1994 report includes 1065 species (802 broadleaved and 263 coniferous, with 495 cultivars and varieties). By the time of his death in 1995 Mitchell had measured and recorded over 100,000 trees on a hand-written card index.

In 1979 the Heritage Gardens Committee of *An Taisce* (The National Trust for Ireland) began an inventory of trees and shrubs in major Irish gardens. It was based on collections in twenty privately owned gardens and a further eight in public ownership. Approximately 117,500 woody plants were recorded, which represented 7000 different species, subspecies, varieties, forms and cultivars (Forrest 1988).

The Tree Register of Ireland

The Tree Council of Ireland and The Irish Tree Society initiated the Tree Register of Ireland (TROI) project in 1999 with the aim of compiling a database of champion trees in Ireland.

Mitchell, during his limited time in Ireland, covered many of the large estates and public parks and gardens throughout the country. Many of Ireland's finest trees are, however, found on private farmland and in gardens. TROI endeavoured to both update the tree measurements taken by Mitchell, and to locate and record (with the help of a network of enthusiastic volunteers) new trees which were growing at less conspicuous locations.

Inclusion criteria for the register

When a tree register is begun it is imperative that structures and guidelines are put in place to ensure that the register contains the best trees. Mitchell's (1994) criteria for choosing outstanding trees were used in establishing the register:

1. trees of known planting date previously measured over a long period,
2. old and venerable specimens that probably represent an ultimate size appropriate to the local site conditions,
3. trees exhibiting good growth, horticultural or genetic value, disease or exposure resistance,
4. any tree that occurs in a unique location or context and so provides a contribution to the landscape, including remnant native vegetation, and trees that form part of a historic landscape, park, garden or urban planting,
5. rare or locally distributed taxa for which little data exist already.

Tree recording

Recording took place over the period 1999-2001.

Locating trees from descriptive annotation and as recorded in all previous listings amounted to a considerable task. Quite a number of the trees were rarities, requiring taxonomic assistance from the National Botanic Gardens.

To enable subsequent relocation of the trees measured, and to enable accurate mapping of trees that were in close proximity to each other, Differential Global Positioning System (DGPS) technology was used. This had an accuracy of ± 1 m. A data logger attached to the GPS allowed all measurements to be recorded with an associated accurate point location.

Apart from the ability to accurately map and relocate specimen trees, the georeferenced data could be added as a layer in a Geographic Information System (GIS) and be analysed in combination with other georeferenced data (Figure 1).

The use of a data logger also allowed for easy uploading of all field data. The measurements recorded for each tree included location, species, girth, height above ground level at which the girth was measured, tree height, tree health and condition, landscape setting and ownership. A number of select trees were photographed. An important part of the information gathering process was to record any cultural significance associated with individual trees, in either a local or national context.

Measurement conventions

In setting up the register it was important to standardise tree measurement. Tree growth can be measured using height, girth, canopy spread, weight, volume and dry matter. Girth and height were the two measurements used, as they are the easiest to take and most commonly used.

Girth was measured at 1.5 m above ground level, or in other cases below that height:

1. Single clean stem (including buttressed and/or fluted stems). Girth was measured at 1.5 m above ground level. (This had been the height used in all previous measurements made by TROBI, and therefore provided a standard reference point for the comparison of measurements.)

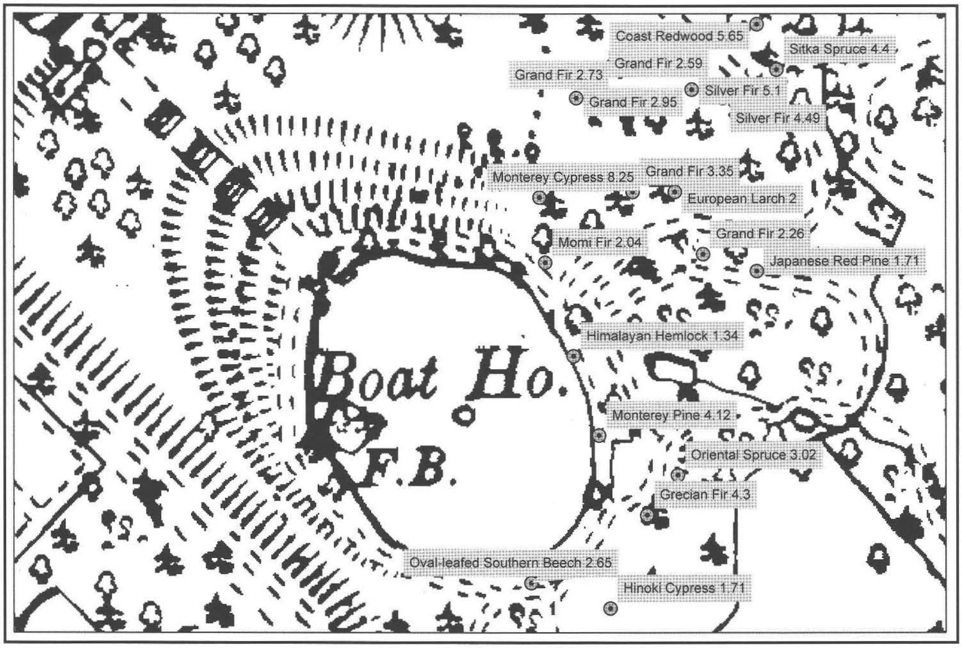

Figure 1. *Tree location data overlain on 6-inch map, Powerscourt Demesne, Co Wicklow.*

2. Single, clearly defined stem with stem irregularities and swelling between ground level and 1.5 m. Girth was measured at 1.5 m above ground level or if the girth was increased by an irregularity at 1.5 m, the girth was measured at the narrowest point between ground level and 1.5 m.

3. Twin or multi-stemmed trees with a fork between ground level and 1.5 m. The girth was measured at the narrowest point of the main stem below the fork. In the case of coppiced trees with stems originating at ground level, the stem group was measured at its narrowest point between ground level and 1.5 m.

Results

Five thousand two hundred trees were measured and recorded over the period 1999 to 2001. Of these, some 3000 had previously been recorded by Alan Mitchell on behalf of TROBI. Some 5000 entries occur on that database but many are repeat measurements of Mitchell's earlier specimens. In compiling the register all of these trees were sought, but many were no longer extant, either due to windthrow or having been felled. Owners, foresters and the public brought the remaining trees recorded in the register to the attention of the recorders. Many trees, previously recorded by one of the authors (Aubrey Fennell), were also included. Other sources of information included Loudon (1838), Lowe (1897) and Fitzpatrick (1932).

All of the ten tallest trees were conifers, comprising three species: Douglas fir, Sitka spruce and wellingtonia (Table 1).

Table 1. *Ten tallest trees in the Tree Register of Ireland (TROI).*

Species	*Location*	*Height*	*Girth*
		m	
Douglas fir	*Powerscourt Gardens, Enniskerry, Co Wicklow*	57.5	4.86
Sitka spruce	*Curraghmore, Portlaw, Co Waterford*	55.0	6.70
Sitka spruce	*Powerscourt Gardens, Enniskerry, Co Wicklow*	55.0	6.40
Sitka spruce	*Caledon Estate, Caledon, Co Tyrone*	55.0	5.77
Sitka spruce	*Shelton Abbey, Arklow, Co Wicklow*	54.5	6.61
Douglas fir	*Avondale Forest Park, Rathdrum, Co Wicklow*	54.0	3.44
Wellingtonia	*Luttrelstown Castle, Castleknock, Co Dublin*	54.0	6.55
Sitka spruce	*Tempo Manor, Tempo, Co Fermanagh*	54.0	5.20
Wellingtonia	*Caledon Estate, Caledon, Co Tyrone*	53.5	6.35
Douglas fir	*Avondale Forest Park, Rathdrum, Co Wicklow*	53.5	3.34

The tallest tree recorded, at 57.5 m, was a Douglas fir at Powerscourt in Co Wicklow (Figure 2). The four next tallest trees were all Sitka spruce.

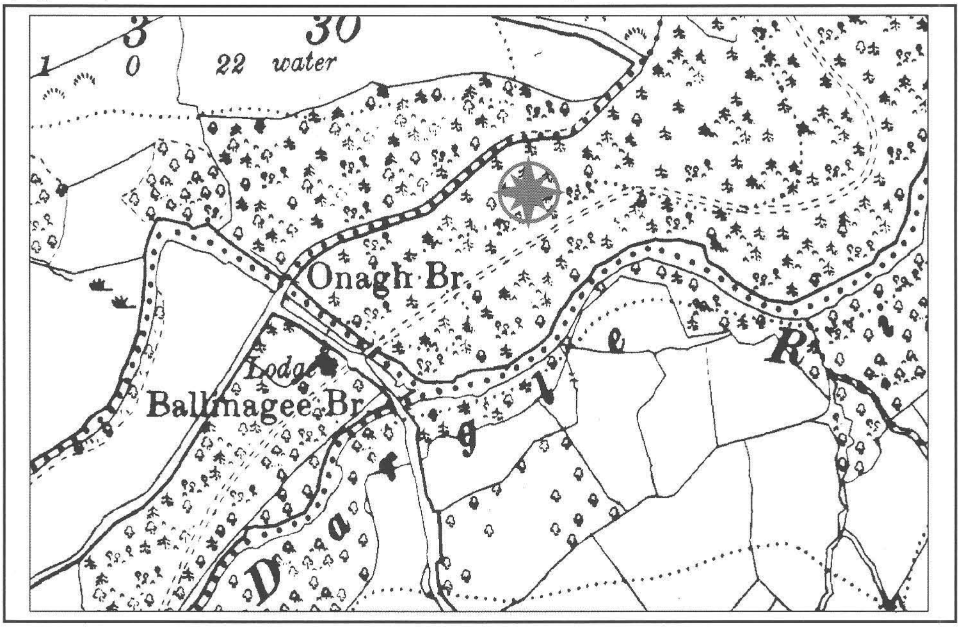

Figure 2: *Location of the Douglas fir at Powerscourt Demesne, Co Wicklow, the tallest tree in the Tree Register of Ireland.*

The specimens continue to grow at respectable rates. The Douglas fir at Powerscourt, was 42.5 m in 1966; when re-measured in 1999 m it was 57.5 m – a growth rate of close on a half metre/year. The Sitka spruce at Caledon, Co Tyrone was 44 m when measured by Mitchell in 1984, and 57 m in 1999 – a growth rate of about 0.9 m/year over the period. Some of these trees are therefore likely, within the coming decade, to be the first recorded trees in Ireland to reach to over 60 m.

Almost all of the tallest conifers were found on acid or near neutral soils. Notable exceptions were at Caledon and at Birr Castle, Co Offaly.

Monterey cypress was the largest girth tree recorded; comprising the first six of the ten largest trees (see Table 2). While the trees had a bushy form their size is nevertheless remarkable, considering they were first introduced to Ireland from California only in the 1840s (Figure 3).

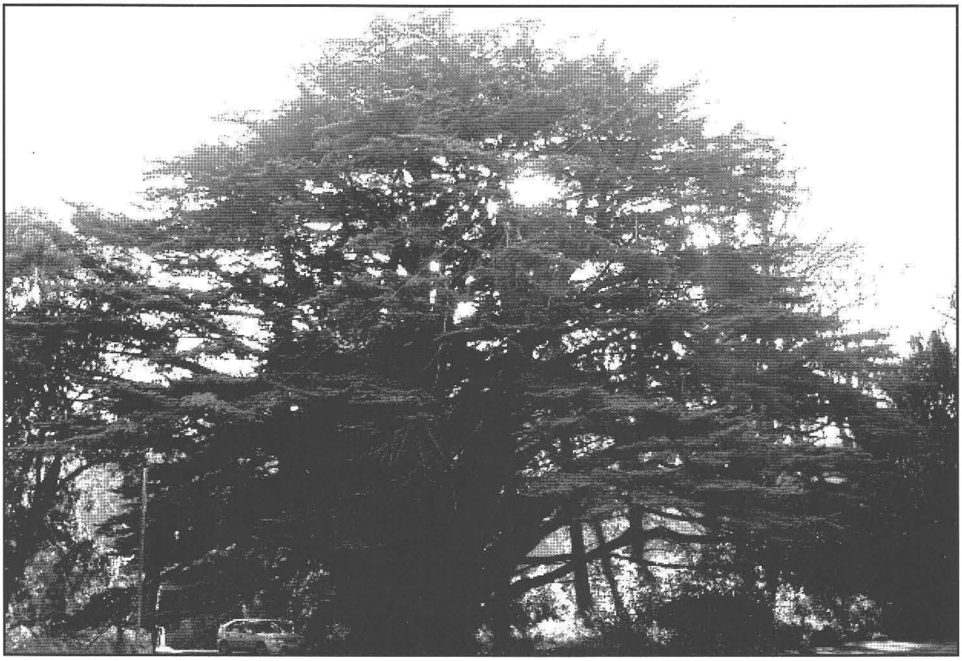

Figure 3: *Monterey cypress at Innishannon, Co Cork.*

Other new champions include a 4.24 m girth monkey puzzle at Carrickmacross, Co Monaghan, a 6 m girth incense cedar at Glenart, Co Wicklow, a 7 m girth Japanese cedar at Caher, Co Clare and a 3.8 m girth maidenhair tree (Ginkgo) at Lucan, Co Dublin.

Only one yew had been previously recorded over 5 m in girth. There are now 20 such trees. The most celebrated aspect of yew is its long life. The largest and oldest tend to be hollowed by decay. Therefore, counting of rings or carbon dating of the centre point heartwood does not tell the full story. Current estimates (Mitchell 1996) give a 5 m girth yew an age of 400 years, therefore the four trees over 6 m in question which were recorded at Bunclody, Co Wexford, Avoca Hand Weavers, Glencormac, Co Wicklow, Doneraile Court, Doneraile, Co Cork and St Patrick's College, Maynooth, Co Kildare are possibly between 700 and 1200 years old.

Table 2. *Ten largest girth conifers in the Tree Register of Ireland TROI.*

Species	*Location*	*Girth*	*Girth height* *m*	*Height*
Monterey cypress	*Ringdufferin House, Killyleigh, Co Down*	12.09	0.2	31.7
Monterey cypress	*Innishannon, Co Cork*	12.05	0.3	27.5
Monterey cypress	*Franciscan Priory, Ards, Creeslough, Co Donegal*	11.58	0.5	29.5
Monterey cypress	*Ballywalter Park, Co Down*	11.29	0.4	25.5
Monterey cypress	*Hockley Lodge, 11 Drumilly Road, Armagh*	10.78	0.9	27.7
Monterey cypress	*Seaforde Gardens, Seaforde, Co Down*	10.47	0.2	34.0
Wellingtonia	*Charleville Estate, Enniskerry, Co Wicklow*	10.38	1.5	27.5
Monterey cypress	*Timoleague Castle, Timoleague, Co Cork*	9.94	0.3	28.0
Monterey cypress	*Muckross House, Muckross, Co Kerry*	9.93	1.0	21.5
Cedar of Lebanon	*Adare Manor, Adare, Co Limerick*	9.90	1.0	19.0

The largest broadleaves such as ash, beech, oak and sycamore were mainly found in limestone river valleys of the midlands, east and south. Common lime, Spanish chestnut and ash were the largest girth trees – all well in excess of 10 m (Table 3).

Table 3. *Ten largest girth broadleaves in the Tree Register of Ireland (TROI).*

Species	*Location*	*Girth*	*Girth height* *m*	*Height*
Common lime	*Florencecourt, Enniskillen, Co Fermanagh*	10.71	0.5	22.0
Spanish chestnut	*Rossanna, Ashford, Co Wicklow*	10.59	1.3	19.0
Ash	*Thurles, Co Tipperary*	10.57	1.4	29.0
Pedunculate oak	*Stradbally, Co Laois*	9.90	1.0	20.2
Spanish chestnut	*Bunratty House, Bunratty, Co Clare*	9.30	1.5	16.0
Common lime	*Forenaughts, Naas, Co Kildare*	9.19	0.6	23.0
Spanish chestnut	*Clonbrook, Ballinasloe, Co Galway*	9.19	1.4	17.0
Pedunculate oak	*Charleville Forest, Tullamore, Co Offaly*	9.11	0.9	12.0
Common lime	*Strokestown Park, Co Roscommon*	9.10	1.1	25.5
Common lime	*Coolmore House, Thomastown, Co Kilkenny*	9.01	0.5	27.0

TROBI recorded just two oaks in Ireland as over 7.5 m in girth. TROI has now located and recorded 25 such trees. Three oaks of 9 m girth tie for the title of Ireland's largest oak. Two of them are located at Charleville Forest, Co Offaly; the other is at Stradbally, Co Laois.

The oldest oak is more difficult to determine. Oaks at Charleville have been ring counted as 450 years old, while the old oak at Abbeyleix Estate in Co Laois could be 600 years old. This is assuming it is the same tree mentioned by Evelyn in the 1660s and measured in 1794 by Samuel Hayes. Oaks 37 m high were recorded in Co Armagh while one near Clonmel, Co Tipperary was measured at 40 m and is probably the tallest native tree in Ireland.

Other notable new champion trees recorded were a sessile oak in Co Tyrone with a girth of 8.3 m, a beech of 7.9 m girth in Co Laois, a sycamore of 7.8 m in Co Meath, a horse chestnut of 6.3 m girth in Roscommon. A hornbeam with a girth of 5.7 m was recorded at Co Wicklow; the same tree was measured at 5.45 m in 1941 and must be all of 400 years old.

European and North American trees such as plane, turkey oak, tulip tree, red oak and black walnut grew best in south Leinster and east Munster. Southern hemisphere genera such as southern beech, eucalyptus and yellow-wood (*Podocarpus*) grew best in the frost-free coastal areas of those provinces.

Relevance to forestry

From a forestry viewpoint, the database contains measurements of all forest species currently grown in plantation forestry and of their potential size and longevity.

Access to the register

The Tree Register of Ireland can be viewed at the National Botanic Gardens of Ireland, at Glasnevin, Dublin.

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Mechanical properties, physical properties and fungal resistance of acetylated fast grown softwoods

I Small specimens

Colin Birkinshaw[1] and Mike D. Hale[2]

Abstract

Small samples of Sitka spruce (*Picea sitchensis*), lodgepole pine (Pinus contorta) and Japanese larch (*Larix leptolepis*) selected from normal commercial stock have been acetylated using the facilities of Stichting Hout Research in the Netherlands. The weight percent gains (WPG) used were 14% and 17% with the spruce, 16% and 19% with the pine and 17% with the larch. The acetylated materials were subject to three point bending to evaluate mechanical property change, three cycle anti-shrink efficiency (ASE) testing, equilibrium moisture content measurement and fungal resistance assessment using *Coniophora puteana*. Mechanical properties showed no significant change following acetylation. Equilibrium moisture contents were much reduced, although there was little difference between the pine at 16WPG and 19WPG. The repeated wetting and drying cycles of the ASE tests indicated that the chemical modification was permanent and the fungal tests showed very significant improvement in durability. Taken overall the results are mostly consistent with those obtained using slower grown Northern European softwoods, and substantiate the property improvement claims made for the acetylation process.

Keywords

Acetylation, chemical modification, fast grown softwood, anti-shrink, efficiency, fungal durability.

Introduction

A previous publication (Birkinshaw 2000) has reviewed the processes for chemical modification of wood and the potential benefits available to Irish timber through modification. It is the intention here to give some preliminary results arising from an experimental project investigating the modification of Sitka spruce (*Picea sitchensis*), lodgepole pine (*Pinus contorta*) and Japanese larch (*Larix leptolepis*). The modification method used was acetylation, which was commissioned in the Netherlands, with the mechanical and physical testing carried out in the University of Limerick and the fungal decay work in the University of Wales, Bangor.

Chemical modification of wood is usually based on treating the wood with reagents which convert the moisture attracting hydroxyl groups on the hemicellulose, cellulose and lignin into more hydrophobic structures. It is well known that the mechanical and physical properties of wood are very dependent on the presence of these hydroxyl groups and their interaction with water, and therefore anything which blocks or removes them will change the properties of the wood. Acetylation, which has been used here, relies on reaction of

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the wood with acetic anhydride to convert the wood hydroxyls into acetate groups (Rowell et al. 1994). Acetylated wood has a much reduced equilibrium moisture content (Yasuda et al. 1995) and therefore better dimensional stability (Rowell et al. 1993), plus a greatly increased resistance to fungal attack (Suttie et al. 1997, Forster et al. 1997, Beckers et al. 1995). Decay resistance is improved through two factors. First, under ambient conditions and out of ground contact the moisture content of the wood is below that necessary for fungal growth, and second because of blockage of the action of fungally-released degradation catalysts (Forster et al. 1997, Peterson and Thomas 1979). Improvements in photostability (Dawson and Torr 1992) and weather resistance of modified wood and durability of modified wood painted surfaces are also reported (Beckers et al. 1998).

Currently there is much interest in chemical modification processes in Europe as they offer an environmentally acceptable way of achieving high levels of durability, with the added benefit of high dimensional stability under changing humidity conditions. Although modification reagents such as acetic anhydride are moderately hazardous and require careful handling, acetylated wood is non-toxic and can be used and disposed of without any special precautions. The regulatory environment in a number of EU countries is strongly against the continued use of heavy metal preservation systems and questions the continued use of creosote. Additionally there are restrictions on disposal of waste timber treated with CCA and similar materials. This regulatory background provides a strong incentive to develop more acceptable methods of preservation, and chemical modification through acetylation is seen as one of the most promising ways forward.

Stichting Hout Research (SHR), the timber research association, in the Netherlands have recently commissioned a pilot plant capable of treating 0.5 m^3 batches, which is sufficient to allow large scale trials of products made from acetylated wood to be initiated. Acetylation of Irish softwoods was carried out in conjunction with SHR who have considerable expertise in the area. This exercise was necessary because chemical modification efforts in Europe have concentrated on permeable and slower grown Scandinavian or Baltic softwoods and on poplar, and the published information deals with the response of these species. It was clearly important to evaluate the effects of modification processes with fast grown Irish timber and in some instances less permeable timbers and so, with the support of COFORD, a project was initiated to acetylate samples of Sitka spruce, lodgepole pine and Japanese larch. These materials were chosen on the basis of the future supply position and as representative of different permeability/penetration classes.

There were two parts to the evaluation programme. First, modification of small samples to allow mechanical and physical testing and fungal durability to be assessed in specimens which, because of the relatively small size, have received a uniform degree of treatment, and then, secondly to investigate penetration, dimensional stability under treatment and the effectiveness of treatment on samples of commercial cross-section and length. The first part of this work is reported here.

Materials and methods

The timbers evaluated were Sitka spruce (*Picea sitchensis*), lodgepole pine (*Pinus contorta*) and Japanese larch (*Larix leptolepis*), selected from normal commercial stock. Clear specimens were used for the testing in order to comply with the appropriate test standards, but other than this the timber used was not subject to special selection. Therefore it was not possible to reliably differentiate, by either inspection or staining, between heartwood and sapwood in the materials used. From an absolute scientific point of view it would be

Table 1. *Materials investigated (WPG = weight per cent gain caused by reaction).*

Sample code	*Degree of acetylation (WPG)*
Spruce 1	13.8
Spruce 2	16.9
Pine 174	16.4
Pine 177	19.5
Larch 1	17.1

appropriate to examine sapwood and heartwood separately, but this would require the selection of non-typical timber.

Modification of the prepared test specimens was carried out by SHR using their established procedure. This involved vacuum impregnation with acetic anhydride followed by heating to promote reaction. The acetylation reaction is exothermic and heat is only required for initiation of the process. Un-reacted anhydride and acetic acid by-product are removed by vacuum. The process was conducted to give a range of levels of modification (expressed in terms of weight per cent gain) (Table 1). As the pine and spruce were deemed the more important materials two levels of acetylation were used with them.

Acetylated samples were tested according to the following standards. Modulus of rupture and modulus of elasticity (MOR and MOE) were tested by three point bending to EN310 using specimens 350 x 20 x 20 mm. Prior to testing samples were conditioned at 20°C and 65% RH. Approximately 20 specimens of each type were tested with equal numbers being stressed in the radial and tangential directions. Fracture surfaces were examined by scanning electron microscopy.

Adsorption isotherms were measured according to the procedure of Martins and Banks (1991), by exposure of oven dried samples, 5 x 20 x 20 mm (longitudinal, radial, tangential), to seven different relative humidities over different types of saturated salt solutions at 20°C until constant weight was obtained. Five specimens of each type were used.

Anti-shrink efficiency (ASE) and treatment stability was obtained by comparing the swelling of the modified material with that of a control as the materials are cycled between oven dry and water saturated (Stamm 1964):

$$ASE = \left(\left(\frac{S_c - S_m}{S_c}\right) \times 100\right)$$

where S_c and S_m are the volumetric swelling, in percent, of the control and the modified materials respectively, and are given by:

$$S = \left(\left(\frac{V_w - V_d}{V_d}\right) \times 100\right)$$

where V_w and V_d are the wet and dry volumes.

Three cycles of water soaking for five days followed by oven drying at 105°C for two days were used. The specimens size was 5 x 20 x 20 mm (longitudinal, radial, tangential) and

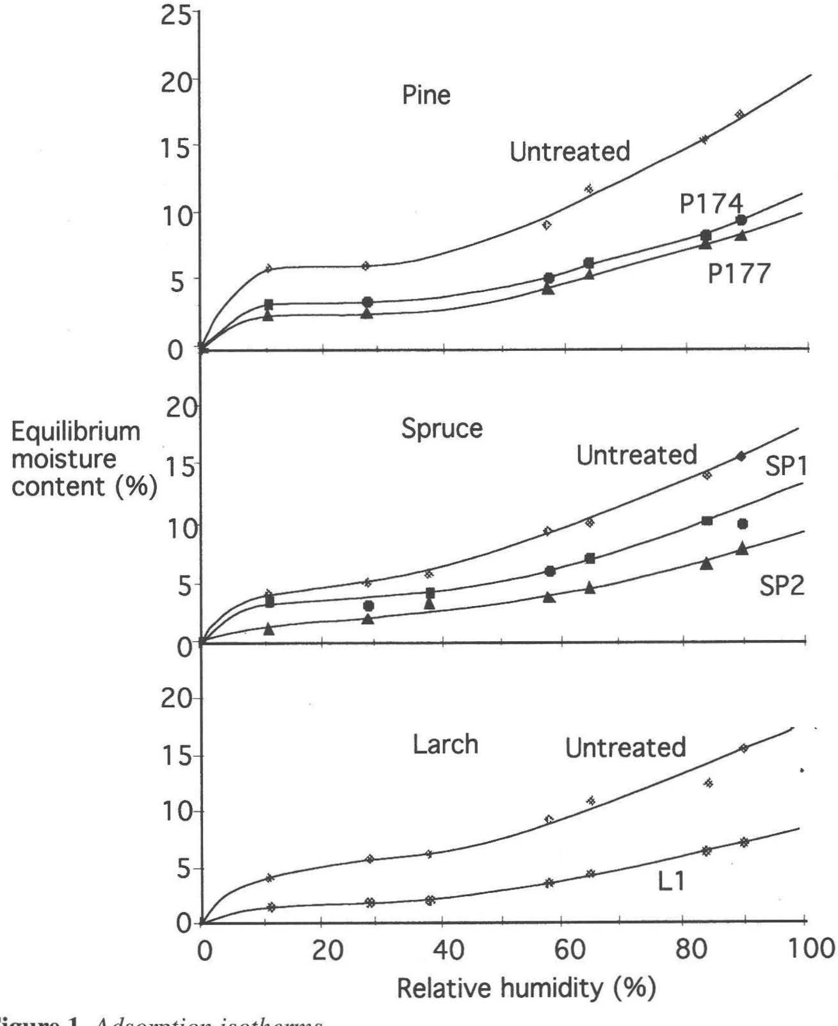

Figure 1. *Adsorption isotherms.*

again five specimens of each type were used.

Decay resistance was assessed by exposure to the brown rot fungus, *Coniophora puteana* (strain, BAM EB15) over 4% malt agar in 150 mm pre-sterilised round plastic Petri-dishes (Corning). Plates were inoculated with the fungus and incubated for 2 weeks at 22°C and then irradiation sterilised (2.5 Mrad) modified and unmodified wood blocks (each nominally 5 x 10 x 100 mm, tangential, radial, longitudinal) were planted, five per Petri-dish, onto the growing cultures. The blocks were separated from the agar by supporting them on an autoclave sterilised high density polyethylene mesh (7 mm mesh spacing). A control set of Petri-dishes, without fungus, was also included for comparison.

Table 2. *Modulus of rupture (MOR) and modulus of elasticity (MOE) results.*

Material	*MOR*	*MOE*
	MPa (standard deviation)	
Spruce		
unmodified	2.81 (0.15)	5.40 (1.28)
13.8 WPG	2.92 (0.55)	5.06 (1.31)
16.9WPG	3.14 (0.60)	6.20 (1.16)
Pine		
unmodified	3.36 (0.40)	5.87 (0.66)
16.4 WPG	4.01 (0.39)	6.71 (0.77)
19.5 WPG	3.81 (0.60)	6.00 (0.64)
Larch		
unmodified	3.78 (0.62)	8.21 (1.98)
17.1 WPG	3.06 (0.92)	6.37 (2.20)

The blocks were incubated for a further 12 weeks at 22°C, 70% RH. For the spruce and larch tests 10 blocks per acetylation level were tested but for the pine 20 were tested. The decay was primarily assessed by weight loss; this was achieved by comparison of the initial oven dry weights and oven dry weights after exposure and expressed as percentage weight loss. The moisture content at the end of the test was also assessed and results were calculated to give moisture contents on a percentage dry weight basis. Blocks which were waterlogged through making contact with the agar were excluded for the purposes of data comparison.

Results and discussion

The adsorption isotherms (Figure 1) show reductions in equilibrium moisture content for all three modified timbers at all relative humidities. The form of the isotherms is generally similar to that reported by others (Yasuda et al. 1995). Under ambient conditions the treated materials contain about half the moisture content of the untreated controls, and with the pine and the spruce, where two degrees of acetylation were used, increasing the degree of acetylation slightly reduces the equilibrium moisture content. However the effect of increasing the degree of acetylation is relatively small, particularly with the pine. This is somewhat different to the European experience.

From the mechanical property results (Table 2) it is apparent that both the pine and the spruce show some increase in stiffness and strength following acetylation, while the larch shows a drop in both of these properties. Comparison of scanning electron micrographs of fracture surfaces of the acetylated materials and the controls showed no differences in the mechanisms of fracture. In interpreting these results two considerations have to be borne in mind. First, in all cases the standard deviations are large, presumably because of the relatively coarse character of the materials relative to the sample cross-sections,

Table 3. *Anti shrink efficiency as a function of wetting and drying cycles.*

Material	*1st cycle*	*2nd cycle* %	*3rd cycle*
Spruce 13.8 WPG	54.17	48.85	60.34
Spruce 16.9 WPG	62.06	52.42	72.97
Pine 16.4 WPG	55.63	51.58	73.17
Pine 19.5 WPG	60.09	49.61	70.55
Larch 17.1 WPG	62.08	61.63	72.12

Table 4. *Weight loss (%) and final moisture content (% dry weight basis) of modified and unmodified blocks exposed to Coniophora puteana and their sterile controls. (Standard deviations given in brackets).*

Material	*Coniophora puteana*			Sterile Controls		
	Replicates	*Moisture content* %	*Weight loss*	*Replicates*	*Moisture content* %	*Weight loss*
Spruce						
Unmodified	8	82 (10.63)	39.8 (2.34)	10	33 (1.64)	-0.1 (0.15)
13.8 WPG	6	86 (11.50)	1.19 (1.42)	7	31 (4.53)	0.41 (0.11)
16.9 WPG	7	46 (10.13)	-0.86 (0.04)	10	18 (2.62)	0 (0.16)
Pine						
Unmodified	5	75 (4.25)	36.5 (2.71)	9	45 (3.93)	-0.18 (0.29)
16.4 WPG	20	61 (10.63)	6 (7.29)	12	25 (1.88)	0.21 (0.13)
	6	62 (5.65)	15.07 (6.78)			
19.5 WPG	20	53 (17.60)	-0.07 (1.00)	16	22 (4.98)	0.12 (0.16)
	16	50 (14.88)	1.05 (0.08)	16	20 (2.46)	0.15 (0.12)
Larch						
Unmodified	10	60 (11.20)	17 (11.19)	10	37 (4.16)	0.2 (0.05)
	7	61 (10.84)	23.24 (6.62)	10	37 (4.16)	0.2 (0.05)
17.1 WPG	10	45 (20.13)	-0.3 (1.16)	10	18 (2.72)	0.4 (0.25)
	8	37 (9.75)	0.12 (0.38)	10	18 (2.72)	0.4 (0.25)

and therefore small changes in properties following modification should not be treated as significant. Second, all materials were subject to the same pre-testing conditioning routine and, as the adsorption isotherms indicate, this means that the moisture content at the time of testing was much lower in the acetylated materials. Absorbed water has a plasticising effect, reducing stiffness, and so the predominant trend towards greater stiffness after acetylation can, almost certainly, be ascribed to the lower equilibrium moisture content. However some reduction in mechanical properties may have occurred because of acetic acid hydrolysis of the cellulose, but this effect is likely to be small relative to the influence of moisture content. Overall the results indicate that acetylation has no significant adverse effect on mechanical properties.

Significant improvements in the anti-shrink efficiency are apparent (Table 3) with the acetylated materials; in all cases the swelling of saturated acetylated samples is less than half that of the controls. Again though, in comparing pine at 16.4 WPG with pine at 19.5 WPG, there seems to be little additional advantage from the higher degree of acetylation. With the spruce, differences in the degree of acetylation have a more pronounced effect.

The anti-shrink efficiency remains relatively constant through the repeat wetting and drying experiments (Figure 2), suggesting that the acetylation is stable within the limits of the experiment and again this is consistent with the experience obtained with more permeable timbers and with wood composites (Larsson and Tillman 1989, Hill and Jones 1996). This result confirms that the modifying reagent is chemically bound to the lignocellulosic materials of the wood. This effect is an important improvement in wood properties.

The untreated spruce and pine test pieces showed high decay giving average weight losses of 40 and 37% respectively (Table 4). The weight losses with the larch were somewhat less (average 17%) but showed greater variation (SD = 11.2) and three of the blocks showed very little decay, presumably an effect of heartwood durability.

Acetylation reduced decay at the lower level of modification in both spruce and pine but unexpectedly it was much more effective in the spruce (only 1.2% weight loss at 13.8 WPG in spruce compared to 6% at 16.4 WPG in pine). At the 13.8 WPG level only one of the ten spruce blocks showed any signs of decay whereas at 16.4 WPG seven of the twenty pine blocks showed appreciable decay and an average of the six most decayed pine blocks was 15% (SD = 6.8). At the higher levels of modification all blocks showed good protection and no decay was noted, although it is interesting to note that the spruce was protected at a modification which was close to that which failed in pine (spruce 16.9 WPG, pine 16.4 WPG). This difference is attributed to different distribution patterns of the modification such that spruce would be expected to show higher modification at the wood surfaces due to its lower overall permeability; alternatively the lower density of the spruce, i.e. thinner cell walls may have had an influence on this.

In the sterile controls of the decay test the final moisture contents of the blocks, which represents the equilibrium moisture content of the wood blocks over agar, reduced dramatically with increasing level of acetylation. This effect was apparent with the decayed blocks but at the lower level of modification in spruce there was no difference in moisture content to the untreated control blocks.

Comparison of the anti-shrink efficiency (Table 3) with the decay results (Table 4) shows that decay can be controlled at levels of modification which do not entirely reduce swelling.

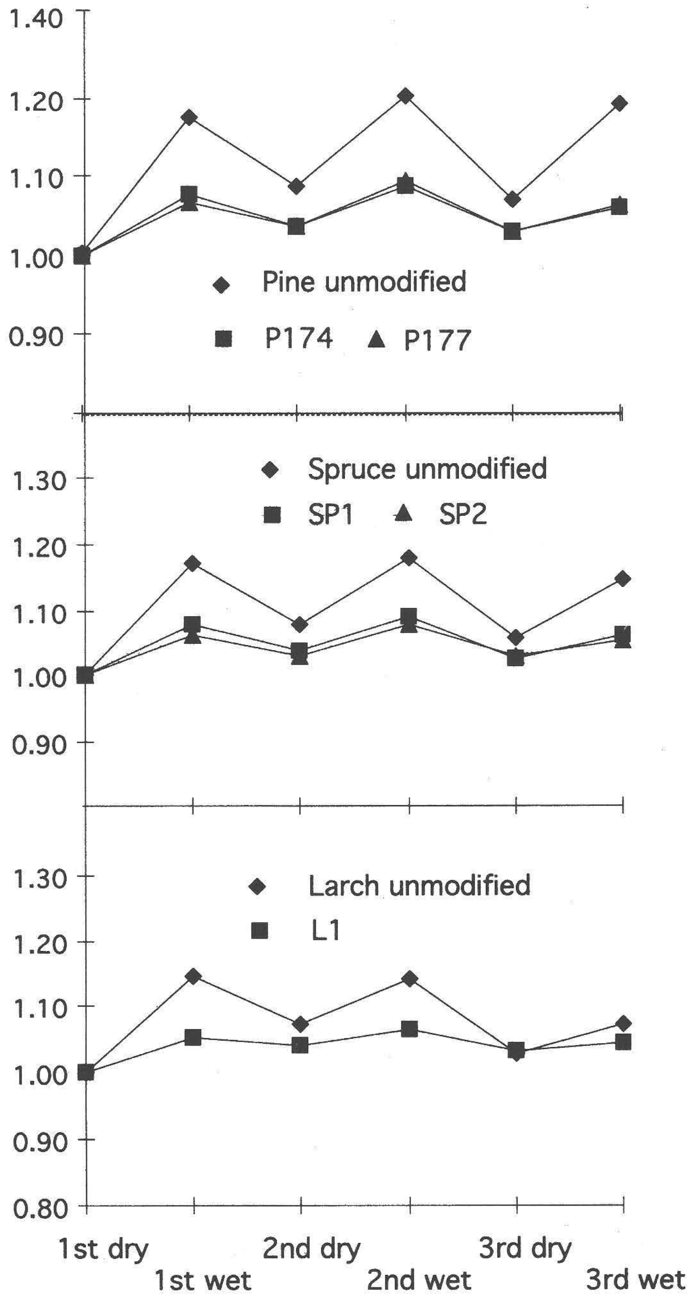

Figure 2. *Swelling stability results. The vertical ordinate shows the relative volume change.*

Conclusions

Mechanical and physical test results obtained with the acetylated materials are broadly in line with what was expected from the European experience.

The most surprising result is that increasing the degree of acetylation of the pine from 16 WPG to 19 WPG has relatively little effect on the moisture absorption behaviour. In all cases the scatter in the results was large. The scatter is thought to arise from two factors. First, the relatively coarse nature of the timber arising from the fast growth and wide ring spacing, and secondly there is the probability that the samples tested contained both heartwood and sapwood. This would affect both the response to acetylation and the subsequent response to moisture change in the acetylated materials. Despite these factors it is considered that the overall pattern of results obtained is reliable.

The results from the fungal decay experiments have demonstrated the increased durability expected but the better performance of the spruce than the pine was surprising given that in the untreated condition it was less durable, and that it is regarded as less permeable to reagents.

Overall the results confirm that the acetylation process offers benefit with the materials examined. It is now necessary to proceed with acetylation experiments using specimens of commercial cross-section.

Acknowledgments

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Jim had started sawing. In the safety of the piercing scream, the sweet sudden scent of fresh resin, I asked, "What was yourself and Jim arguing about?

"O that," he shook with laughter. "He took in some contract timber."

"What's that?"

"We don't do it any more except we know the people. A fella might have a few trees he'd want sawed, to save him buying timber, and we used to give him a price. A lot of that stuff came from trees they used to plant round houses, beech mostly, and you'd never know what you'd run into, nails by the no time, handles of buckets, links of chains."

"They could be dangerous," I said.

"They'd go through you like fucking bullets except they're mostly rotten. They've been hammered in years ago and the wood has grown over them. I saw them ruin more saws than you can name," he was relaxed, holding forth.

"What's this got to do with the argument between Jim and yourself?"

"He took in a few big oaks for this fella that he knows. And I was going to use the big saws."

"Are the oaks all right?"

"Of course they are. But you have to make a stand sometime round here or you'd wind up taking orders. There's no giving of orders as it is."

"I can't see you taking orders," I said.

"You can never be too sure of that," he shook with the laughter of pure pleasure as he wiped his eyes with the enormous scarred hands. "To make sure of that, you have to keep sitting upon the other fella every chance you get."

I hung about until they closed the mill, and after that it gradually grew plain that he was loathe to go into the house in case he'd meet Cyril or even possibly my aunt.

From *The Pornographer* by John McGahern, published by Faber and Faber, 1979. Reprinted by kind permission of the author.

John McGahern was born in Dublin in 1934 and grew up in the Shannonside village of Cootehall, Co Roscommon, where his father was the local Garda sergeant. His first novel, *The Barracks*, was published to great acclaim in 1963. His second novel, *The Dark,* (1965) was banned in the Republic of Ireland by the Censorship of Publications Board, and that, and his marriage to a divorcée, led to his departure from the teaching post he held in Dublin in the archdiocese of John Charles McQuaid.

His books have won many prizes, and McGahern is as famous internationally as he is at home. He now lives and writes in Co Leitrim.

It may be mentioned that the execrable practice of nailing fences to living trees is often to be met with in rural parts of Ireland.

(Selection and note by Wood Kerne)

This contribution from Wood Kerne is, regrettably, his final *Trees, Woods and Literature* column in *Irish Forestry*. Many well known Irish and international writers have appeared over an extended period, their work sometimes used to illustrate a particular aspect of forestry or wood use.

While *Trees, Woods and Literature* will continue to appear the Wood Kerne sobriquet will remain firmly with the author (Ed.).

Forest perspectives

This new section of the journal is devoted to short articles dealing with past events, practices or personalities. Articles on these themes are welcome and should be addressed to the Editor.

The first article in the series is taken from an appendix to *Changing Times – Ireland since 1898* by Edward MacLysaght (see below for biographical sketch).

Some aspects of the Civil Service

I am still a farmer in Clare as well as a civil servant but I find myself more and more attracted by the fascination of forestry. It is the sense of continuity which makes silviculture so satisfying an occupation. I feel as I see trees taking root and thriving, that even if the exigencies of the uncertain world we live in should decree that I should not be followed here by my own descendants, someone at any rate will benefit in the future by what I am doing. A man establishes a pedigree herd or a specialized library and how often does it happen that on his death his life work is dispersed at an auction sale; so too the ruins of the once apparently everlasting landlords' houses of the nineteenth century, to be seen all over the face of the country, are ocular evidence of the futility of imagining that one can leave a mark on the future. But a well-established wood will remain until it is mature; and if the trees planted are hardwoods, with a fair proportion of oaks in their composition, the chances are that it will be there several hundred years hence. I do not seem to mind the fact that the name of the planter of a wood is seldom if ever preserved, so well expressed in the Irish proverb, '*maireann an tor ar an gelaidhe ach ní mhaireann an lámh do chuir*', for there is a definite satisfaction in saying to oneself, 'here is something which will last'.

Following the establishment of a Department of Agriculture as a prelude to Home Rule a Forestry Division was added. A. C. Forbes, an Englishman, was the first Forestry Director. He was followed by one Crozier, a typical Scot of pawky humour and very inelastic ideas on forestry. When his term of office expired, the British regime, under which one expected men of his type to be appointed, was a thing of the past and under the new system his successor had to be chosen by a selection board. In this case the board consisted of an official of the Department of Finance as chairman -it was J. J. MacElligott -my friend, Michael Deegan, the secretary of the Department of Lands (of which Forestry is a branch), another official whose name and personality I forget, and two laymen -Robert Barton and myself. The applications for the job were numerous, some 65 if I recollect aright. Each of us was furnished with a complete copy of the credentials of all of these, perusal of which made it obvious that 40 or 50 of them were quite unsuitable while the other 20 or so had qualifications worthy of careful consideration. The first meeting of the selection board was called for 3 p.m. on a day when there happened to be a Davis Cup match taking place at the Fitzwilliam Club. We have only limited opportunities of seeing first class tennis in Dublin and I bought a ticket thinking that, as I expected play to continue till nearly 6 p.m., I would be able to watch it for an hour or two: I argued that all we had to do that first day was to pick out the more likely candidates and arrange for the more lengthy work of interviewing them on a subsequent occasion. How wrong I was! At 6 p.m. we were still ploughing conscientiously through the list, obvious duds being scrupulously considered, whose claims I personally having read their applications would have dismissed in thirty seconds. Eventually at any rate a preliminary selection was decided on. The dozen or so chosen for further consideration included several from various continental countries -in one case we paid the fare of a Norwegian to come to Dublin by air for interview.

The man who impressed me most favourably was the only Irishman on the list: a genuine Irishman at that with an O name, hailing from Co. Limerick. In voting for him, I was in a minority of one. I may have been wrong because so far from blowing his own trumpet, he was of the self-depreciating type and may have been lacking in the drive necessary in a director whose main function was to be the reorganization and vitalizing of a service which up to then had been somewhat stagnant; but with the arguments used by the other selectors against him, I still do not agree. Most of this man's forestry career had been in India: consequently, they argued, he could know nothing of Irish forestry requirements. My answer was that he was therefore in no danger of starting with preconceived ideas -he would hardly be likely to advocate the growing of mahogany or teak in Ireland -whereas a man with experience in a country not altogether unlike Ireland might tend to favour practices unsuitable to our usually damp summers and mild winters. Moreover, I urged, Mr O'F. knows the Irish people, as well as the Irish climate, and this appears to me to be a prime essential in a Director of Forestry, since so much of the success of an ambitious afforestation programme depends on the acquisition of land from landowners who are far from forestry-minded and on creating enthusiasm in a staff hitherto accustomed to indifference almost amounting to defeatism. As I say, I was in a minority of one so there was no more to be said. I then concentrated on pushing my second choice, one Reinhardt, a German. Barton agreed with me in this; the others were undecided. As usually happens in a committee, when two or three members have decided views and the rest have not, the former carry the day. The result was that Reinhardt was appointed. He was, in fact, only a moderate success and when the War broke out in 1939, he returned to Germany and the senior permanent official, a dour Scot called Dr Anderson, was automatically promoted to the directorship. After a while he resigned, only to be succeeded by another official, again a Scot but not a dour one, an able after-dinner speaker who potters along awaiting his approaching civil service pension. I have hopes that the next director will be the young and energetic Irishman who now occupies the position of chief inspector.

Taken from Appendix B, *Changing Times – Ireland since 1898* by Edward MacLysaght. Published by Colin Symthe, Gerrards Cross, London. Reprinted here by kind permission of the MacLysaght family.

Edward MacLysaght (1887–1986) was born in Somerset and educated in England. He came to Ireland in 1908 when his father bought a farm of 600 acres (240 ha) near Tuamgraney, Co Clare, half of which was leased to the Forest Service starting in 1926. He joined the Gaelic League, learned Irish and was nominated to an Industrial Resources Commission set up by the 1918 Dáil. He was elected a member of the first Free State Senate.

In 1939 he published *Irish Life in the Seventeenth Century* (revised and enlarged in 1950), an account of everyday social life at that period. He became an Inspector for the Irish Manuscripts Commission and joined the staff of the National Library in 1943. Later he became Chief Herald at the Irish Genealogical Office and in 1949 Keeper of Manuscripts at the National Library. The culmination of his life's work came with the publication from 1957 onwards of a series of books on Irish families and Irish surnames.

In his memoirs he records a visit in 1914 by "A.C. Forbes the head of state forestry, an Englishman, who is, by the way, devilish uninteresting outside the subject of trees."

Edward MacLysaght appears in the lists of members of the Society of Irish Foresters published in *Irish Forestry*, Vol. 6, 1949, Vol. 12(1), 1955 and Vol. 30(2), 1973.

It has not so far been possible to identify the writer's favoured candidate, the 'genuine Irishman...with an O name hailing from Co. Limerick'. If any reader can help in this regard the Editor would be pleased to learn details.

Selection and note submitted by Niall OCarroll.

Book reviews

Sitka spruce in Ireland. Padraic M Joyce and Niall OCarroll. COFORD, 201 pp. Price €30.

The successful partial restoration of Ireland's forest cover in the 20th century can be attributed for the most part to the performance of Sitka spruce. First discovered by Archibald Menzies, a Scottish naturalist, in North America in 1787, the species is now the backbone of the country's forest industry. It is a species the industry can be proud of, including the thousands of forestry employees in rural Ireland whose weekly pay cheques derive directly from its attractive and versatile wood and fibre. Nursery owners, establishment, tending and harvesting employees, in addition to hauliers, sawmill and panel mill employees and a host of other direct and indirect interests all benefit greatly from the presence of the species.

Following the success of the earliest plantings in Ireland in the first half of the 19th century Sitka spruce gradually grew in popularity gaining a firm presence, based on performance, in the 20th century. By the year 2000 it represented 65% of the public forest area and almost 60% of all new plantings in the country.

The authors document the story behind the successful performance of the species over the years and the many lessons and mistakes that have been incurred along the way. The book is an essential read for those with an interest in plantation forestry covering all aspects from the growing and management of the species through to the processing side. It is a book that should also be read by many of the ill-informed critics outside the industry. However, one has to question if they will given the one hundred and sixty one pages of at times highly technical script (plus an excellent bibliography and glossary). As with many other books on forestry the text is pitched at a forestry audience. The industry needs to get the other stakeholders on board.

The book is well laid out and the various sections fit together smoothly. There are some excellent photographs but one has to wonder why the camera stayed so long at Glendine and did not source out opportunities elsewhere given the many opportunities in this regard. A small irritation is the use of both metric and imperial measure in the earlier sections. Are we not full Europeans yet!

Ten main sections cover the background to the species, provenance and breeding, establishment and nutrition, injurious factors, the environment, growing space, wood properties, quality and uses, growth and yield predictions together with guidelines on investment analysis in forestry. A number of the themes running through the sections such as the one on investment analysis are common to forestry generally and not just Sitka spruce. Interesting snippets of information surface along the way making it an essentially easy read despite the high technical content.

Sitka spruce in Ireland draws heavily on the results from research on the species and reflects the authors direct involvement in a number of the programs in earlier years, notably crop establishment and nutrition and growing space (thinning/respacing and yield prediction). Research on breeding and provenance is also well covered and the book serves as an excellent reference document. One could question the need for so much detail in some of the sections, particularly for instance on the thinning and spacing trials which extend to twenty five pages compared to nine lines on deer damage which is now a widespread problem in the Wicklow area. A section on Sitka spruce and the environment covers a number of topics including carbon sequestration, landscape, amenity and recreation considerations in addition to water, soil, game, diversity and global warming. Although the authors put the record straight in relation to a number of misleading findings on water influences in the literature in recent years a more holistic approach to the species and its environment might have been adopted. Rather than emphasise the positive impact of the species they tend to go on the defensive and in doing so virtually acknowledge that the negatives outweigh the positives. No mention is made of the positive social impacts in areas such as the Slieve Blooms and in Wicklow for instance and instead a somewhat defensive discussion on landscape aesthetics is afforded three full pages. However, the text rightly acknowledges the need for values other than the visual to be considered when dealing with the landscape issue.

Section 9 which deals with managing Sitka spruce for quality wood will be of considerable interest to farmer growers in particular whose small plantations will need to be tended and nurtured in order to ensure they attract buyers in the future given the scale involved. The recommendations for practice on page one hundred and forty two might have been considered at the end of the some of the other sections thereby making the book a practical manual for growing Sitka spruce effectively.

Surprising omissions perhaps are any discussion on the possible use of the species for energy or on the use of continuous forest cover rather than conventional clear felling systems in the future. However, as the authors state in their brief reference to global warming, the book is concerned "primarily with the present and historical past " rather than" to speculate in a realm which is as yet mainly hypothetical".

All in all an excellent publication and a good buy. Read it.

Michael Carey
(Michael Carey is forestry and management consultant)

Native trees and forests of Ireland. David Hickie (with photography Mike O'Toole. Gill and Macmillan, 141 pp. Price €30.

This is a book principally for the reader who seeks a very broad view of the native trees and forests of Ireland. It represents a new style in popular (as contrasted with technical) forestry publications in that it is lavishly illustrated with beautifully reproduced photographs by Mike O'Toole and with illustrations by Austin Carey. There are approximately 81 full-page photographs and 60 pages of text.

The book is presented in seven chapters with a foreword by Michael Viney and an appendix which gives some details of the Millennium Woodlands. It is intended as a celebration of the People's Millennium Forests Project and relies heavily upon a mixture of folklore, myth, spirituality and history. Most of the mythology and history is contained in the first three chapters which consist largely of a skeletal distillation of previously published material concerning the landscape and woods of Ireland by such authors as Frank Mitchell and Eileen McCracken. Chapter 2 includes a very brief account of the remnants of native woods in such places as Wicklow, Killarney, Charleville Estate and Macroom.

Chapter 4 deals with individual native trees and presents some useful (though not new) information about the trees and the woods they produce. However, the technical content is sketchy and is diluted by interpretation of tree and place names. Some very surprising omissions in this section include whitethorn and spindle tree although details on crab apple and strawberry tree are included. The purpose of the photographs and sketches of the individual species is not explained but they will be of little value to the amateur for identification purposes. Some of the detail is also difficult to accept, e.g. on page 60 the reader is informed that "Oak grows slowly as a seedling but at a faster pace as it matures, which is up to 200 years". It is widely acknowledged that oaks have rapid height growth in the early years and that current annual height increment can culminate between 10 and 40 years depending on site quality. The scientific proof for birch as a soil improver is also tenuous.

The chapter entitled *Using Native Wood* provides little detailed information about using native wood *per se* but includes sections on the Sustainable Use of Woodlands and the Certification of Wood Products. It features native wood products such as Hand Made Kitchens, the Dunbrody Replica Emigrant Ship and Sculpture in Bog Oak.

The final sections cover a wide variety of topics including the Conservation of Irish Native Woods and the Native Woodland Scheme. Many of the individuals and organisations active in the protection and promotion of native trees and forests are acknowledged in this chapter as are the actions which they have taken in saving a number of native woods from destruction.

Native Trees and Forests of Ireland is a handsome book. There is no indication in the book as to the intended audience but amateur ecologists and nature lovers will find it an excellent read and it will broaden their knowledge. The photographs and illustrations are superb, there are few typographical errors and the entire book is well presented. While my academic colleagues and I could quibble over many of the points that I have highlighted in this review, I would be pleased to buy this book as a present to my suburban neighbours or members of my family. For the specialist, this book has some interest, but its tendentious style (plantations are bad) makes it one that is unlikely to find a lasting place on the bookshelves of many members of the Society of Irish Foresters.

John J. Gardiner
(John J. Gardiner is Professor of Forestry at University College Dublin)

59th Annual Study Tour
South Africa
May 18-31 2002

Introduction

Forty-four members of the Society departed Dublin Airport at 2 o'clock on the afternoon of Saturday 18 May, and flew to Johannesburg via Amsterdam. We arrived at Johannesburg at 8 o'clock on Sunday morning, where we were met by our tour guide Georg von dem Bussche, a native of Germany and professional forester, who had emigrated to South Africa 34 years ago. Georg proved to be a perfect host and guide for the duration of the tour.

On the journey to our first stop at Pretoria, Georg provided the group with a snapshot of South African life, politics and forestry. Indigenous forests cover only 0.3% or 300,000 ha of the land surface. Savannah woodlands extend to some 12 million ha. Commercial plantations comprise 800,000 ha of pine, 600,000 ha of eucalypts and 100,000 ha of wattle. Around 30% of the plantations are publicly owned, mainly by South African Forestry Company Ltd (SAFCOL). The company utilises plantation forests only. It was in the process of being privatised. In the private sector two companies Mondi (the Anglo American Forestry Company) and Sappi, own half the forests. Private companies and individuals own the remainder.

John Mc Loughlin, Convenor

Sunday 19 May

The group's first stop was at Union Building in Pretoria, a red sandstone masterpiece designed by the famous English architect Sir Herbert Baker. Pretoria has been the seat of successive governments since the Union of South Africa and remains the administrative capital of South Africa. The city, once the capital of the old Boer Republic of Transvaal, contains constant reminders of its Afrikaner past - from its architecture to the massive Voortrekker Monument that dominates the hill in the south west of the city. It is also a reminder of how far South Africa has come politically. It has remained the administrative capital. President Mandela was sworn in here, as was the current president Thabo Mbeki.

One of the distinctive features of Pretoria is the jacaranda tree (*Jacaranda mimosaefolia*) which lines streets throughout the city.

After our stop at the Union Building, the group travelled north past fields of maize in Gauteng Province. The area is known as highveld, with an altitude of 1600 m. We travelled through tree savannahs where the trees are mainly indigenous. Slowly we descended to the lowveld, to Magoebaskloof at the escarpment of the Northern Limpopo Province, where the treescape changed to a mixture of indigenous forests and pine and eucalypt plantations. We stayed the night in the Magoebaskloof Hotel, near Tzaneen, Northern Province.

Monday 20 May

The group had an early start, departing from the hotel past mango, orange and tea plantations, avocado farms and the occasional roadside spectacularly flowering African flame tree (*Spathodea campanulata*). We arrived at our first stop, the Duiwelskloof Nursery where we were met by the Louis van Zyl, nursery manager and Sonia du Buisson, genetics manager. The nursery is part of the Northern Timbers enterprise which includes forests and sawmills. The company was founded by Dr Hans Merensky who made a fortune in diamond and platinum mining. He used much of his fortune to establish education funds and grants to forestry.

Sonia du Buisson explained the Northern Timber approach to tree improvement where genetic selections are influenced heavily by wood quality as well as growth and yield. Their approach in breeding pines and eucalypts is to increase important strength characteristics such as density and reduce spirality and splitting.

The clonal banks and vegetative propagation nursery was established in 1986 with mainly *Eucalyptus grandis*. There were later selections for tree improvement programmes in *E. saligna,* followed by hybrid breeding, such as *E. grandis x camaldulensis*.

There was a strong emphasis on clonal material but in the forest clones are mixed with seedlings. Northern Timbers does not plant more than 15 ha of clonal material in any one block. While seedling material provided much faster growth in afforestation sites in the first 4 years, clonal material usually passed them out at that stage and provided much better yields. Sonia gave demonstrations of rooted cuttings of Eucalyptus and explained the scheduling of plant production from greenhouse to nursery to forest.

The Hans Merensky Holdings forest was at altitude from 800 m, where the average annual rainfall was 1200 mm. This has been as low as 412 mm and as high as 2779 mm. Northern Timbers has 14,000 ha of forest – over 80% plantation (the remainder is indigenous forest). *Pinus patula* sawlog timber is produced on a 25-year rotation, mining timber on 8-year rotations. The density at planting is 816 stems/ha (3.5 x 3.5 m spacing) for sawlog production, while mining timber production is spaced at 2.0 x 3.0 m.

The group visited a site that had been clearfelled in December 2001. All the lop and top was burned: research has shown that a cool burn does not have a deleterious effect on the soil. Reforestation is carried out manually. A good size pit is dug and water is often added, and wood chip mulch to retain moisture and keep the soil cool as the heat from the soil can scorch stem of the seedling. Chemical and mechanical weeding are carried out until the crop is established. A stand of *Pinus patula* eighteen months old had a mean height of three metres. It had already received a weeding and pruning. Pruning is carried thereafter every 2-3 years up to 50% of live crown is pruned. Containerised plants are used and planting is carried out throughout the year. Establishment costs amount to R1800 (€190) per hectare.

Some of the group visited Magoebaskloof Sawmill where the guide was Marius Koch, Production Manager. The mill operates on one shift and produces about 80,000 m^3 of *Eucalyptus* and pine annually. It employs 120 people which, compared to an Irish mill, is highly labour intensive. Recovery was around 50%. The main products were mining timber and planked timber for construction, flooring and veneer. The sawn timber was exported or sent to furniture factories. This was air dried to 20% moisture content and then dried down in compartment kilns to 12%, over a period of 20 days. The timber quality was excellent and knot-free (due to pruning). While some of the timber is finished and manufactured in South Africa, most is exported to China and Malaysia through Durban. Surprisingly, we were shown trial exports of mining timber for the UK market.

Lunch was at a giant baobab or Kremetart tree (*Adansonia digidata*). It grows in very dry areas with rainfall as low as 250 mm/annum. The tree grows for about 300 years, after which the interior starts to rot. This causes heat to build up inside the trunk and it eventually combusts spontaneously. Within hours nothing is left except ashes, a dramatic end to a tree that can have a diameter in excess of 10 m and heights of 25 m. The lunch location tree was about to self-combust some years previously; locals however put the fire out and scooped out the burning interior. The shell had been converted into a very novel pub location.

In the afternoon the location was the Sapekoe Tea Plantation where the owner provided a colourful description of tea growing and harvesting and how to make a good cup of tea. He spoke with scorn of the use of teabags and the indefensible habit of using milk with tea.

After the tea sampling, the group visited the Commonwealth Plantation, established in 1914, which comprised a number of *Eucalyptus* species, in particular *E. microcorys, maculata and paniculata*. In 1964 the Merensky Trust decided that the plot would be preserved and dedicated to the 1935 Commonwealth Forestry Conference. The tallest tree in the plot when it was measured in 1997 was *E. microcorys*, at a height of 68 m. All the eucalypts were impressive, most with heights in excess of 55 m with breast height diameters up to 87 cm (*E. microcorys, maculata*). The group returned to the Magoebaskloof Hotel for the overnight stop.

Donal Magner

Tuesday 21 May

We departed from Magoebaskloof hotel at 8.00 a.m. We took a drive to the Big Forest nature reserve, an area of indigenous forest that once formed part of the large Afro Montane forest. It stretches from the low veld to the high veld and has an annual rainfall of 2000 mm. Settlers began felling timber in 1870 and by 1895 the area had been heavily exploited. The recovery of the woodland began in 1913 when a Conservator for Forests in the Union of South Africa was appointed.

The kloof (valley) was named after Magoeba, a chief of the Ba Tlou people. These peoples were unique in South Africa as they were the only known forest dwellers. Some of the better known indigenous species in the forest were red stinkwood (*Prunus africana*), yellowwood (*Podocarpus falcatus*) and African mahogany (*Khaya nyassica*).

We passed through plantations of *Pinus patula*, the most common pine species, *Pinus taeda* and *Eucalyptus grandis* before reaching plantations owned by SAFCOL, the state-owned South African Forest Company. This plantation contained trial plots of *Eucalyptus saligna* and *Pinus patula*. *Eucalyptus saligna* was introduced here by James O'Connor. The *Eucalyptus saligna* plantation contains what are thought to be the tallest planted trees in the world and the plots are protected. Our first stop was at a memorial erected in his honour.

James O'Connor (1884–1957) was an eminent forester of Irish extraction, who was educated in Scotland. He is remembered for his outstanding work on correlated curve trends derived from the relationship between height and stem diameter, as influenced by thinning intensity and spacing. He was the first to introduce *Eucalyptus sciatica* into this region. Towards the end of his career he turned his attention to the conservation of indigenous species.

Of the introduced pines, *Pinus patula* has been the most successful; *Pinus taeda* is not preferred due to the high content of reaction wood. An interesting fact was the emphasis placed on density in timber grading. Japanese cedar was also planted but was confined mainly to riparian zones.

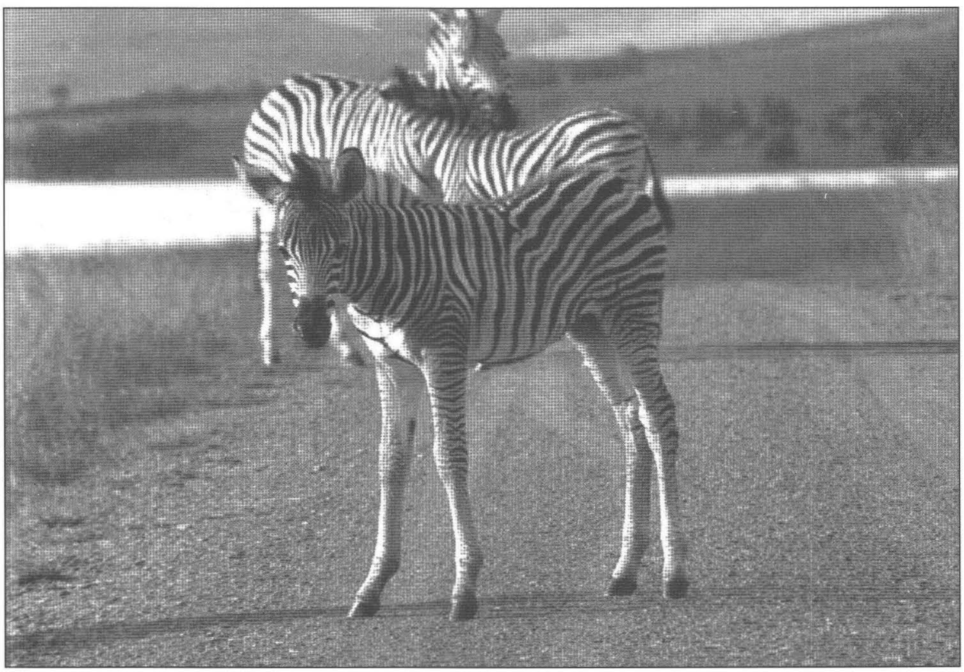
At the second stop of the day we were met by the local forester John Magoebas who showed us a trial plot of Outeniqua yellowwood (*Podocarpus falcatus*). This is the only indigenous species with commercial potential. It is capable of growing to heights of over 40 m with an annual increment of 6-8 m^3/annum. The trial plot was 20 years old, planted at 3 x 3 m, and had a high percentage of good quality trees. The proposed rotation is 40 years at which time the average DBH will be 40 cm. The timber is high quality, selling at up to 2000 rand/m^3 (€220).

The next plot was African mahogany (*Khaya nyassica*). The species is under threat in South Africa and is not planted as a commercial crop. The trial plot was 20 years old, planted at 4 x 4 m. The final crop will have 200 trees/ha. Although the timber is very valuable and can be grown on a 40-year rotation the form was poor – the trees had suffered shoot borer damage. However, as indigenous species only cover 0.3% of the land surface in RSA, the species will continue to be planted for environmental reasons.

We moved on to the final stage of our journey to the Kruger National Park, stopping on the way to look at banana plantations and specimens of the magnificent East African flame tree. This is a very low rainfall area and all crops except mango need irrigation. The Marula trees are grown here commercially for their fruit. We passed through the lowveld area to the savannah bush veldt of the Kruger Park. Mopani is the main tree species in this area, is scrub-like but an important source of food for elephants.

We entered the Kruger Park at Phalabowa and travelled to our destination at Letaba getting our first glimpse of zebra, impala, warthogs, waterbucks and hippopotami. We arrived at Letaba in the late afternoon and had a relaxing evening strolling through the wooded camp-site as we viewed the animals coming to drink in the Letaba river at sunset.

Michael Doyle



South African zebra crossing.

Wednesday 22 May

Having spent the night at Letaba rest-camp located within the central section of the Kruger National Park the party had an early start the following morning. At 5.30 figures were moving purposely among the trees and buildings in the direction of the commotion at the gates.

There was a great atmosphere of anticipation as participants were being directed to jeeps by torch-light. Rugs and blankets were piled on the passenger-seat of the jeep and a rifle was placed along the dashboard. The convoy of four jeeps left the camp swiftly and the gates were slammed closed as the last vehicle went through.

As we drove along the road the reason for the presence of the rugs and blankets became apparent as the cold air engulfed the open jeeps and everyone wrapped a portion of a rug or blanket around them to preserve body heat.

The jeeps abruptly came to a halt and the guide drew our attention to a group of impala which was resting under trees. Their under parts, rump and chin are white which made them noticeable when the guide's search light shone through the trees and undergrowth. Impala are gregarious animals and known for their speed and ability to leap.

A herd of zebra was spotted by a member of the party as it grazed on the grass and browsed on the scrub. They need water daily and rarely wander very far from water sources.

Further along the road an elephant was noticed standing among large scrub. A fully-grown bull can weigh more than six and a half tonnes. Elephants like many other animals of the wild are gregarious and usually live and roam in herds of 10 to 20. Herds are on the move night and day in pursuit of water and fodder. The elephant has special importance for hunting; the Big Five are: elephant, rhino, lion, leopard and buffalo.

As the guide and the party were on alert for additional elephants a pair of giraffes were spotted with heads over the surrounding undergrowth browsing on the acacia trees. Giraffes are out and about in the early morning, they are very vulnerable when drinking water but they are capable of landing a powerful kick which can have fatal consequences for a would-be predator.

The sunrise was spectacular and sudden. The first sighting of the new dawn was a herd of buffalo which was grazing some distance from the road. They never stray far from water especially in dry periods.

What turned out to be the final sighting of the morning were several hippos submerged in the water. Hippos spend most of the day submerged, feeding on bottom vegetation. Only at night do they emerge from the water often wandering long distances from their aquatic haunts to graze.

After the eventful morning and a breakfast cooked in the open, the party adjourned to stroll through the park and study its present day importance and history.

Small groups of African people inhabited the flat plains, but malaria, bilharzias, tsetse flies, and murderous heat kept the wider world at bay. European settlement came late to the region. In 1725 the Dutch East India Company, attracted by rumours of gold, sent an expedition from Baia de Lourenco Marques (modern Maputo) to explore the northern interior. This was the first European expedition to have entered the lowveld. It got as far as Gomondwane, near present-day Crocodile Bridge, before hostile local Africans forced it back. In 1836 two separate Voortrekker parties set out to find a way which would lead from the interior to the east coast. Both expeditions were disastrous: one was slaughtered by Shangaan warriors and the other was almost wiped out by malaria, although a few survivors managed to make it to Delagoa Bay.

The arrival of these survivors alerted a Joao Albasini to the potential for lucrative business between the hinterland and the coast. In the late 1830s he opened a trading post near the present-day Pretoriuskop rest camp, and became the first European resident of the lowveld.

In 1870, gold was discovered in the uplands. Thousands of fortune seekers arrived in the region. As there were no towns, shops or farms, the speculators hunted for their food, and depredation of animals in the area became wholesale.

Eventually, visiting Boer hunters, who shot only what they needed, observed the excessive killing and reported it to the Transvaal Republican authorities in Pretoria. In 1889, as the eastern gold rush fizzled out, President Paul Kruger urged his parliament to create a sanctuary to protect the remaining wildlife of the Lowveld. Eventually, in 1898, some 4600 square kilometres between the Sabie and Crocodile rivers were proclaimed the Sabie Game Reserve.

This was the birth of the Kruger National Park, a project which the British endorsed when they took over the region. In 1902 a Scotsman, James Stevenson-Hamilton was appointed as the first warden of the reserve. During the next 40 years he did more than any other individual to nurture this natural heritage.

In 1903 a second reserve was proclaimed which encompassed land further north between the Letaba and the Limpopo rivers. In 1926 both reserves, and the farmland between them, were consolidated by the South African Parliament into the Kruger National Park. Later still, more land was added and the reserve reached its present size of about 21,000 square kilometres.

Today, the park offers the opportunity to observe, in an area the size of Wales, an unequalled variety of wildlife at close proximity.

In the afternoon the party was taken on a walk through the park to observe and identify the trees growing there. The apple-leaf tree *Lonchocarpus capassa* was described as a tree found on all soil types in the park, the biggest specimens are confined to flood plains elsewhere, but the tree is usually found small. The leaves fall in spring and within a very short period are eaten by elephants. The tree is considered a slow grower.

The Cape ash *Ekebergia capensis* has a very wide-spreading, dense crown and pendent branch terminals. This tree is found within the park but is rare as it prefers moist conditions. The leaves and roots have medicinal properties and are used for this purpose.

The Weeping Boer-bean *Schotia brachypetala* is a deciduous tree, with a round umbrella-shaped crown and drooping branch-ends. It grows on the river banks of the rivers within the park. Nectar, which drips to the ground when a branch is shaken, is eaten by baboons, monkeys, birds and insects. The wood is used for the manufacture of furniture, as it grows slowly.

The Lala palm *Hyphaene natalensis* is a medium sized tree (15 m) and is common in the park. It grows mainly on the basaltic soils along its eastern side. The large fruits are found in pendant clusters (6 cm diameter). The fibres from the leaves are used for the manufacture of mats, hats and ropes.

A common tree throughout the park and the rest centre is the umbrella thorn tree *Acacia heteracantha*. It provides most of the shade around the accommodation units at the rest camp. It has a twisted fruit which is found on the ground at all times of the year.

George von dem Bussche and the local guide who was an authority on trees, concluded the activities for the day that had begun in the cold darkness and ended in bright, warm sunshine.

Frank Nugent

Thursday 23 May

Another early morning safari at 5.30 provided the chance to see more wild game before the tour's long drive south through the Kruger National Park to our next destination Sabie. The highlight of the drive was the sighting of a pride of lions eating a zebra that they had just killed. As the bus progressed southwards large expanses of Mopani bush provided a dramatic backdrop to giraffe and other species. The tour stopped briefly at Sabie Camp for lunch. The camp had an interesting museum explaining the social and natural history of this part of the Kruger Park. On leaving the camp the woody savannah gradually gave way to farmland and extensive pine plantations, as we gradually climbed to 300 m above sea level to a wetter climate.

On arrival at our hotel in Sabie two speakers from SAFCOL, Nic Truter (Regional Manager for the Komatiland Forests in Mpumalanga North Region) and Gerrit Marais gave a presentation on the operations of the company. The salient features of the company in the area were:

Total managed area	113,000 ha
Planted area	61,000 ha
Annual harvest	1,000,000 m^3

Of the harvest approximately 59% enters the sawn timber market. The main species are pine and eucalypt. Pine pulpwood accounts for another 11%, while other uses, including veneer, poles, mining timber and small wood make up the reminder.

The species breakdown by area was as follows:

Species	*Area ha*
Pinus patula	23,145
Pinus elliottii	17,338
Pinus taeda	7,199
Pinus elliottii x caribaea	4,222
Other pines	1,609
Eucalyptus grandis/saligna	4,555
Eucalyptus cloeziana	714
Other eucalypt species and hybrids	891
Other species	1,347
Total	**61,000**

The main field activities include an extensive pruning programme of 18,458 ha. Up to seven prunings can take place during a rotation, depending on site productivity. Pruning is important to improve timber quality in fast growing species like pine. Detailed pruning schedules have been established and pruning records are strictly maintained.

The region employs in excess of 900 staff with approximately 1200 contract labour. The main regional focus over the last 8 years has been primarily:

- elimination of unproductive growing stock such as *Pinus taeda,*
- upgrading of nursery and nursery practices,
- establishment of fertiliser programmes,
- refined growing polices and formulation of Best Operating Practices (BOP),
- silvicultural audits,
- genetic improvement,
- development of pole working circles.

Computerisation and the use of Geographic Information Systems ensure that SAFCOL can plan its operations to help maximize revenues and volume production. A fully integrated budgeting system produces detailed monthly financial reports which enable foresters to manage the estate effectively. All forest operations are carried out in conjunction with SAFCOL environmental policy and the standards set out by the Forest Stewardship Council (FSC).

Gerrit Marais, Environmental Manager for the Komatiland Forests North Region, made a presentation on Environmental Policy in plantation forestry and FSC certification.

SAFCOL environmental policy is far reaching and gives guidance on a wide range of areas. An Environmental Management System, based on ISO 14001, is used to measure performance standards, which in turn meet the principles of the Forestry Stewardship Council. Management of Environmental Impacts on soil, water and biodiversity are important in SAFCOL. Forest Certification by FSC was awarded to SAFCOL, Mpumalanga region, in 1996. Certified forests are visited every 6 months to ensure they continue to comply with the principles and criteria of FSC.

SAFCOL have devised an Environmental Policy and continually strives to improve performance in accordance with a number of goals in the following key areas:

- performance standards,
- management of environmental impacts,
- social environment,
- conservation,
- land use,
- R&D,
- training and education,
- contractors, suppliers and customers,
- environmental audits and reports.

SAFCOL conducts environmental audits on all forest operations on a biennial cycle and publishes an annual report on environmental performance. Prior to starting any afforestation environmental impacts are assessed and consultation takes place with relevant bodies. SAFCOL also supports R&D to minimize environmental impacts and to optimise the use of resources on a sustainable basis. The services provided by contractors must comply with environmental standards and include environmental considerations in procurement decisions. The management of biodiversity in natural ecosystems and the protection of rare and endangered species, communities, habitats and archaeological or cultural artefacts is an important aspect of an environmental policy.

The introduction of FSC and the implementation of an Environmental Policy have resulted in a change of mindset in the operation of the forest business. Over 85% of South African forests are now certified by FSC, which has enabled markets to be secured and maintained abroad. FSC certification is expensive but is necessary if South Africa wants to maintain its market share. Concern is sometimes expressed about the lack of clear instruction and direction given on some aspects of the certification process by certifiers. In general the FSC process has been good for South African forestry and has helped SAFCOL to manage its forests to acceptable environmental standards.

It was concluded from the question and answer session that followed, that there was a need for countries involved in the FCS process to come together and to collectively discuss their experiences. Countries working together and with the FSC would ensure that the FSC branding reflected the aspirations of communities, growers and timber producers.

Fergus Moore

Friday 24 May

As we boarded our coach outside the Floreat Hotel we were joined by Nic Truter the SAFCOL regional manager.

On the outskirts of Sabie we passed a sawmill which processed timber from the SAFCOL owned Tweefontein plantation, this is an extensive area of some 12,700 ha of mainly *Pinus patula* plantations.

The first stop was at Tweefontein Nursery where we were introduced to Nico Olivier, the nursery manager. The necessity for hygiene in all operations was emphasised as disease or fungus can have catastrophic effects on the viability of the whole enterprise and on the profitability of plantations in the region. There was an outbreak of the *Fusarium* fungus as recently as 1998. The consequences of this had brought about a determination by staff that there will not be a reoccurrence. As well as the routine practice of hygienic practices, there is an annual hygiene-day.

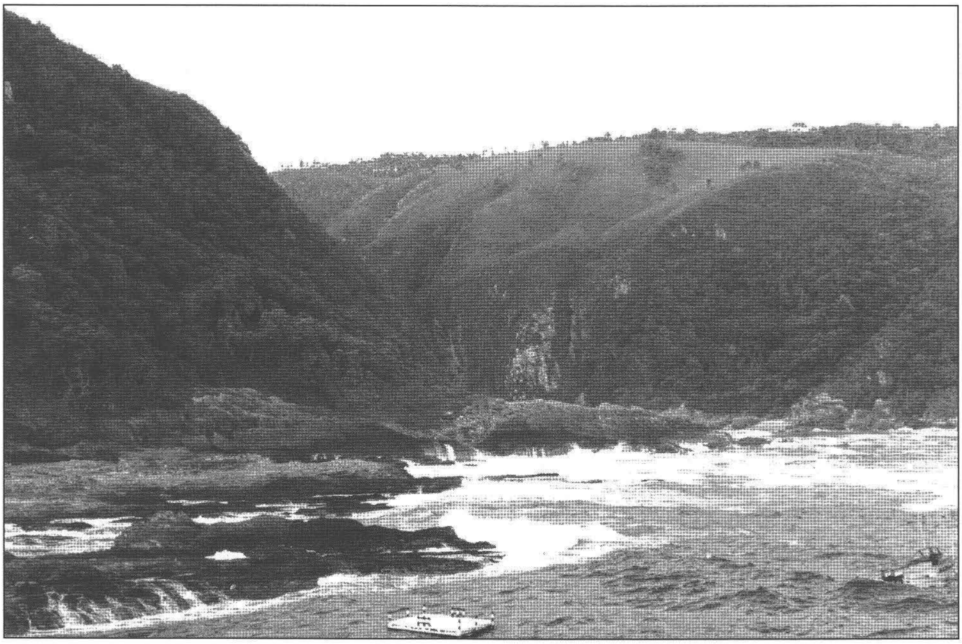
The species grown in the nursery were *Pinus patula* and *P. elliottii* and a hybrid of the two that exhibits phenomenal growth rates. The *P. patula* is grown from seed and the hybrid from cuttings. The growing medium is a mixture of composted bark with a pH of 5.5. The fertiliser programme was discussed at some length and the use of the correct amount of nitrogen was stressed. The use of too much nitrogen can promote the growth of *Fusarium.*

The nursery produces eight to nine million plants per annum and has a full time staff of twenty-one. Manual labour is used quite extensively as the labour is available and is currently cheaper than mechanisation.

Departing the nursery we headed for the surrounding countryside to see the terrain which would be forested by the plants from the nursery. As the surface deposits of gold ran out and the shafts and tunnels cut into the hillsides in search of deeper veins mining became uneconomic and the landowners in the area diversified into forestry and created some of the country's largest plantations. *Eucalyptus* and *Pinus patula* now cover much of the regions cool uplands.

We stopped at a 2-year old *Pinus patula* plantation which had been preceded by a *Pinus elliottii* crop. The new crop was fertilised using a slow release fertiliser, applied manually from containers made for the purpose. These crops are grown to a DBH of 42 cm, which is achieved after 25-30 years. Crops are high pruned to a height of 9.5 m. No pruning takes place after the crop reaches an age of eleven years.

The next stop was at a 13-year-old *Pinus patula* plantation. It was planted at 2.7 x 2.7 m spacing, resulting in a stocking of 1372 plants/ha. Crops may be thinned on seven occasions between establishment and maturity. The crop had 649 stems/ha and would receive



Tsitsikamma

two further thinnings, reducing it to a final stocking of 280/ha. The final standing volume being planned for is 575 m^3/ha, at about 25 years of age. The monetary value of the crop was in the region of 70,000 rand/ha (about €7800/ha). Pruning is cost effective as pruned material attracts a premium price at harvesting.

The final stop was at an area recently replanted with *Pinus taeda*, canopy closure will be at three years and until then contractors are responsible for vegetation control. There was a history of baboon damage in this area; the problem is alleviated by trapping or shooting. There was a discussion on forest certification and the standards expected by the FSC auditors. SAFCOL is obliged to leave areas extending to 20% of their reforestation programme for biodiversity purposes.

The Chairman for the day thanked Nic Truter of SAFCOL for his time and expertise. The remainder of the day was spent at MacMac Falls, the Pilgrims Rest and God's Window, noted scenic and historical sites. We overnighted at the Sanbonani hotel, Hazyview.

Joe Fenton

Saturday 25 May

We departed Hazyview on the long bus journey to Johannesburg to catch an internal flight to Port Elizabeth on the southern coast. We arrived late in the evening as dusk was falling. We left the city, which is situated on the shores of Algoa Bay, to travel along the Garden Route to Tsitsikamma Lodge, Storms River. The Garden Route backed by the Outeniqua, Tsitsikamma and Langkloof mountain ranges extends from Storms River mouth in the east to Mossel Bay in the west.

Sunday 26 May

On Sunday we travelled to Tsitsikamma National Park. This park was designated in 1964 and extends for 68 km from Nature's Valley to Oubosstrand and stretches seawards for some 5.5 km. The total area is 75,000 ha with 60,000 ha under the control of the State Forest Department. The area we visited was Afro-Montane, evergreen, uneven-aged mixed habitat of native tree species. The forest is divided into three main climatic types. The wet forest type is found along the slopes of the mountain range where high rainfall and generally cool climate is experienced. The moist forest type along the upper plateau constitutes the best developed high-forest, with a high percentage of utilizable trees. The dry forest type is found along the coast with generally a composition of thorny and shrub-like tree species. In all there are 120 indigenous tree species in the area.

Multiple use management principles are applied. These include:

- recreation,
- maintenance of biodiversity and
- sustainable utilisation of the natural resources.

The management of recreation facilities is of increasing importance and a further 20% of the forest will be used for recreational purposes. The facilities offered suit the forest environment and include picnic sites, hiking trails, bike trails and scenic spots and drives. Some 20,000 visitors visit the area annually.

Conservation management includes the eradication of invasive plants, the maintenance and protection of species like elephants and blue duikers and the protection of the natural forests from fires and unauthorised use of forestry resources i.e. theft of ferns and poaching.

Sustainable utilisation management is practised on only 20% of the total natural forest area and is based on a senility criteria yield regulation system to ensure that only those trees are removed that would die naturally in the not so distant future. Horses are used to extract timber as machinery is only allowed to travel on slip paths to ensure continued protection of the area. Timber is auctioned twice yearly, to supply local furniture industry. Annual revenue is 10 m rand (€1.11m).

At the first stop a stinkwood species (*Ocotea bullata*) was seen. It is an evergreen, with a dark brown timber similar to mahogany. The timber is very valuable, making up to 10,000 rand/m^3 (€1,100/m^3). It regenerates from coppicing. White alder (*Alnus rhombifolia*) is another endemic species to the area. Again it is a valuable timber, which is used for door frames and other outdoor uses. Leather leaf fern and seven-weeks fern also occur in the forest. Twenty percent of the fern used in the world floristry industry comes from South Africa. About 2 million rand worth of ferns are exported to Europe, mainly Holland, annually.

At the second stop Outeniqua yellowwood (*Podocarpus falcatus*) was found. One tree was 800 years old, had a height of 36.6 m, a trunk length 18.3 m, crown spread of 32.9 m, trunk volume of 50.9 m^3, with a girth of 8.9 m (equivalent to 8 adults linked with arms outstretched). It has an erratic growth pattern, similar to yew. The less vigorous the growth the more the production of lichens – they are an indication of the health status of the tree. The timber makes 2,000 rand/m^3 (€222/m^3). The timber can be kiln dried very easily and is used in the manufacture of furniture.

The more energetic members of the group went on 4-5 km walk on the Rattle Trail through tropical forest at its best – hot and humid!

After a short bus ride we stopped at Storms River Mouth Rest Camp for lunch. After a light lunch, most of the group climbed the steep river mouth trail and descended down to cross the Hangbrug Suspension Bridge.

The next stop was the Paul Sauer Bridge over the Storms river. It is 190 m long, with an arch span of 100 m, and is 123 m above water level. Bungie jumping takes place here – but alas we had no volunteers!

Finally on our journey back to Tsitsikamma Lodge we saw an area destroyed by fire caused by lightening in 1998 in which 3,500 ha of pine was burned in four hours. It has now been replanted with slash pine (*Pinus elliottii*). Back at the Lodge we had time to relax before yet another fantastic culinary experience and end to a most enjoyable day.

Brigit Flynn

Monday 27 May

After leaving our hotel we visited a plantation owned by MTO Forestry (Pty) Ltd. which is a subsidiary of SAFCOL. This plantation was 4,300 ha in size, situated close to the town of Knysna, which is on the Indian Ocean.

SAFCOL commenced business in April 1993, with all shares owned by the central government on behalf of the people of South Africa. SAFCOL directly employs over 2,000 people in its operations and indirectly at least another 3,000 people, through contractors who carry out harvesting, silvicultural and many other activities. Three and a third million cubic metres (under bark) are harvested annually, with a turnover in excess of 500 m rand/annum (€55 m). SAFCOL's forestry division manages 44 plantations and its processing division comprises five 5 sawmills. The company manages in excess of 400,000 ha including 260,000 ha of plantations.

Forest Stewardship Council (FSC) certification of all SAFCOL's operations was achieved in 1995 and has been retained ever since.

SAFCOL is currently in the process of restructuring; being sold off bit-by-bit and the company will ultimately cease to exist. This will however signify the achievement of the original goal in forming the company.

An outline of the Kruisfontein plantation was presented as follows:

Total area forested	4,300 ha
Annual average rainfall	960 mm
Yearly sustainable volume production (under bark)	36,000 m^3
Timber usage	
Saw timber	85%
Poles	10%
Veneer	5%
Species distribution	
Pinus radiata	57%
Pinus pinaster	9%
Pinus elliottii	8%
Acacia mearnsii (wattle)	8%

Eucalyptus diversicolor (karri)	6%
Pinus taeda	2%
Others	10%

Staffing

Area manager[1]	1
Harvesting forester[1]	1
Silvicultural forester[1]	1
Labourers (silviculture + harvesting)	25
Contractors (silviculture + harvesting)	35

[1]Manage and harvest Buffelsnek property also (8,000 ha).

Costs

Labourers (per unit per day)	R136 (€15)
Harvesting (per m^3) cable yarding (30% of area)	R65 (€7)
To roadside (per m^3) skidding	R41 (€4.5)
Restocking (per ha)	R2,200 (€244)
Weeding (per ha)	R750 (€83)
Pruning (to 7 m per ha)	R121 (€13)

Main problem areas

Cost of weeding (*E. diversicolor* and A. *melanoxylon.* infestation)

Poor growth (MAI of $9m^3$/ha/yr)

High labour costs R55 (€6)/day in northern South Africa

Close proximity to town (theft, cattle, fires and off-road bikes)

The present policy objective is the production of high quality saw timber. This will be achieved by having no further regeneration of *Eucalyptus diversicolor* (karri); areas of Kruisfontein will be converted to *Pinus radiata* due to its considerably higher financial returns.

Natural regeneration is not practiced with *Pinus radiata* as better results are achieved by planting with an F2 seed provenance, which originated in New Zealand. All plants are grown from containerised cuttings, which are produced in eight months to an average height of 15 cm at a cost of R350 (€38)/1,000.

When harvesting is completed all slash has to be cut lower than knee height. Planting holes are dug with a mattock-like tool, to a size 25 cm square, 20 cm deep at a spacing of 3.5 x 3.5 m giving 800 trees/ha. A half litre of water containing aquasoil at a mix of 3 g/l of water is added to each planting hole, together with fertilise. Containerised plants are inserted using a special hand operated planting tool with up to 5 cm of the plant collar inserted below ground level.

Reforested sites are kept almost totally free of any competing vegetation with the use of Garlon in particular, but diesel oil is also used to spray coppice shoots, as Garlon is not as effective in killing these.

First thinning is carried out at eight years leaving a stocking of 500 trees/ha. All branches up to 5 m are removed at first thinning to ensure that the knotty core is no more than 15 cm in diameter. A second thinning is undertaken at 13 years, in which a further 200 stems are removed leaving a final crop of 300 trees/ha. A second lift pruning to 7 m is then undertaken.

Pine poles are produced in 20 to 25 years, while large sawlog 40 cm + under bark and veneer wood is produced on a 30-35-year rotation.

Sawlog timber achieves a price of approximately R100 (€11)/m^3 underbark, standing and is cut to 13 cm top diameter.

The provision of fire lines to a width of 20 m is necessary to avoid fire damage because of the dryness of the climate.

No felling permit is necessary for the harvesting of commercial timber but is necessary to fell any timber in the indigenous woodland.

Under FSC rules reforestation is necessary but areas incapable of producing a mean increment greater than 4 m^3/ha/year need not be reforested. These areas must be cleared of all exotic vegetation and handed over to the government who may then allow them to be used for agricultural or other purposes.

Species selection is based on soil analysis and the most productive species for that particular soil type is then planted in pure blocks.

No planting is allowed along riparian zones in an effort to conserve water, which is an extremely scarce resource. A water tax is being imposed on forestry, no new planting (afforestation) is allowed.

We made our may to our overnight destination at Santos Beach Hotel, Mossel Bay.

Ted McCarthy

Tuesday 28 May

After a hearty breakfast we left Mossel Bay, where Bartholomew Diaz landed in 1488, followed by Vasco da Gama in 1497, and headed west to Cape Town, one of the jewels of the Garden Route.

The drive took us on a 400 km route passing the Langeberg mountains, the highest peak reaching over 1500 m, with flat rolling field to the sea and Cape Agulhas where the Indian Ocean meets the Atlantic Ocean. We passed ostrich farms where there had been a thriving ostrich feather industry prior to the World War I, but now the farms have a second life supplying meat and leather, mainly to the North American market. We saw the blue crane, the national bird of South Africa, as we drove west. Large farms were on either side of the road, the main crops being wheat, barley and sheep.

We arrived at Stellenbosch, adjacent to Cape Town, for lunch. Stellenbosch was established on the banks of the Eerste River by Governor van der Stel in 1679. It is the second oldest town in South Africa renowned for it stately oaks (which are preserved national monuments), its Cape Dutch, Victorian and Georgian architecture, stately buildings and the old Afrikaans-language university of Stellenbosch, established in 1918, which now has over 17,000 students.

We had a presentation on education in forestry by John Mortimer, a fifth generation South African forester. After qualifying in forestry John spent seven years in Canada, then came back home to work in the wood processing industry. He rose to be chairperson of the South African Lumber Millers Association and now is the Manager of the Faculty of Forestry at the University. This is a newly created post with responsibility to restructure the Department of Forestry and its courses to the needs of the end market, be they industrial, conservational, silvicultural or other stakeholders.

The university courses covers the full range of activities along the wood value chain:

- silvics and forest management,
- forest engineering,
- community forestry,
- conservation ecology,
- solid wood processing.

They also run a non-research forest masters degree programme where students from any background, be it furniture design, timber frame or game management, are welcome.

John gave us his version of the role of new forester as follows:

In the changing world of the profession and the demands being made on managers of forests, the following definition could well apply: to be able to think strategically about the sustainable forest and its role in society: in the value chain, in its social functions and its ecology. The forester will be equipped to make major decisions and recommendations concerning forests. He/she will be indispensable in this role and will be the first person called upon when such decisions and recommendations are required, be they finely focused at the local level, or be they region, national or global

....it has become clear that there is both a need and an opportunity to explore ways to collaborate together on international forest issues. As it evolves, forestry is redefining itself, and through this redefinition, the very nature of what the term forestry represents is changing. As leaders in forest education we need to communicate the changes we believe are taking place, we need to reach out to those who still hold images of what forestry was and show them all it has become and where we hope in the future to be.

He also quoted Jack Saddler, Dean of Forestry at University of British Columbia, on his view of the role of forestry education.

It is not enough to just educate any longer, we must, through international cooperation and as individual entities, actively share our knowledge and attract the attention of students and the public alike to the range of options available through stewardship of forests and the values they maintain.

The chairperson thanked John for his thought provoking talk on the new approach to forestry education being undertaken in South Africa. There could be lessons learned from the approach being taken in relation to the changing need and demand placed on the Irish forester today and the role of the Irish third level education institutions in supporting him or her.

Overnight accommodation was at the Commodore Hotel in downtown Cape Town where a good evening was had by all at a waterfront restaurant in the Victoria & Albert Wharf area.

Richard Lowe

Wednesday 29 May

We departed Cape Town and headed south for the Cape of Good Hope travelling through the State Nature Reserve.

The Beacon of Hope is situated at the junction of the earth's two most contrasting water masses the Atlantic and the Indian Oceans. Geographically, however, the Indian ocean

Fynbos ueretarion

merges with the Atlantic Ocean at Cape Agulhas

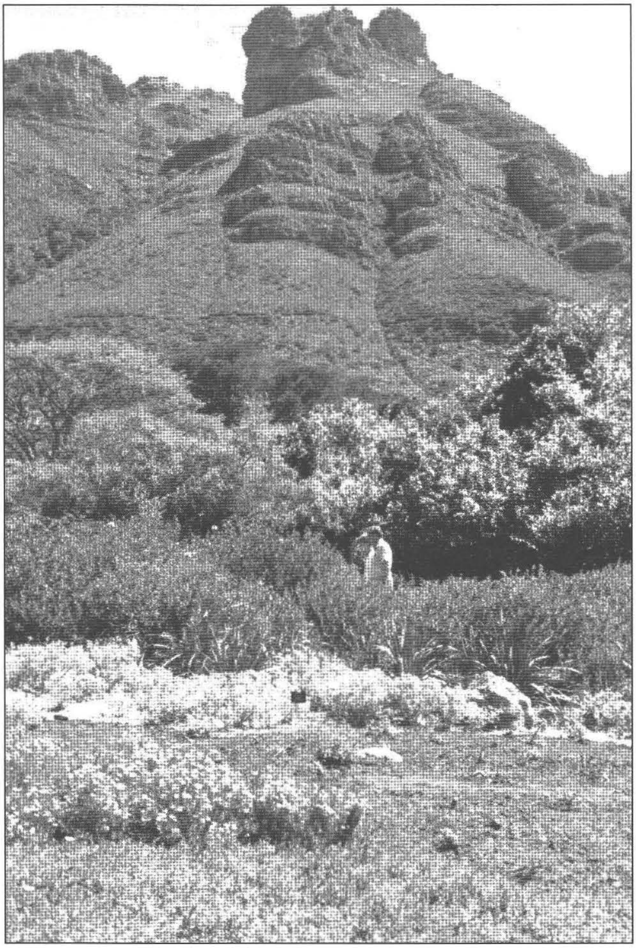
The Cape of Good Hope is home to at least 250 bird species. The flowering vegetation of *Erica* and *Protea* spp. attracts sunbirds, sugarbirds and other species in search of nectar. The cape is an integral part of the Cape Floristic Kingdom, the smallest but richest of the world's six floral kingdoms. This comprises a collection of up to 1,000 plant species, of which a number are endemic. The climate of the south-western and southern cape, with predominantly winter rainfall (between 400-2,000 mm) and hot, dry summers has led to a development of a unique array of plant species known as fynbos. Fynbos is essentially a fire-adapted heathland, consisting of a remarkably rich array of distinctive plants, including *Erica* and *Protea* spp.

The local authority proclaimed the area a nature reserve in 1938 and it was incorporated into the Cape Peninsula National Park in 1998. It encompasses 7,750 ha of rich and varied flora and fauna. Its 40 km coastline stretches from Schuster's Bay in the west, to Smitswinkel Bay in the east.

Large animals are a rare sight on the cape, but there is an abundance of small animals such as lizards, snakes and tortoises. There are some herds of zebra and eland.

The strategic position of the Cape of Good Hope between two major ocean currents ensures a rich diversity of marine life. The marine life east and west of Cape Point is markedly different due to sea temperature - the cold Benguela current to the west contrasts with the warm waters of False Bay to the east. The area offers excellent vantage points for whale viewing. The southern white whale is the species most likely to be seen in False Bay between June and November. Seals and dolphins can be seen occasionally.

After returning from Cape Point we visited Kirstenbosch National Botanical Garden.



Kirstenbosch National Botanic Garden

The National Botanical Institute is an autonomous, state aided organisation whose mission is to promote the sustainable use, conservation, appreciation and enjoyment of the exceptionally rich plant life of South Africa, for the benefit of all people.

The garden is sanctuary to about half of South Africa's indigenous flowering species. It is the best known of South Africa's eight botanical gardens – it was the first in the world to showcase indigenous plants and now shows 6,000 different species. In 1896 Cecil John Rhodes bought Kirstenbosch, a 152 ha farm, as a first step towards preserving Devil's Peak and the eastern slopes of Table Mountain as a National Park. Kirstenbosch was selected for its current role in 1913, when it was officially declared the first national Botanic Park in South Africa. Its aims were to promote the study, preservation and cultivation of indigenous flora.

The continuous work and research that is carried out at Kirstenbosch is critical to the maintenance of the fragile ecological balance of South Africa's environment. In addition scientists are doing valuable exploratory work in the field of the curative properties of many of the indigenous plants and flowers.

After a guided tour of Kirstenbosch we visited Table Mountain. It was partially covered by static cloud – known as the table cloth – which covers it for much of the year. This extraordinary natural feature is a 350-million-year-old massif of sandstone and shale. It has always had a magnetism over the centuries, from sailors weary from months at sea, who saw it as a welcome landmark to twenty first century visitors, thousands of whom each year ascend its 1,086 m summit by cable car.

Records show that about 4,000 years ago, the lower slopes of Table Mountain were covered by groves of silver tree, *Leucadendron argenteum.* The tree, the largest of the *Protea* family, was brought to near extinction by the Dutch settlers, who felled them for firewood.

A century later another threat to the mountain's ecological balance was posed by urban development creeping up its slopes. The mountain was finally declared a national monument in 1957, a decision which pleased ecologists and many South Africans.

Today, numerous organisations protect its welfare. The silver tree has been re-established and is well protected by strict regulation.

The group took the cable-car ascent to the summit and enjoyed the panoramic views.

Overnight accommodation was at the Commodore Hotel, Cape Town. After dinner, the President Trevor Wilson thanked Georg von dem Bussche for his wonderful organising abilities and for the great success he had made of the tour - it would go down as one of the most memorable. He also complimented the Convenor John Mc Loughlin and those associated with organising and planning the tour.

Study Tour participants

Thursday 30 September

On the final morning the group was free to do last minute shopping before commencing the long journey home, a journey made longer because of an airline pilots strike. We departed Cape Town for a short stopover at Johannesburg en route to Amsterdam. The next flight was to Manchester and then a bus to Holyhead and finally, twenty-four hours later, the group arrived at Dunlaoghaire by boat.

Tim O'Regan

Attendance: Peter Alley, John Brady, John Brosnan, PJ Bruton, Michael Carey, Tadhg Collins, John Connelly, Tom Costello, Michael Doyle, Frank Drea, Ken Ellis, Jim Fanning, Joe Fenton, Brigit Flynn, Matt Fogarty, Tony Gallinagh, Sean Galvin, Christy Hanley, George Hipwell, Liam Howe, Jim Hurley, Larry Kelly, Richard Lowe, Donal Magner, Tony Mannion, Fergus Moore, Ned Morrissey, Fergal Mulloy, Liam Murphy, Ted McCarthy, Pat Mc Cluskey Kevin Mc Donald, John Mc Loughlin (Convenor), Jim Mc Namara, Jim Neilan, Frank Nugent, Michael O'Brien, Pat O'Callaghan, Liam O'Flanagan, Tim O'Regan, Joe Treacy, Donal Whelan, Trevor Wilson (President).

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

Máirtín Ó Neachtain
1933-2002

The death took place of Máirtín Ó Neachtain on the 15th July 2002 at his home near Oranmore, Co Galway.

He lived a full and rewarding life and because of his calm manner was liked and admired by all who came in contact with him.

After completing his secondary education in 1953 he commenced his forestry training at Avondale. His first official assignment was as an assistant forester to Kilworth forest in 1956. He then transferred to Glen of Imaal forest, where his twin characteristics of concern and generosity asserted themselves when the forester-in-charge Tom O'Neill died suddenly in 1959.

He was subsequently promoted to forester-in-charge at Killakee forest; some years later he was transferred to Ballyfarnon forest in Co Roscommon before finally transferring to Castledaly forest in Co Galway where he served until he availed of the early retirement scheme introduced by Coillte in 1993.

Máirtín was endowed with a persuasive style of management; instructions were issued firmly and cordially. This approach was adopted when dealing with the various levels of management, timber merchants and trespassers. A reciprocal approach from superiors was appreciated and proved most effective.

Woodlands were spiritual places for Máirtín; the tree stands, riverbanks and old demesne avenues; all had a regenerative power which he experienced in the forests he managed. He often talked about this on the many Society tours in which he participated, especially on the memorable tour to British Columbia, Canada in 2000, which sadly was to be his last.

Change may be the only constant in life and in fact Máirtín's own life was to undergo dramatic changes over its duration. He was a native Irish speaker who spoke very little English until he went to secondary school. Following secondary school he embarked on a forestry career while coming from a locality that did not have a forestry tradition. On leaving Coillte in 1993 he commenced a degree course in Irish literature and Greek and Roman civilisation at University College Galway. Three years later he graduated with first class honours. Finally, he was invited to become a tutor at the university, based on his language fluency and academic qualifications. Sadly, this opportunity and an acceptance as a law student had to be abandoned when his illness was diagnosed.

In a society that increasingly elevates achievers there is sometimes a realisation that the constant need to achieve becomes tedious and ultimately destructive. The achievements of Máirtín Ó Neachtain are in sharp contrast to this trend, Máirtín appeared to have achieved a fine balance between ambition and achievement.

Máirtín's funeral took place to his native Inverin where he was buried at Knock cemetery overlooking Galway Bay.

We extend our sympathy to his wife Phyllis, daughters Blathnaid and Ciara, sons Eoghan, Aodh and Art.

Fear caoin carthanach ab ea Máirtín
Ar dheis Dé go raibh a hanam uasal

Tony Gallinagh

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Contents