IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

Volume 50, No. 2, 1993

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Cover: Remaining snags and regeneration following the Mt. St. Helen's eruption as seen on the US Study Tour.

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Society of Irish Foresters

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Comparative Irish and American Hardwood Culture

*I. One Tree to the Acre: The Value and Silviculture of Fine Hardwood Management on Small Woodlots in the Midwestern U.S.**

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***Adapted from an Environmental Institute – UCD/COFORD sponsored presentation in Dublin, June 4, 1993.**

Summary

Because the midwestern US and Ireland share similar agricultural landscapes, information on hardwood culture and reforestation efforts is presented for comparison. Historically, the respective land areas were once heavily forested, but land clearing for agriculture in both countries has resulted in relatively small, fragmented woodlots. This makes farm-forestry an important component of forest production in these landscapes. The status of Indiana hardwood forest is provided with current growth and species trends. Timber values and recent timber sales figures by species are included for contrast with Irish woodlots and the long-term trends of sawlog prices in Indiana are provided which show the competitive rates of return that hardwood management can bring.

Introduction

Much of the midwestern U.S. shares a common ecological landscape with rural areas of Ireland. Broad-leaved forest, once covering most of Ireland and the eastern U.S., has been dramatically reduced by human activity i.e., conversion to agriculture (Watts 1985, Edwards 1985, Noss 1987). Thus, the resulting landscapes are a patchwork of relatively small woodlots in an agricultural matrix (Figure 1). This similar heritage has led to parallel ecological and economic problems. Economically, the focus on agriculture in both countries has led to a general decline in the quality of the woodlands. Silvicultural practices have been neglected, with high quality stems usually selectively removed to provide short-term income to farmland owners. Characteristic of Irish woodlands (Cross 1987), this is also reflected in the scarcity of management on private lands in the eastern U.S. (Nyland 1992). In Indiana, for example, only 20% of timber sales are conducted with the aid of a forester. Additional problems include overgrazing in woodlots (causing defect and rot in existing trees as well as loss of regeneration), a

Figure 1. Typical northern Indiana landscape of small forest properties enclosed in an agricultural matrix, often connected by hedgerows.

decline in the available hardwood resource for industry, and the reliance of a large segment of the population on agricultural commodity production.

Ecologically, forest fragmentation is recognized in both countries as contributing to the decline or extinction of wildlife and plant species; species associated with the interiors of undisturbed forests and important for maintaining biodiversity (Jeffrey 1984 in Cross 1987, Noss 1983). The establishment and conservation of the broad-leaved forest resource in both countries is demanding alternative (and creative) silvicultural practice including a shift away from clearcutting, use of new tools such as tree shelters, establishment of a distribution of age classes, increasing rotation length for some species to increase tree size, and production (either naturally or artificially) of standing snags and dead and down timber for wildlife use (Neff 1974 in Cross 1987, Parker 1989).

Involvement by farmland owners and the introduction of grant schemes for planting and stand management are assisting in the effort to maintain quality hardwoods in both countries.

Historical Forest Cover

The historical midwestern U.S. landscape, and specifically that of the state of Indiana, can be pieced together from travel accounts of pioneers and surveyors (McCord 1970) as well as historical legal documents. Pollen records also present the earlier dynamics of forest species migration into the area during post-glacial development (Delcourt and Delcourt 1987). At the time of intensive settlement in the late 1700's to early 1800's, a forested landscape dominated by mesic forest species was found (87% of the 9.2 million hectare land area of Indiana) with the balance in prairie and wetlands to the north. Heavy clearing of forests for farming occurred during the mid 1800's in Indiana and today only 19% of the land area remains under forest cover. In comparison, Ireland's forests once covered nearly all of the island, reaching their maximum around 5000 B.C. (Cross 1987). Clearing of forest began much earlier in Ireland of course, and by the Middle Ages, Ireland had acquired much of its present landscape, with only 1% of the land under native hardwood forest today.

With such major clearing of forest land, associated animal species have undoubtedly been impacted in both countries. In Indiana, forest clearing has been associated with the loss of buffalo, wolves, black bear, and various other mammal and bird species from the state.

The Forest Resource Today

Today's midwestern U.S. forest is dominated not by the mesic, late-seral species of the past, such as sugar maple (*Acer saccharum* Marsh.) and American beech (*Fagus grandifolia* Ehrh.), but by more xeric species, the red and white oaks (*Quercus* spp.) and hickories (*Carya* spp.). The dominance of oak, however, is transient, due to the abuse of the forest during settlement. The use of fire by Native Americans was adopted by the large numbers of Europeans settling in Indiana and it was common for large fires to be burning across the state in the 1800's. In addition, the Europeans brought livestock that were left to graze in the forests, impacting regeneration. These heavy disturbances arrested succession, maintaining mid-tolerant species. Thus, with settlement came a shift in forest species, from late-seral, very shade-tolerant species to the mid-tolerant oaks and hickories whose ability to quickly resprout after disturbance allowed eventual dominance in the forests of the state and region. With the removal of fire and woodland grazing from the landscape since the early 1900's, Indiana's forests are returning to their original composition, where oaks are mixed with 20 to 30 species of other hardwoods (Table 1). Irish forests seem to be similar in that the large oak component found today is a function of management during the 18th and 19th centuries. Previously, as in the U.S., oak would have been found in association with other tree species according to site (Cross 1987, Mitchell 1976, Edwards 1985).

Table 1. Stand tables presenting numbers of trees per hectare by species and tree size for two Indiana woodlands on moist and dry sites.

A. Southeast Purdue Agriculture Center Woodlands – Mesic Site, Two-Aged Stand 50-110 Years, Good Productivity.

	Diameter Classes (cm)													
Species	5	10	15	20	25	30	35	40	45	50	55	60	65	
REM	12	12	5	13	9	8	9	16	7	3	1	1		96
SHH	4	13	17	16	15	1	11	3	1					81
SWG		1	17	13	11	4	11	1	3	3				64
SAS			3	4	5	5	5	3		1	1			27
BLG	13	24	7	3			1	3	5		3			59
SWO				3	7	5	5	3			1			24
YEP						1		1	1		1		3	7
WHA		1		3	9	5	4	3						25
NRO		1	1	1		1			1		1			6
WHO					3		1	1	1					6
BIH				1	1		1	3						6
REE	5	5	5	1	1						1			18
BLC	5				1			1						7
PIO								1						1
DOG	21	5												26
AMB	36	1												37
HOR	12	1												13
Totals	108	64	55	58	62	30	48	39	19	7	9	1	3	503

B. Clark State Forest – Xeric Site, 70-90 Years, Poor Productivity.

Diameter Classes (cm)

Species	5	10	15	20	25	30	35	40	45	50	55	60	65	
WHO	5	12	9	17	23	44	44	27	8	8	1			198
BLO	4				3	4	1	4	4	1	1	1		23
PNH	3	11	8	9	5	1	1							38
SCO								1						1
DOG	44	8												52
SHH	12	12	1	1										26
REM	8	9	1	1										19
WHP	11	8												19
SUM	1	5	1	1										8
VIP					1									1
REC	4	3												7
BLG	1	3												4
SAS	1	1												2
WHA			1											1
REE	3													3
RED		1												1
BLC	1													1
Totals	98	73	21	28	33	49	46	32	12	9	2	1		404

Species Key

Code	**Common Name**	**Scientific Name**
AMB	American Beech	*Fagus grandifolia* Ehrh.
BIH	Bitternut Hickory	*Carya cordiformis* (Wangenh.) K. Koch
BLC	Black Cherry	*Prunus serotina* Ehrh.
BLG	Black Gum	*Nyssa sylvatica* Marsh.
BLO	Black Oak	*Quercus velutina* Lam.
DOG	Dogwood	*Cornus florida* L.*
HOR	Hornbeam	*Carpinus caroliniana* Walt.*
NRO	Northern Red Oak	*Quercus rubra* L.
PIO	Pin Oak	*Quercus palustris* Muenchh.
PNH	Pignut Hickory	*Carya glabra* (Mill.) Sweet

REC	Redcedar	*Juniperus virginiana* L.
RED	Redbud	*Cercis canadensis* L.*
REE	Red Elm	*Ulmus rubra* Muhl.
REM	Red Maple	*Acer rubrum* L.
SAS	Sassafras	*Sassafras albidum* (Nutt.) Nees
SCO	Scarlet Oak	*Quercus coccinea* Muenchh.
SHH	Shagbark Hickory	*Carya ovata* (Mill.) K. Koch
SUM	Sugar Maple	*Acer saccharum* Marsh.
SWG	Sweetgum	*Liquidambar styraciflua* L.
SWO	Swamp Chestnut Oak	*Quercus michauxii* Nutt.
VIP	Virginia Pine	*Pinus virginiana* Mill.
WHA	White Ash	*Fraxinus americana* L.
WHO	White Oak	*Quercus alba* L.
WHP	White Pine	*Pinus strobus* L.
YEP	Yellow Poplar	*Liriodendron tulipifera* L.

*Understory tree only

In Indiana, species dynamics are creating several problems. The reliance on oak by forest industry is mandating a shift in species used in furniture, paneling, and other segments of the industry as quality oak logs become more scarce. For over a century, U.S. foresters have recognized the difficulty in regenerating oak as natural succession without severe disturbance replaces oak with the late-seral maple and beech. Today, the oak-hickory cover type accounts for only 33% of Indiana timberland, down from 61% in 1966 (Smith and Golitz 1988). Thus, millions of dollars have been funneled to research oak regeneration systems. Similar efforts for growing oak and other fine hardwoods are developing in Ireland (e.g., Fitzsimons and Luddy 1986, Neilan 1992, Markey 1992) though land availability and longer rotations are problems to overcome. Our biological understanding is improving (Gillespie 1992), but social constraints are requiring a diversification of production systems. In the U.S., aesthetic and environmental concerns in the Midwest continue to increasingly limit silvicultural practices suited to oak regeneration and harvesting. As a result, oak management is being shifted from public lands to woodlands of private ownership, woodlands in the agricultural matrix. Similarly, economic and social dynamics in Ireland are opportune for promoting diversification of traditional farming (with surplus supply) into forestry as well as diversifying state forestry plantings to include hardwoods to a greater extent.

Indiana's forest resource today covers a wide range of sites and productivity classes, just as for Ireland. The standing growing stock volume (trees greater than 13 cm to a 10 cm top) averages 85 cubic meters per hectare. Standing sawtimber volume (trees greater than 30 cm to a 23 cm top) averages 11,043 board feet per hectare or 62.5 m^3/ha.[1] Net annual growth of growing stock averages 2.5 m^3/ha/yr, quite low. Actually, potential growth is at least two to three times higher (5-7 m^3/ha/yr) but many of Indiana's forests are overmature and/or have been degraded by selective cutting. Net annual growth of sawtimber (>30 cm) averages 418 board feet per hectare per year or 2.4 m^3/ha/yr, nearly three times the rate in 1966. Biomass averages 171 green Mg/ha (Smith and Golitz 1988). Examination of species distributions shows the trend of increasing growing stock, but also the decline in oak dominance as maple, yellow poplar (*Liriodendron tulipifera* L.), and white ash (*Fraxinus americana* L.) increase in numbers (Figure 2). Size class distributions also show the maturity of Indiana's hardwoods with relatively small areas of semi-mature and regeneration size classes (Figure 3).

The majority of the forestland in Indiana is structually even-aged and in the past even-aged techniques were used for regeneration. As most Indiana forest land is in private hands (1.5 million hectares of 1.8 million or 83%), future management will most likely convert these stands to uneven-aged stands where the conversion to sugar maple will be accelerated (Gillespie *et al.* 1993). Private ownership probably also accounts for the over-maturity of the forest, and lack of younger stands.

Value of the Hardwood Resource

Recently, a question was posed for Irish Forestry, "The question is can we afford to invest in hardwood production, will there be a return on any investment made?" (Gallagher 1987). In the U.S., the Central Hardwood region contains some of the most valuable timber in the world, and the best quality oak and black walnut (*Juglans nigra* L.) logs in Indiana are often shipped to European markets. Analysis of some recent Purdue University timber sales shows excellent returns (Tables 2 and 3). In the Nelson-Stokes woodlot, approximately 25 trees per hectare were harvested in 1992 (Table 2), giving an average value of roughly £170[2] per tree. This is well within the potential of Indiana hardwoods stands, however, this potential is not often realized due to repeated selective cutting.

[1] Board foot measure is the preferred sawtimber measure in much of the U.S. Unfortunately, conversions are species and size specific, and there are a number of board foot rules. All board foot measures reported here are International 1/4-inch rule and 5 board feet per cubic foot is used as the conversion to cubic meters. This conversion is taken from the USDA Forest Service Resource Bulletin NC-108, Indiana Forest Statistics. Cubic foot – board foot conversion rates for 9" to 29" trees (22.8 - 73.7 cm) range from 4.8778 to 5.2718 for hardwood trees (International 1/4-inch), thus 5 board feet per cubic foot was chosen for convenience.

[2] The exchange rate used in all calculations is $1.50 = IR£1.

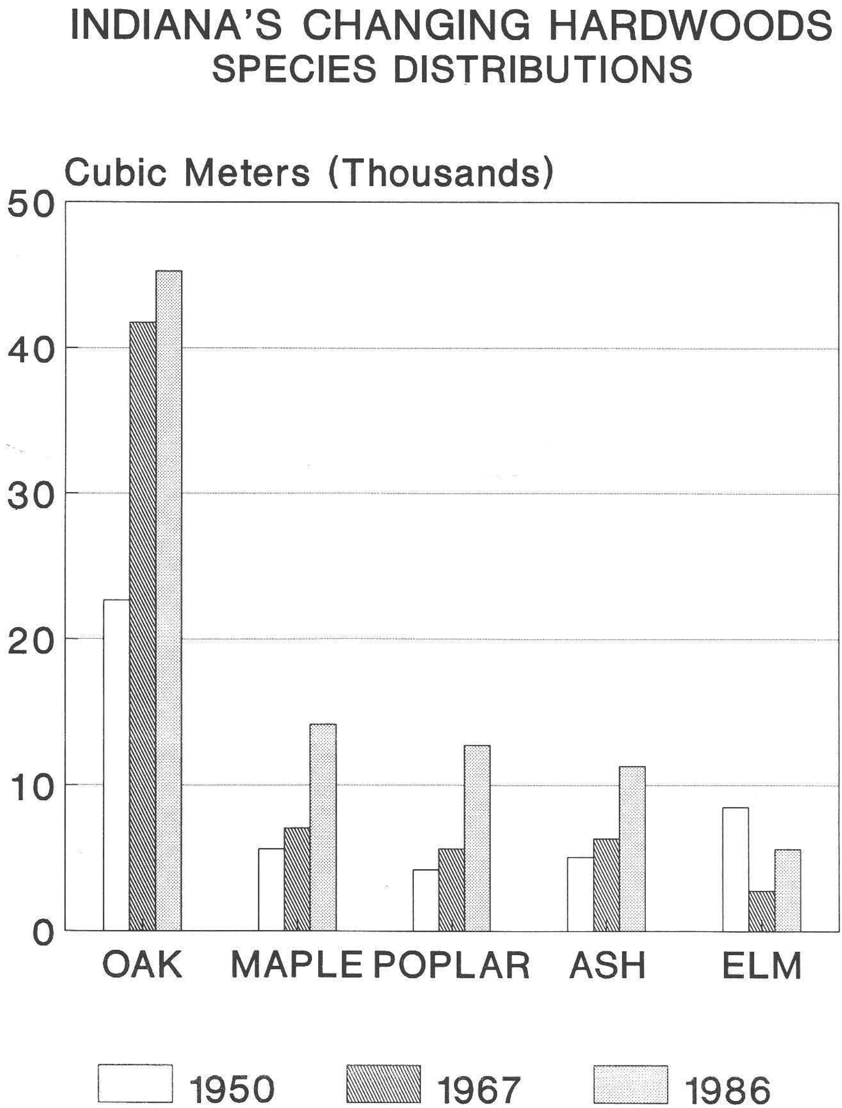

Figure 2. Species dynamics in Indiana forests over time. (Adapted from Smith and Golitz, 1988).

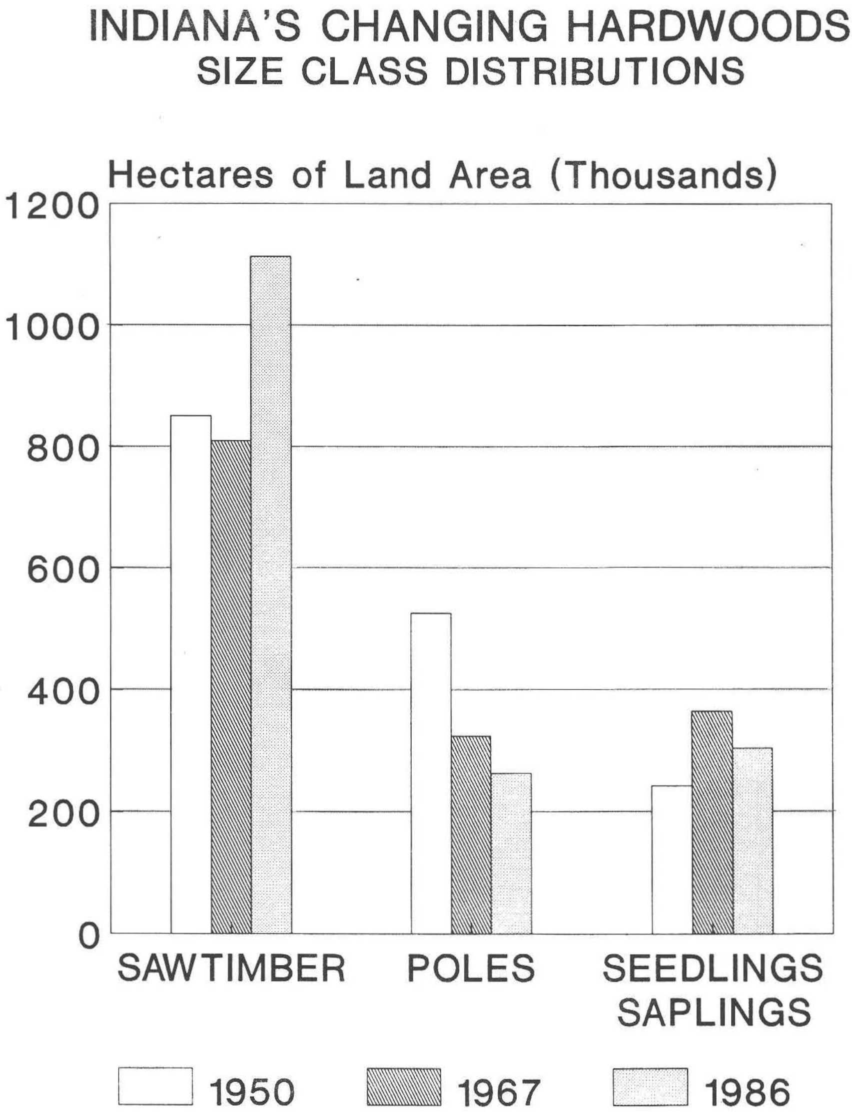

Figure 3. Size class distributions for Indiana forests over time. (Adapted from Smith and Golitz, 1988).

This particular stand will provide 1-2 more harvests (thinnings) before being regenerated. The 8% real rate of return places management of this stand well in excess of many alternative investments, even with the purchase of land and timber in 1960. It should be noted that some costs have not been figured into this simplified analysis. Annual property taxes would be an additional cost, but because of Indiana tax incentives for forestland, this cost becomes minimal. Also, administrative management costs (e.g. management plans, soils maps, etc.) are not included as these functions are normally provided to landowners by government foresters (at the State level). What costs there are for mature stand management (e.g. fence maintenance, timber sale marking) are either cost shared by government grant schemes or taken out of sale proceeds. Sometimes, however, the State District Forester will also mark timber sales. Thus, the information and extension component for forestry seems much stronger within the U.S. government (Federal and State) than within the Irish government. Finally, sale proceeds would be subject to the U.S. income tax structure.

Table 2. Cash flows and rates of return for a recently-harvested central Indiana hardwood stand. Adapted from Mills (1993).

Nelson-Stokes Woods, Compartment 2
36.2 hectares

			Volume per Hectare	
		Bd. Ft.	Cubic	
Year	Activity	Cash Flow (IR£/ha)	(Int. 1/4")	Meters
1960	Purchase			
	Land	-50		
	Timber	-200	11,935	68
1977	Salvage	8	205	1
1992	Harvest	4,280	10,667	60
	Residual Stand	5,617	21,142	120
	Land Value	412		

Range of Bids: IR£85,926 – 154,667

Rate of Return = 12 – 12.5%
(8% after inflation)

In a second Purdue University timber sale, a much higher rate of return (20%) was earned, again including purchase of land and timber (Table 4). This was an exceptional stand with large trees of high quality. Examples such as this are becoming more scarce, and tree dimension requirements have

Table 3. Timber sale tally for Nelson-Stokes woodland, 36.2 hectares.

Species	Number Of Trees	Estimated Volume Board Feet (Int. 1/4"Rule)	Estimated Volume Cubic Meters
Red Oak (*Quercus rubra* L.)	206	108,541	615
White Oak (*Quercus alba* L.)	228 (47 veneer)	81,895	464
Hickory (*Carya ovata* (Mill.) K. Koch)	227	68,885	390
Basswood (*Tilia americana* L.)	21	6,918	39
Sycamore (*Platanus occidentalis* L.)	8	6,285	36
Sugar Maple (*Acer saccharum* Marsh.)	20	4,689	27
White Ash (*Fraxinus americana* L.)	69	36,206	205
Chinqapin Oak (*Quercus muehlenbergii* Engelm.)	26 (3 veneer)	8,898	50
American Beech (*Fagus grandifolia* Ehrh.)	35	8,306	47
Red Elm (*Ulmus rubra* Muhl.)	38	14,800	84
Yellow Poplar (*Liriodendron tulipifera* L.)	10	7,527	43
Black Walnut (*Juglans nigra* L.)	55 (21 veneer)	15,446	87
Black Cherry (*Prunus serotina* Ehrh.)	4	2,033	12
Blue Ash (*Fraxinus quadrangulata* Michx.)	2	1,143	6
Sassafras (*Sassafras albidum* (Nutt.) Nees)	24	6,646	38
Hackberry (*Celtis occidentalis* L.)	3	1,966	11
Misc.*	6	1,285	7
TOTAL	982	381,469	2,161

*Includes honey locust (*Gleditsia triacanthos* L.), red maple (*Acer rubrum* L.), and Kentucky coffeetree (*Gymnocladus dioicus* (L.) K. Koch) been greatly reduced. Thus, much smaller logs are now being harvested and trees are grown to smaller sizes.

Table 4. Cash flows and rates of return for a recently-harvested southern Indiana hardwood stand. Adapted from Mills (1993).

Cupps Chapel Woods
15.4 hectares

Year	Activity	Cash Flow (IR£/ha)	Volume per Hectare Bd. Ft. (Int. 1/4″)	Volume per Hectare Cubic Meters
1973	Purchase (Land and Timber)	–659	22,306	126
1977	Harvest	1,352	3,403	19
1982	Road Repair	–15		
1992	Harvest	4,509	14,401	82
	Residual Stand	3,929	18,073	102
	Land Value	412		

Range of Bids: IR£38,631 – 69,333

Rate of Return = 25%
(20% after inflation)

These stands are examples of existing stands that were purchased and managed. Returns from these properties are inflated due to increasing land values as competition for alternate land uses increased. But this would be true whether the crop was trees, corn, or hay. The value of the mature timber, however, demonstrates the benefit of purchasing timber in mid-rotation where quality stands can be found. Alternatively, the purchase of undervalued land can also lead to large returns. Examples of this strategy can be found in the U.S. where bottomlands that periodically flood are sold at a low price by farmers. Foresters purchase such lands and plant high-value bottomland species (e.g. black walnuts, wet-site oaks) which exhibit very high growth rates on these sites where crops or pasture would be destroyed. Beyond land speculation, timber management of existing stands provides competitive returns where individual hardwood growth is accelerated through thinning operations. Increases in size, value, and product grade with management are the real factors contributing to the profitability of existing stand management. Many future stands are only now being established, either by farmers or other landowners. The returns made from these stands are also favorable. During a recent Society of American

Foresters (Indiana Chapter) workshop, private consulting, state, federal, and university foresters put together an example of the costs and return from an 80-year rotation, mixed-hardwood plantation (Table 5). Assuming in this instance that the land was already owned, the landowner could expect a real return of 4 – 4.5% (all monetary values in this analysis are uninflated). Thus, with purchase of nursery seedlings, site preparation and planting, weed control for three years (herbicide), and pruning and precommercial thinning, a competitive rate of return can be earned by the landowner. This is without any government grant schemes or premiums. Where these programs are used by landowners, particularly farmers taking marginal land out of crop production, the return would be substantially higher.

Table 5. Cash flows and return from a hardwood plantation in Indiana given 1993 prices and returns.

Hypothetical Mixed Hardwood Plantation

Year	Activity	Cash Flow (IR£/ha)	# of Trees/ha
0	Plant/Weed	–494	1,680 @ 2.5m
1	Weed Control	–66	
2	Weed Control	–66	
8	Prune	–99	
18	PreComm Thin	–82	740
25	Thin	25	494
40	Harvest	165	247
60	Harvest	4,118	124
80	Harvest	8,237	0

Rate of Return = 4 – 4.5%

The real value, however, comes from black walnut trees. Because of the price commanded by walnut, foresters often manage walnuts individually, and it is the first species distinguished in any inventory process. The record price for a single black walnut tree (from Ohio) was £23,333. Today's prices would be higher. Foresters also recognize that a single, high-quality walnut tree on an acre can pay for the management of the associated timber – thus the title of this paper. On a volume basis, walnut prices are 20-40 times those of other quality hardwoods, and it is the species of choice for plantations throughout the Midwest. Most of the effort of genetic improvement in the Midwest has been spent on walnut and growth rates for improved stock compare very favorably with other important forest species (Table 6). Presumably, these rates would be matched or exceeded for these same species growing in Ireland for the reasons outlined below. The Indiana hardwood industry has used 30 cm logs for walnut veneer though it prefers a 40+ cm log. Given the growth rates for improved walnut, these diameters could easily be reached in 35-40 years. At the Purdue experimental forest, one such walnut clone is 36 cm DBH at 22 years of age (Beineke, pers. comm.). Walnut rotations can be realistically set at 45-55 years, but the rate of increase in value at this size argues for longer rotations. Clearly, owner objectives and cash flow needs would dictate rotation length beyond 40 years. Irish analyses typically use a 60 year rotation for ash (*Fraxinus excelsior* L.) and sycamore (*Acer pseudoplatanus* L.) (Neilan 1992, Fitzsimons 1987). With improved seed sources or substitute species of equal or greater value (such as black walnut), financial comparisons would be more favourable due to both value and shorter rotations.

Table 6. Comparative diameter growth rates of major hardwood species in Indiana.

Species	Diameter Increase Per Year
White Oak (*Quercus alba* L.)	0.46-0.51 cm
Red Oak (*Quercus rubra* L.)	0.51-0.76 cm
Hickory (*Carya ovata* (Mill.) K. Koch)	0.25 cm
Sugar Maple (*Acer saccharum* Marsh.)	0.50 cm
Beech (*Fagus grandifolia* Ehrh.)	0.25-0.50 cm
Improved Black Walnut (*Juglans nigra* L.)	1.27-1.95 cm

Irish Conditions

In addition to the value of hardwoods, several other factors should be considered by Irish foresters when planning investments. First, the climate in Ireland is such that abundant rainfall and moderate annual temperatures make Ireland an ideal location for growth of most hardwood species. This is due to the lack of hot, dry periods when water deficits slow tree growth. In addition, with cooler and wetter conditions, trees allocate less carbon to roots and more to stems as well as requiring less carbon for maintenance respiration, i.e., more stays in the tree. This sort of climatic synergism can be seen for other species that have been imported to new locations, for example loblolly pine (*Pinus taeda* L.) which supports the paper industry in southern Brazil (Gillespie, unpublished data). This argument must be qualified where

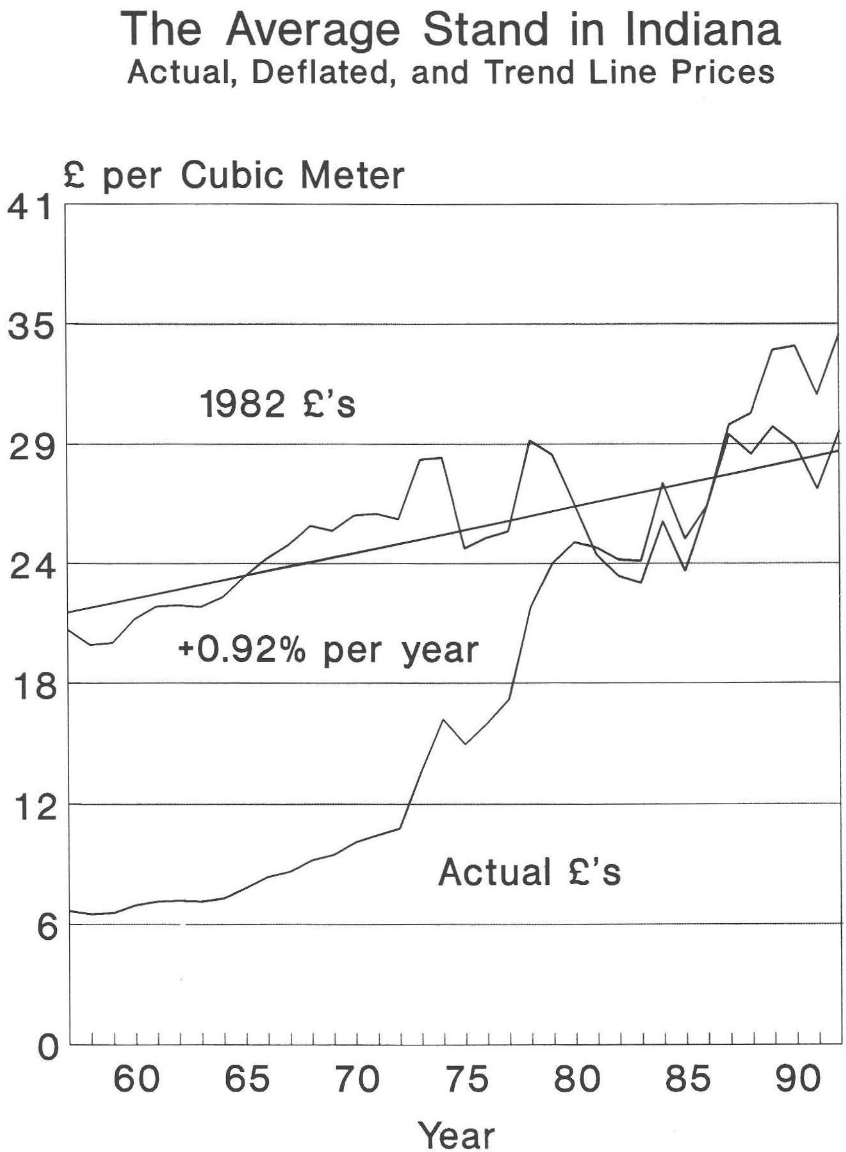

Figure 4. Prices for sawlogs (25+ cm DBH) from a hypothetical stand in Indiana comprised of an "average" or typical mix of species and sizes. The defined stand remains unchanged for all years of analysis and adjustment to 1982 is in dollars; conversion assumes a constant dollar:pound exchange rate of \$1.5 = IR£1. (Adapted from Hoover *et al.*, 1992).

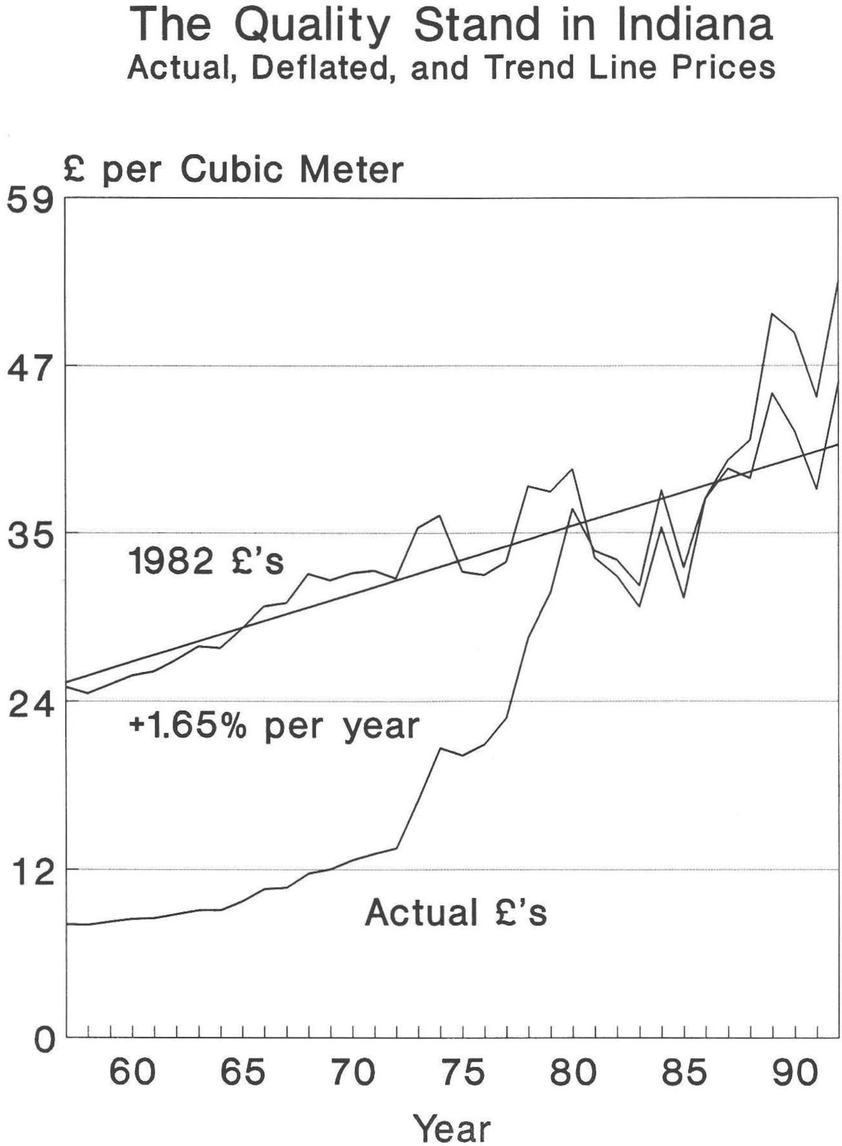

Figure 5. Prices for sawlogs (25+ cm DBH) from a hypothetical stand in Indiana comprised of a better-than-average mix of valuable species and sizes. The defined stand remains unchanged for all years of analysis and adjustment to 1982 is in dollars; conversion assumes a constant dollar:pound exchange rate of \$1.5 = IR£1. (Adapted from Hoover *et al.*, 1992).

restricted annual growth improves product quality in current markets (e.g. veneer oak).

Secondly, Ireland imports both temperate and tropical hardwoods for indigenous industries. As environmental pressures continue to grow, and as sources become depleted, inaccessible, and of lesser quality, importation will be less cost effective. At this point, native sources will be much more attractive financially and socially. But thinking should not be restricted to supplying Irish industries, though this is currently the necessity. Hardwood exports to the EC might be much more attractive financially where markets differ from internal Irish markets. As stated previously, Indiana hardwoods are regularly exported to many different countries in the EC and the requirements (in terms of raw material dimensions and grain patterns, etc.) are often mutually exclusive due to different consumer preferences. Thus, not all investment decisions can be made using internal conditions and rates of return, particularly with regard to hardwoods.

In Summary

The opportunity cost of minimal hardwood management for the U.S. and Irish governments is appreciable, and the private sector in each country is taking the lead in planting and management. With good cooperation, this should not pose a problem. Long-term data support the private sector initiatives (Figures 4 and 5). Increases in hardwood prices above inflation are 1-2% each year (Hoover *et al.* 1992). Coupled with volume growth of 2-3% annually, returns are 4-5% for hardwood timber, easily competitive with many investment alternatives. Additionally, increases in quality and log grade with tree growth provides an additional return of 2-3%. Thus, hardwood production is clearly an attractive investment, and demand continues to grow. Social and environmental constraints are the real challenges for foresters in both the U.S. and Ireland as we move into the next century.

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Comparative Irish and American Hardwood Culture

II. The Diversity and Effectiveness of Grant Schemes for Promoting Forestry in Rural Areas of the Midwestern U.S. and Ireland.

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Summary

Though farming and forestry have traditionally been antagonistic, current economic and environmental necessities are promoting new partnerships. Reforestation efforts on farmland in the US and Ireland are making effective use of government subsidies to farm owners for planting trees, though significant challenges lie ahead. Analysis of the type and objectives of grant schemes, however, shows differences in Irish and American approaches. Irish grants are much more strongly aimed at promoting the business of forestry and cover a wider variety of costs and related infrastructure. Differentials are included to promote farm-forestry and hardwood planting. American grants, particularly annual payments, are much more of an attempt to control soil and water quality degradation, over-production of commodities, and commodity prices. Future success of these grant schemes in both countries will depend on the forestry community's ability to educate an agricultural population and to accept mixtures of agriculture with traditional forestry.

Introduction

The return of forest cover to agricultural land is a signal of change. In developing countries, this change is often a decrease in soil productivity, the intrusion of uncontrollable weeds, a change in land tenure, but also a diversification of the cropping system. In industrialized countries, the changes are just as complex, but the conversion to forest is more a recognition of the futility of farming, the loss of a tradition. In contrast to the developing-country farmer who considers trees as another crop or part of a needed fallow cycle, the industrialized-country farmer has spent his farming career removing trees. Thus, we should not expect farmers to quickly embrace tree production in the industrialized world; even though conversion can be quite profitable.

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Foresters are little different. Having spent decades lamenting the clearing of forests for agriculture, they are quick to support programmes and legislation promoting conversion back to forest cover. But there are always specific definitions and requirements for this forest cover, reflecting traditional forestry values such as compartmentalized stands or target stocking levels.

This antagonistic nature of traditional farming vs. traditional forestry is heightened by the need for annual income in the rural setting. Thus, annual income should be a strong focus for farm-forestry incentives in addition to support for forest establishment and maintenance. Each industrialized country has different programmes addressing these issues. This paper will compare the approaches taken by the U.S. and Ireland.

Grant Schemes

Both Ireland and the U.S. midwestern state of Indiana (of comparable land areas) have a variety of grant schemes that promote forestry. These derive from three policy tools, (1) Cost-Sharing forestry practices, (2) Annual Payments for converted acreage, and (3) Tax Incentives to promote and maintain conversion to forest cover.

In the U.S., these tools are implemented in national policy. But also, each state typically has several programmes of its own involving cost-sharing

Table 1. U.S. federal and state-level (Indiana) agencies from which forestry assistance is available through forestry or agricultural programmes.[1]

Federal
- USDA Forest Service
  - Stewardship Incentive Programme (SIP)
  - Forest Improvement Programme (FIP)
- USDA Agriculture Stabilization and Conservation Service/Soil Conservation Service
  - Agricultural Conservation Programme (ACP)
  - Conservation Reserve Programme (CRP)

State
- Indiana Department of Natural Resources, Division of Forestry
  - Classified Forest
  - Classified Field Windbreak
- Indiana Department of Natural Resources, Division of Fish and Wildlife
  - Classified Wildlife Habitat

Industry[2]
- Various Forest Products Companies
  - Cooperative Forest Management Programme

[1] Adapted from Miller and Seifert (1992).

[2] Though not widely found in Indiana, nearby states with a large industry base may have companies helping landowners by providing seedlings and management services.

Table 2. Cost-shared activities for forestry in Ireland and Indiana, USA.

	U.S.	Ireland
Afforestation		
Site Preparation	Yes[1]	Yes
Drainage	No	Yes
Planting	Yes	Yes
Fertilization	Yes	Yes
Fencing	Yes[2]	Yes
Fire Protection	Yes[3]	Yes
Establishment needs after planting	Yes[4]	Yes
Stand Tending		
Timber Stand Improvement (including thinning and pruning)	Yes	Yes
Firebreaks/Reservoirs	Yes[5]	Yes
Reconstitution after damage	Yes[6]	Yes
Forest Roads		
Forest Development Grade	Yes[7]	Yes
Extraction Grade	No	Yes
Harvesting Equipment		
Purchase	No	Yes
Development	No	Yes
Research and Pilot Projects	No	Yes
Aid to Woodland Associations	Yes[8]	Yes

[1] Both for artificial and natural regeneration in some programmes.
[2] Only for protective measures against wildlife damage.
[3] Possibly under one programme, but not well used.
[4] Varies by programme, 1-4 years of weed control after establishment cost-shared.
[5] Possibly under one programme, no reservoir construction however.
[6] Emergency timber stand improvement funds available for reconstitution after tornados and windstorms.
[7] Funds only available for costs related to road design and layout.
[8] A small programme exists within the Indiana DNR Division of Forestry to provide funds to private organizations for Forest Stewardship.

and/or tax incentives. Though control of major programmes resides in Washington, even federal programmes are influenced at the state level by local federal agents or state district foresters responsible for specific counties across each state (Table 1). These agents typically work in concert with each other when applying programmes, crossing governmental levels and agencies. Ireland, of course, is small enough to maintain central control, and forestry programmes are administered by the Forest Service. As a result, the programmes fall under one title and there is little confusion as to what is grant-aided or cost-shared, and when and how a farmer or other landowner obtains government support for forestry. This is a problem in the U.S. where the diversity of programmes (Table 1) and their regulations often leads to farmer confusion or inaction. Certainly, the government agents and foresters are in place to assist farmers and other rural landowners, but even the civil servants appeal to their superiors for consolidation of programmes. Because many of these programmes are political in nature, there is little hope of a more simplified structure and one of the greatest challenges for U.S. rural forestry will remain one of educating the rural landowner of the options and convincing him of the benefits of maintaining or establishing forests.

In addition to the structural simplicity of the Irish cost-sharing grant schemes, the grants themselves are aimed specifically toward forestry (Table 2). The flexibility of the Irish grant schemes is evident in the broad range of forest activities that are cost-shared. This is particularly critical for Ireland given the largely administrative role of the Forest Service and the corporate role of the semi-state land management entity, Coillte. With this dichotomy, some forest activities would inevitably suffer, for example, research into new forest species or silvicultural systems. The grant assistance for research or "Back-up Measures" provides some funds for private research where government agencies are not likely to invest time or money given their respective missions.

Because of the relative lack of research, particularly in relation to integrated farming and forestry, certain forestry practices have been turned down for grant assistance. For example, silvo-pastoralism is not presently accepted for grant aid in Ireland even though such systems (e.g. pasture under black walnut in the Midwest, U.S.: Kurtz *et al.*, 1984, Campbell *et al.*, 1991) have been shown to be profitable elsewhere and grant-aid documents specifically mention agroforestry. Just as it is difficult for farmers in industrialized countries to accept tree crops, it is perhaps difficult for foresters in these countries to accept and support forestry in settings other than contiguous stands of trees.

Certainly, Ireland should not be singled out. In Indiana, the Classified Forest Act does not provide tax relief to forests that are grazed, even though this research is in place (Kurtz *et al.*, 1984). This, of course, is due to the historical abuse of forests by overgrazing and the reluctance to again introduce livestock to the forest. But this also discourages the practice of cutting silage or hay under trees (and there is substantial literature pointing to the increased quality of forage under scattered trees).

It can also be seen from Table 2, that the Irish go far beyond the U.S. in supporting forestry infrastructure in terms of roads, equipment, and aid to woodland associations and cooperatives. This is due to the Irish focus on forestry development whereas many of the U.S. programmes are for agriculture stabilization of prices, production, or soils (Table 3). Concern regarding overproduction as well as farming of marginal, highly-erodible land has driven farm programme development in the U.S., where forestry is only one of several options for farmers. Within these programmes, a balance is sought for forest cover vs. non-forest/non-crop cover and thus forestry is always promoted as an alternative for land undergoing conversion. Through these cost-share programmes, Indiana forest cover has risen from 15% of the total land area in the 1930's to 19% today, 6,120 hectares of new forest having been planted in the last 5 years.

The introduction in Ireland of the EC-subsidized Western Package and its replacement, the Forestry Operational Program 1989-1993, have combined with falling returns to farming to stimulate a dramatic increase in planting from 7,459 hectares in 1982 to 22,298 in 1991. While State planting has risen, the main thrust of the improvement has come from the private sector. Enticed by these cost-share programmes, the percentage of total planting undertaken by private investors has increased from 7.9% to 49.7% in the same space of time. This increase has resulted in a change in the type of land being planted. New planting mostly takes place on highly productive, sheltered grass/rush lowlands (Convery and Clinch, In Press). The objective stated in Ireland's National Development Plan 1994-1999 is to plant 30,000 hectares per year to the year 2000 (Government of Ireland 1993).

Also of note are the Irish rates for cost-sharing. These are variable by landowner class, with a premium for farmers, farmland, and hardwoods (Table 3). U.S. programmes do not differentiate between landowners and thus are less effective as a rural development tool. Additionally, in the U.S. system, hardwoods are preferred in some programmes, but no additional funds are used to cost share hardwood plantings.

Premiums, or annual payments to farmers are also undertaken in both the U.S. and Ireland, but again, the policy aims are different. In Ireland, the premium goes to farmers who convert land to forestry, and until recently farmers had to meet specific income and residency requirements to ensure that primary farmland and farm income was being diverted to forestry (Table 4). Hardwoods also enjoy a greater subsidy as well as having five extra years of premium payment (Irish Forest Service 1990). Farmers who qualify for cost-sharing automatically qualify for premium payments. The U.S. Conservation Reserve Program is designed only to remove marginal lands from production and to place a permanent cover on these lands to halt erosion and water quality degradation. This is a successful, but expensive programme which provides five extra years of premium payment for the planting of trees rather than a herbaceous cover crop. Thus, in the U.S., only farmers with highly erodible soils on their farms are eligible for annual payments to offset loss of annual farm income due to the planting of trees. And only 2.5% of the over 200,000 hectares enrolled in CRP in Indiana have been planted to trees, approximately 5,200 hectares. Clearly, forest is not the preferred cover for U.S. farmers in the Midwest.

State programmes to promote forest cover have concentrated on property tax relief (Table 5). Unlike Ireland where there is no land property tax, each unit of land in the U.S. is taxed annually based on value and primary

Table 3. Cost-share restrictions for Irish and American programmes.

U.S.	**Cost Share Rate**	**Land Area**	**Maximum Payments**	**Other Restrictions/Notes**[1]
Agricultural Conservation Programme	65%	0.4+ ha 2+ ha for Timber Stand Improvement 400 ha maximum	£365/ha[2] £6700/year	Timber only one of many objectives and cover types.
Forest Improvement Programme	65%	4+ ha 400 ha maximum	£365/ha £33,333/year	Must be in counties with a minimum forest cover and appropriate soils. Timber management only.
Stewardship Incentive Programme	75%	0.4+ ha 2+ ha for Timber Stand Improvement 400 ha maximum	£420/ha £6700/year	Multiple objectives. 3 additional years of weed control cost-shared at 65%. Must have stewardship plan.
Conservation Reserve Programme	50%	Variable - function of per hectare reimbursement until maximum is reached	£280/ha £33,333/year	Take land out of production, no income allowed. Highly erodible land only. Tree cover for 30 years. Less than 50% conifers allowed, and only for wildlife or nurse crop. No grazing.
Ireland				
Afforestation[3]	Variable – Farmers: 85% Other Landowners: 70% Coillte:[3] 65%	Variable – Conifers: 2+ ha (1+ ha when next to existing forest) Hardwoods: 0.25+ ha	Variable – Non-Ag. land: £900/ha Ag. Land: £1,100/ha Hardwoods: £2,000/ha	Minimum plantation width is 40 metres. Species must be approved. Provenance must be certified for some species. Plantation must be fenced. Must be maintained for 10 years. Conifers must be commercial.

Table 3 (Continued)

Woodland[3] Improvement/ Reconstitution	Variable – Farmers: 85% Other Landowners: 70% Coillte: 65%	NA	Variable – Conifers: £900/ha Hardwoods: £2,000/ha	Hardwood stands mostly / Repair damage from natural causes.
Forest Roads	80%	NA	£12/meter	Must meet Forest Service specifications for plantation development or timber extraction grade.
Harvesting Equipment	45%	NA	Variable – Determined by Minister	Investments in felling, processing, and extraction equipment cost-shared. Equipment development for Irish conditions cost-shared.
Research and Association Aid	60%	NA	Variable – Determined by Minister	Projects selected by contribution to forestry sector development.

[1] Each programme has specifications for minimum stocking and maximum spacings.
[2] An exchange rate of £1 = \$1.50 is used in all conversion calculations.
[3] Coillte is the Irish Forestry Board, a semi-state company.

Table 4. Annual payment programs for farmers in Ireland and the U.S.

U.S.	**Length of Payment**	**Amount of Payment**	**Conditions**
Conservation Reserve Programme	Trees – 15 years	Variable – bid placed by farmer; typically £124-165/ha[1]	Highly Erodible Land Land taken out of production:[2] Grasses – 15 years Trees – 30 years Trees only one option of many cover types. Maximum land area defined by available monies and county-specific soil types. No other cost-sharing allowed in addition to 50% for establishment costs.
Ireland			
Forest Premium Scheme	Conifers – 15 years Hardwoods – 20 years	Variable – Conifers: Non-ag. land: £50/ha Ag. land: £116/ha (1st 8 ha) £86/ha (>8 ha) Hardwoods: £116/ha	Annual off-farm income not more than £13,900/yr. Farmer resides on or near plantation. Maximum amount for conifers is £6,000/year. Must meet standards of cost-sharing grant schemes. No other premiums allowed.

[1] An exchange rate of £1 = $1.50 is used in all conversion calculations.
[2] Though still part of law, long-term removal from production is no longer enforced after payments have ended.

use. Where land is converted to forest or where trees are established as windbreaks, the state reduces the tax liability to the landowner to promote the conversion or retention of forest land. Taxes affect forestry differently in each state as some states have additional requirements (e.g. tax on wood from timber harvests). Unlike Ireland, no felling license is required however. For Indiana forestland owners, this programme is attractive if they wish to retain forest cover long-term. As there is a penalty for withdrawal, many landowners are reluctant to commit their land feeling that this will reduce future options. Also, property taxes are used to fund school systems in the U.S., and Indiana communities with a large forest base closely examine each forest allocation, i.e., there is a counter-incentive for communities to deny land reclassification if possible.

Table 5. State of Indiana property tax incentive programmes for forestry.

Program	Land Area	Incentive	Restrictions
Classified Forest	4+ ha	Reduce tax liability to £1.65/ha assessed value[1,2]	Area must be contiguous. No buildings except sawmill. No grazing. Classification remains with transfer of land, penalty for withdrawal. At least 740 trees/ha or 9 square metres/ha basal area.
Classified Field Windbreak	15m x 122m minimum size	Reduce tax liability £1.65/ha assessed value	Free tree seedlings from to state. Spacing 5 x 5m at most. At least 3 rows of trees. Agricultural land only.
Classified Wildlife Habitat	6+ ha <4ha in forest	Reduce tax liability to £1.65/ha assessed value	Balance of land area in wildlife cover or food plots. No crop can be raised.

[1] Actual assessed values for farmland in Indiana range from £13 - 17/ha for taxation purposes. Thus, forestry programmes can reduce taxes by 90%. Farm land prices range from £850 - 4900/ha.

[2] An exchange rate of IR£1 = $1.50 is used in all conversion calculations.

Investment in forestry in Ireland is exempt from income tax and corporation profit tax, and dividends are tax-free to Irish residents. However, losses cannot be offset against taxable income from other sources. Capital gains from the sale of timber by individuals (not companies) are free from capital-gains tax. Standing timber inherited or received as a gift qualifies for agricultural relief whereby the value of the property for tax purposes is reduced by the lesser of 50% or £200,000. Forestry is exempt from value-added tax and timber sold, leased, or conveyed with land is not liable for stamp duty (Gillmor 1992).

Proposed Grant Scheme Changes

Though Indiana and U.S. cost-share programmes change somewhat from year to year, modifications are minor and involve fiscal allocations to states or programmes rather than modifications in programme requirements or restrictions. Ireland's grant schemes, however, are quite dynamic, with improvements implemented during each programme cycle. Grants available to all potential investors in forestry are being increased in the Irish Government's new forestry programme (Table 6). At time of writing, these changes were being proposed to, but not as yet approved by the EC Commission. The largest increase (50%) goes to those planting hardwoods.

Table 6. Proposed 1994 changes in Irish farm-forestry programmes pending EC Commission approval.[1]

Proposed Cost-Share Grants (£/hectare)			
Non-Ag. Land:			1,300
Ag. Land:	Conifers	– Diverse[2]	1,800
		– Non-Diverse[3]	1,500
	Hardwoods	– Oak and Beech[4]	3,000
		– Other Spp.	2,400

Proposed Annual Premiums[5] (£/hectare)					
Farmers:	Non-Ag.Land:			130	
	Ag.Land:	**Conifers**		**Hardwoods**	
		Non-Diverse	**Diverse**	**OakandBeech**	**Other Spp.**
Severely Disadvantaged[6]		155	190	235	220
Less Severely Disadvantaged		190	220	265	250
Non-Disadvantaged		220	255	300	280
Non-Farmers/Companies:	Non-Ag.Land:	Conifers		80	
	Ag. Land:	Conifers		100	
		Hardwoods		120	

[1] Irish Forest Service 1993b.
[2] Less than 60% Sitka spruce or lodgepole pine (*Pinus contorta* Dougl. ex Loud.), and 10% hardwoods where possible.
[3] Sitka spruce and lodgepole pine.
[4] *Quercus* spp. and *Fagus sylvatica* L.
[5] Farmers - payable for 20 years.
Non-Farmers/Companies – payable for 15 years.
[6] Land quality classifications with higher premiums for better quality agricultural land due to higher opportunity costs.

Premiums are also being increased and lengthened, with an increase in the hardwood premium of more than 100%. The objectives outlined by the government are to increase the area under forestry from 7% to 10% of the total land area by the end of the decade, encourage hardwood planting to enhance the environment, improve the welfare of farmers by diversifying agricultural incomes, create over 600 new jobs, and stimulate rural development (Irish Forest Service 1993a).

Conclusions

The variety of grant schemes in Ireland and the U.S. has had mixed success in promoting forestry and aiding rural development. This mixed success is despite the fact that timber production is often more profitable. For example, a hectare of crop land will provide a farmer with a gross income of approximately £500 for corn or soybeans in the U.S. After costs, a net income of £50-115 is realized. Annual payments for forestry in lieu of crop income can well exceed this amount (Table 4). Additionally, Christmas tree income can approach £1000/ha/year after 6-7 years where markets are strong (Parker, pers. comm.). The mixed success of the U.S. programmes is in part due to the objectives of policies, which are designed for agriculture problem resolution, and not forestry per se. Many farmers choose alternate land uses which do not commit their lands for long periods of time. This mental transition from an annual crop to a long-rotation crop is difficult for farmers, with outright resistance by some organized farmer groups. Resistance is due to the fear of the loss of private property rights on land that receives government aid. Such fears have been justified where wetlands, highly erodible land, or endangered species have been involved. Beyond these problems is the lack of funds for large-scale programmes to promote conversion of agricultural land to forest land. Again, a significant challenge is education of the rural landowners as to the benefit of forests for economic and ecological reasons. The grant schemes of Ireland, being designed specifically for forestry development, are much more effective in both the public and private sectors. With larger benefits for farmers, farmland, and hardwoods, Irish policies aid in rural development to some extent and also try to address the imbalance of conifers and hardwoods. Despite these policies, however, evidence suggests that Sitka spruce (*Picea sitchensis* (Bong.) Carr.) is still the most widely planted species (Convery and Clinch, In Press), and it remains to be seen whether the substantial increases in the hardwood grants and premiums proposed in the new forestry programme will have any impact. Ireland has the additional handicap of its colonial history and the value-system of the rural population which associates hardwood trees with British rule and land confiscation. Thus, the Irish challenge is also one of education. To help in this respect, there is a need to develop extension materials for landowners willing to plant conifers and particularly hardwoods. Education and extension will promote forestry in both countries.

But in both countries, promoting forestry will aid those already beginning to undertake such endeavors. These are the innovative farmers, but also the lawyers, businessmen, and other mostly middle-class landowners who have idle investment/family land or whose primary occupation does not require an income from the land. For a farmer to set aside farmland for any length of time precludes an annual income, making any such option unworkable, no matter how attractive the long-term financial gains may be. Short-term income is needed to provide food and shelter for the family. Thus, the forestry programmes in place today in these two industrialized countries will promote forestry over agriculture, but only for those who can afford the conversion. In this regard, the Irish system is much more equitable, as most farmers are eligible for premiums. But for forestry to serve as a true rural development tool, forestry programmes must adapt to allow short-term and medium-term income from the land in concert with long-rotation forest products. Also, systems must be developed, and existing systems implemented, which allow agriculture to mix with forestry in time and space, optimizing the flow of products and cash from a unit of land. These systems are being developed worldwide. The real challenge is to convince traditional farming and traditional forestry advocates that the two can be mixed successfully and be implemented in farm-forestry policy, a formidable task. Simply, forestry as a rural-development tool must consider the farmer as well as the forest.

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Future Options for the Genetic Improvement of Conifers

Part II: Longer-Term Technologies

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Summary

Developments in the areas of micropropagation, "rejuvenation", cryogenic storage, in vitro selection, somaclonal variation, molecular genetics and genetic engineering offer potential new tools for forest tree improvement. Because of the technologies involved, these techniques are not widely employed in tree improvement programmes at the present. This paper summarises the current state-of-the-art of these techniques and provides some suggestions as to how they might be employed in tree improvement programmes in the future.

Introduction

Part I of this paper (Thompson and Pfeifer, 1992) reviewed the current methods used in the genetic improvement of forest tree species, discussed several near-term technologies and suggested how they may be used in tree breeding in the near future (next 5 years). The purpose of this paper is to look further into the future, to review longer-term technologies and attempt to predict how and when they may affect tree breeding in the next 10 years and beyond.

Micropropagation

Micropropagation is a technique that straddles the border between Near-Term and Long-Term technologies. Some applications of micropropagation are already being successfully used in tree improvement programmes, however, their full application to tree improvement will require more time for improvement in the efficiency of the systems and proof of quality and uniformity of the plants produced.

Micropropagation employs the same basic principles as macropropagation (rooted cuttings) except for the fact that the size of the original plant part employed is much smaller (tissues, cells or ultimately a single cell). In micropropagation the small size of the original plant part (explant) requires precise control of both its chemical and physical environment. Cells and tissues are fed with nutrients, sugars and growth regulators under controlled conditions of light and temperature. Plant growth is controlled by the applied plant growth regulators to stimulate shoot or root formation. By regulating the type, amount and sequence of the plant growth regulators, the type of plant growth can be controlled. These methods date back to the late 1930's, but only since the 1970's has there been interest in growing plant cells and tissue in culture for the commercial production of plants. Currently some 212 million plants are produced by micropropagation in western Europe (Pierik, 1990).

Under the general category of micropropagation there are two basic methods which can be used to multiply plants in culture or as it is also known, "in vitro". The first is by a process known as "organogenesis" in which plant organs (shoots and roots) are induced to form. This is basically a multi-step process consisting of (1) culture establishment, (2) bud induction, (3) shoot elongation, (4) root induction, (5) root elongation and (6) transfer to soil. Each step requires a different growth regulator treatment and all manipulations are done by hand in a sterile environment. This results in micropropagated plants which are more expensive to produce than by conventional seed or cutting propagation methods.

The main advantage of micropropagation is in the number of plants it can produce. Ideally with seeds or cuttings, each seed or cutting will produce only one plant. In micropropagation each culture produces several shoots, which can be divided and induced to multiply and produce more shoots. Typically woody plant multiplication rates in culture vary between 3 to 10 shoots per original shoot, depending on the species (oak=3, cherry=10). Another advantage is that the cycle can be repeated indefinitely. Thus, at least in theory, the number of plants produced from one original explant would be unlimited.

Organogenesis is usually most easily accomplished with juvenile tissues. Embryos are removed from ungerminated seed or very young (2 to 4 week-old) seedlings and used to initiate cultures. Unfortunately material of this age has not yet demonstrated it's genetic potential. Only by using seed resulting from controlled crosses of two parents that are known to produce high quality offspring can improved performance be assumed.

The major disadvantage of micropropagation is that it is a very labour intensive process. Labour typically accounts for 60 to 75% of the production cost of micropropagated plants. Of the total 212 million plants multiplied in tissue culture mentioned above, only about 1.3 million are forest trees, mainly broadleaf species (oak, cherry and birch) for horticultural purposes. Only very high value material or species that cannot be propagated by conventional means can afford to be propagated in this way. Commercial propagation by organogenesis is difficult to justify economically because of the low cost of conventional forest tree seedlings. There have been attempts to automate the micropropagation process including the use of robotic manipulators to reduce labour costs, but this work is only in its early stages. It is both quite complex and very capital intensive.

In most cases the high production costs of plantlets produced by organogenesis means that they will not be used directly in the production of forestry planting stock on a large scale. One exception to this is the Monterey pine (*Pinus radiata*) organogenesis system employed by Tasman Forestry Ltd. in New Zealand (Gleed, 1991). Alternatively, micropropagated trees could be used to produce stock plants which are grown to provide cuttings for rooting in traditional ways (John and Mason, 1987). This would reduce the amount of time required to produce a large number of genetically improved plants for trials and also spread higher propagation costs over a larger number of plants.

Nevertheless, reasonable numbers of plantlets of a number of forest tree species have been produced since the mid 1970's. Currently about 1.25 million micropropagated birch plantlets are undergoing field trials in Finland (Jokinen *et al.*, 1990). Among the conifers there are probably more than 10,000 loblolly pine and 5,000 Douglas- fir plantlets in the U.S., several thousand maritime pine and coastal redwood plantlets in France and about 10,000 Monterey pine in New Zealand, all produced by organogenesis. In general, the field performance trials of this material have shown that after

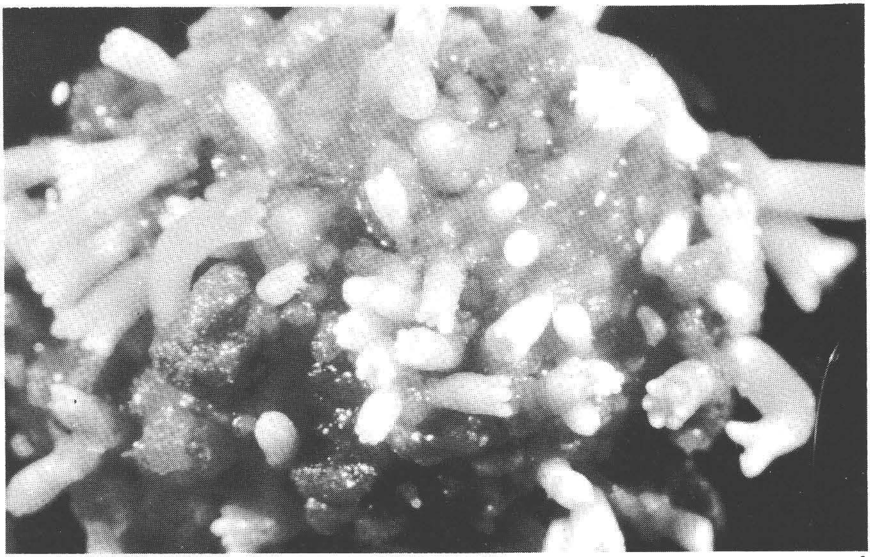

Figure 1. Developing somatic embryos of Sitka spruce (*Picea sitchensis*) on a mass of embryogenic callus initiated from a zygotic embryo.

a longer establishment time than seedlings, the micropropagated conifers grow at an annual growth rate comparable to the seedling controls (Ritchie and Long, 1986; Amerson *et al.*, 1987).

In addition to organogenesis, a second type of micropropagation is known as "somatic embryogenesis". In this process ordinary cells of the plant (somatic cells) are made to mimic the cells in a seed to produce structures that look and act like embryos. Although this process has been possible in some plant species since the late 1950's, it has only been possible in the conifers since the mid–1980's. In this process, zygotic embryos are removed from seeds and placed in culture. Under the influence of certain combinations of nutrients and growth regulators, special cells are formed which mimic zygotic embryo formation in seeds. Somatic embryos have shoots and roots which are formed in one step, rather than the several steps required in organogenesis. Because the process is simplified, production costs for somatic embryos should be less than for plants produced by organogenesis. Somatic embryos can also be produced in liquid media in bioreactors similar to those used to grow large amounts of bacteria. In Norway spruce it has been estimated that one liter of embryogenic cells would contain between 50,000 and 100,000 somatic embryos. Taken together the scale-up possibilities and the opportunity to reduce labour costs make this process very attractive. The process of somatic embryogenesis in conifers has been reviewed recently by Tautorus *et al.*, 1991 and its potential commercial application to forestry by Gupta *et al.*, 1993.

Currently there are small field trials of conifer somatic embryos of Norway, interior and Sitka spruce, Douglas-fir, loblolly pine and Monterey pine at various stages of testing in Europe, North America and New Zealand. None of these trials is more than a few years old and results to date show normal growth, but several years of field growth and detailed genetic analysis will be necessary to confirm that there are no problems with the propagation method. The largest field trials are with Norway spruce in the United States where some 3,000 somatic embryo plantlets are undergoing tests (Gupta *et al.*, 1993). At present this techniques is successful with embryos from seed and needle tissue form seedlings up to 12 months old (Ruaud *et al.*, 1992). Attempts to extend this ability to tissues from mature trees of proven superior traits are in progress.

"Rejuvenation"

Because both rooted cuttings and micropropagation (organogenesis and somatic embryogenesis) are most successful in very juvenile tissues (excised embryos or young seedlings), attempts have been made to try to "rejuvenate" tissues of mature, proven superior trees by returning them to their responsive, juvenile condition. In nature mature trees "rejuvenate" themselves when they flower and produce seed which is juvenile. It may be that if mature tissues can be induced to form somatic embryos in culture they will have undergone "rejuvenation".

There are several claims of "rejuvenation" of mature tissues by growing them for extended periods of time in culture. These claims, however, are based on the morphological appearance of the plants. The fact that a plant "looks juvenile" is not enough to claim true rejuvenation. Aging or maturation is a change in a number of characteristics which include the ability to form roots, leaf or needle morphology, bark characteristics, growth rate, occurrence of plagiotropic growth, flowering ability and several other characteristics. These characteristics may change at different rates as the plant ages almost as if they were regulated by different internal clocks. For example, changes in leaf morphology usually occur long before the onset of flowering in many woody species. Claims of "rejuvenation" are usually based on a change in only one of these characteristics. In order for rejuvenation to be practical, all characteristics should be returned to the juvenile state. If complete rejuvenation is possible, then material from selected, tested superior individuals can be rapidly multiplied by vegetative propagation (rooted cuttings or micropropagation).

Cryogenic Storage

If true "rejuvenation" is not possible, either in the short or long term, then a system that would allow for storage of material in a state where it will not age or mature would provide an alternative solution to the problem. One way to accomplish this is by cryogenic storage of tissues at liquid nitrogen (−196° C) temperatures. In this way both organogenic tissues (Toivonen and Kartha, 1989) and embryogenic tissues (Kartha *et al.*, 1988) have been stored for extended periods of time. Using this method a tissue sample would be divided with one half used to regenerate plants by organogenesis or embryogenesis and the other half stored in liquid nitrogen. After the necessary period of field testing (6 to 15 years), the best individuals would be identified and tissues could be retrieved from cryogenic storage and multiplied to produce "field tested" superior material.

In Vitro Selection

In screening trials, large numbers of seedlings are exposed to a selective agent and the resulting "tolerant" or "resistant" individuals are isolated (De Souza *et al.*, 1990). An alternative method is to grow large numbers of cells in culture and expose them to a selective agent. Examples include selection for resistance to pathogens and stress. Families of larch have been screened in culture for resistance to the fungal pathogen *Mycophaerella* which correlated well with field performance results (Ostry *et al.*, 1991). Loblolly pine families have been screened in culture for the ability to survive drought which also correlated well with field performance of the same families (Newton and van Buijtenen, 1986). In vitro screening could provide a first screening of genotypes which might help reduce the number of individuals in field trials. It is important to remember, however, that in vitro screening cannot replace field testing.

Somaclonal Variation

Plant cells when grown in an unorganized condition in culture for long periods of time may develop changes in gene expression for a variety of reasons. This type of variation is known as "Somaclonal" variation (*somatic* or body cell). These changes may result, in some cases, in useful new genotypes. An example of this is *Populus* resistance to a leaf spot disease caused by the fungi *Septoria* which was generated in culture (Ettinger *et al.*, 1985). Another example is the selection of cherry cells that are tolerant to salt and drought stress and the regeneration of tolerant plants (Ochatt and Power, 1989). Somaclonal variation may prove to be very useful in species where genetic variation is limited, such as many agricultural species. Its usefulness in genetic improvement of forest trees remains to be demonstrated, where it can be argued that there is still a large amount of under-utilized genetic variation in the "wild population". Thus the utility of somaclonal variation in tree improvement programmes will require additional time to demonstrate its potential.

Basic Genetic Knowledge

Our basic understanding and knowledge of the genetics of all forest tree species is very primitive compared to the situation in agricultural and some horticultural crops. We know how many chromosomes are present in the normal diploid level in all major species, but beyond that we know very little. The reason for this is that we are working with essentially a wild population much like all agricultural crops were several thousand years ago. Forest trees have not undergone the extensive inbreeding work to produce homozygous lines that has occurred in most agricultural crops.

One of the reasons why interest in biotechnology and molecular biology is so high in forestry is because, rather than being 50 to 100 years behind agriculture, forestry is perhaps only 10 or 20 years behind in biotechnology and the chance of keeping up is much better than with conventional breeding.

Molecular Genetics

Genetic selection probably first began when primitive man collected and planted seeds from plants that had characteristics he could use. The concept that information on chromosomes in the nucleus of the cell determines how a plant will look or act only helped to explain what man had already been doing for thousands of years. The discovery in the 1950's that DNA was the key chemical mechanism for encoding this information has led to the age of biochemical or molecular genetics. In spite of these discoveries, advances in forest genetics and tree improvement have continued to progress at a slow pace. This is mainly because of the long time required to breed trees and the resulting lack of knowledge of the basic inheritance patterns of major traits in forest trees. In contrast, one of the plant species that is being used today in plant molecular biology experiments is *Arabidopsis thaliana* which can be grown from seed to flowering plant producing seed in 28 days.

Much work has been done in forestry using plant metabolites as indirect indicators of their genetic background. Terpene analysis allows the identification of population origins of certain species (Forrest, 1990).

The study of genetics at the molecular level offers an opportunity to study the mechanisms of inheritance at the finest level of detail. One aspect of this work attempts to develop libraries of genetic information. Because there is so much information in the DNA of living organisms it is necessary to cut it using enzymes into more manageable segments for study. To develop a library covering 99% of the human genome would require 800,000 DNA segments. In order to cover the genetic information of a black spruce (*Picea mariana*) at the same level, it would require 3.2 million DNA segments (Cheliak and Rogers, 1990). The conifer genome is one of the largest, probably as a result of its ancient ancestry.

The DNA in cells is "translated" into proteins which have either structural or regulatory functions. These regulatory proteins are known as enzymes. Comparing differences in the same enzymes between individual plants (known as isozyme or isoenzyme analysis) has been used as a tool in forest genetics for many years. Its major use is in identifying cultivars (Tobolski and Kemery, 1992) as well as mislabelled seed lots. It has also been used in checking the purity of seed orchard seed by detecting foreign genotypes that could only be accounted for by pollen from outside the orchard, as well as determining evolutionary relationships between species of forest trees (Szmidt and Wang, 1993).

Rather than attempting to look at the entire genome of the conifers it is also possible to look only at genes that are active during certain stages of development in the life of the tree. For example, it is possible to look at the genes or gene products (messenger RNA) which are active only when the tree is forming flowers or seed, forming roots, breaking buds, etc.

This information can also be used to compare differences in the DNA fragments and see how they differ between individuals. These fragments differ in size and can be separated by gel electrophoresis and will produce a pattern unique to that individual. Any change, such as a mutation, will result in a different pattern. This type of analysis is known as Restriction Fragment Length Polymorphisms or RFLP. Neale and Williams (1993) have recently published a review of RFLP technology and how it could be used in tree improvement.

RFLP techniques can be used to identify the location of specific genes within the genome. They cannot recognize the gene itself but can tell where it is located within the total genetic information of the individual. This information can produce a "genetic map" of a species by comparing differences in RFLP patterns between individuals with known different genetic traits. In human genetics similar maps provide the ability to estimate the relative risk of producing an offspring that would have a possibility of certain genetically controlled disorders.

In most plants, major traits are controlled not by one gene but by several different genes in different locations known as Quantitative Trait Loci (QTL). In tomato it has been found that 6 specific QTL control fruit size, 4 other QTL control the solid content of the fruit and 5 QTL regulate the acidity of the fruit. These are important characteristics in breeding tomato fruit with desired characteristics. Now that these QTL are known, breeding programmes can more effectively work to develop new tomato varieties with special characteristics. At present no QTL are known in any woody species, but within the next few years this could become an important tool in tree breeding.

RFLP technology can also provide a way to identify families, or clones by looking at their unique genetic "fingerprint". In this way it will be possible to check "superior" material is indeed what it is purported. Certain artificial sequences can be inserted into a genotype to act as "signature" or "logo" should there be a dispute over ownership or origin of genetic material. An example of this is the identification of *Cornus* genotypes using DNA patterns or "fingerprints" (Culpepper *et al.,* 1991) and to distinguish between species where morphological characteristics may not be reliable (Bobola *et al.,* 1992).

Genetic Engineering

The goal of all breeding is to identify beneficial genes and bring as many of them together in one individual as possible. Selective breeding is one way to accomplish this, but it is slow, especially with forest trees. Since the 1970's techniques have been developed that speed up this process. They involve the identification, localisation and isolation of genes for specific traits using some of the techniques previously described. Recent reviews of transformation and genetic engineering in woody species have been published by Manders *et al.* (1992) and Schuerman and Dandekar (1993).

Once a gene for a desired trait is known and has been isolated, it is necessary to insert it into the target plant. There are several methods to do this, one of which involves a naturally occurring soil bacterium called *Agrobacterium tumefaciens* which causes the crown gall disease on plants. This organism has developed a method to insert its genes into a plant host.

The desired gene is inserted into a special region of the bacterial genome which is inserted into the host plant genome when it is inoculated with *Agrobacterium.* Unfortunately some conifer species appear to be quite resistant to *Agrobacterium* infection, so other methods may be necessary.

Another method uses plants cells in culture which have had their cell walls removed by an enzyme. These plant cells, called protoplasts, are surrounded only by their cell membrane, and are either injected directly with the foreign DNA or, they are placed in an electric current which encourages the uptake of the foreign DNA (electroporation). The limiting factor with protoplasts is the ability to produce protoplasts which can be treated and then regenerate complete plants from the protoplasts. Currently this is not possible with all species of plants and the conifers are among the most difficult to regenerate from protoplasts.

Perhaps the most dramatic method for gene insertion is the "biolistic" or "gene gun". This method uses microscopic gold beads which are coated with the foreign DNA which are fired into the cells. The beads penetrate the cell and place the gene directly into the cell close to the nucleus. This method avoids problems of regeneration from protoplasts because almost any type of tissue can be treated including intact zygotic embryos. Thus, the method of inserting foreign DNA into cells is no longer the limiting factor in genetic engineering.

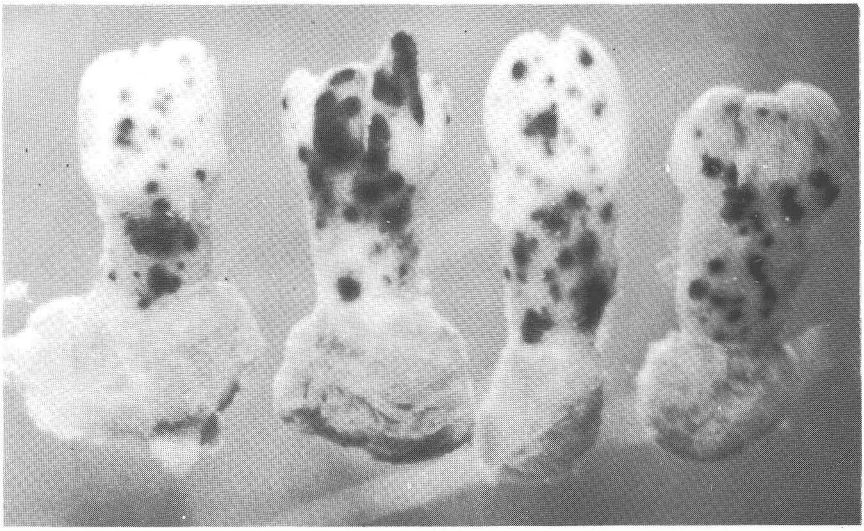

Figure 2. Transient GUS (ß-glucuronidase which produces a blue pigment in transformed cells) expression in white spruce (*Picea glauca*) zygotic embryos following gene insertion using particle accelation ("gene gun") methods.
(Photograph courtesy of Dr. David Ellis, Department of Horticulture, University of Wisconsin, Madison, Wisconsin, USA).

Genetic engineering, like so many things, is not as simple as it first appeared. At one time just getting the foreign DNA into the cell was believed to be the major stumbling block. Once this was accomplished getting the foreign DNA to insert itself into the host DNA became the problem. Once it was inserted, questions as to how to regulate the expression of the gene arose. Most processes in biological systems are "turned on" and "off" at the appropriate times during development and are not "on" at all times. For example, hybrid poplar trees that contained a foreign gene coding for proteinase inhibitors to confer resistance to *Septoria* leaf spot had significantly less total basal diameter growth as compared to the control plants after two years in the field (McNabb *et al.,* 1991). Just how to regulate expression of these foreign genes may prove to be a *very* formidable task.

Exactly which genes to insert into the engineered plant pose another set of problems. The obvious traits to incorporate into genetically engineered trees such as growth rate, wood production, disease resistance etc. are usually traits that are regulated by several genes. At present, methods for the insertion of foreign genes are limited to one gene at a time. Thus, in addition to the complexity of isolating the series of genes involved in a certain process, there is the technical problem of inserting them one at a time.

In the conifers, very few single gene traits are known. Among these are a gene for resistance to white pine blister rust, synthesis of specific monoterpenes and the narrow crown form of Norway spruce. Unfortunately, although there is evidence that each of these traits is controlled by a single gene, none of these genes has been identified or isolated. Most of the genes that have been inserted into woody species are marker genes used to demonstrate the successful insertion and expression of the gene such as antibiotic resistance genes ((Charest *et al.,* 1991), a gene that produces a blue pigment in cells (Duchesne *et al.,* 1991; Goldfarb *et al.,* 1991; and Stomp *et al.,* 1991) and the gene for firefly luciferase (Campbell *et al.,* 1992).

Genes for insertion into conifers are not be limited to genes isolated from conifers. A bacterial gene for resistance to the herbicide glyphosate resulted in tolerance to this herbicide when inserted into a hybrid poplar clone (Riemenschneider *et al.,* 1987). Protoplasts of conifer embryogenic cells have been inserted with foreign bacterial genes that serve as markers of transformation. To date, there has been only limited or "transient" expression of these genes in conifers (Tautorus *et al.,* 1991). Current genetic engineering research projects include insertion of genes for insect resistance (Strauss *et al.,* 1991), drought tolerance (Newton *et al.,* 1991) and wood formation (Whetten and Sederoff, 1991) as well as studies of genes resulting in maturation (aging) (Hutchinson and Greenwood, 1991) and photosynthesis (Gustafsson *et al.,* 1991).

Figure 3. Glyphosate resistance clearly demonstrated. Poplar plants with the resistant gene in the background. Normal stock in the foreground.

Conclusions

Due to limited space the techniques discussed in Part I and II of this paper were arbitrarily divided along the line of when a technique would likely be ready for use in tree improvement programmes. An arbitrary dividing line of within or beyond 5 years was selected. Some of the techniques that have fallen into this long-term group are already being used. Micropropagation is a good example of this. Micropropagated Monterey pine are already in the field in New Zealand and somatic embryos of interior spruce are in field trials in Canada. Most of the other techniques are only being used at the research level at this time, but predicting how long they will take to reach general use is difficult.

Cold storage or cryopreservation (storage at liquid nitrogen temperatures of −196° C) of organogenic or embryogenic cultures may permit storage of valuable genotypes in a stable, propagatable state while they are being field tested. In addition, if "rejuvenation" methods can be proven to be effective this will permit the propagation of mature tested superior individuals, initially by rooted cuttings, and perhaps later, by micropropagation.

In vitro selection techniques offer a more effective and faster way for the selection of genotypes with certain desired characteristics. The selection techniques need to be correlated with field trials to prove their effectiveness. The use of somaclonally derived variations will require more diligent evaluation. The fact that the variation originated during the culture period means that other undetected variation may also exist. This will require extensive field testing before it can be incorporated into propagation or breeding programmes.

Isozyme, and in the future, RFLP techniques will undoubtedly add to our basic understanding of conifer genetics. Isozyme pattern studies are presently used to determine the purity of seed being produced from seed orchards. They have also allowed studies of the inheritance patterns of Douglas-fir which led to the discovery that cytoplasmically inherited traits were passed through pollen, rather than the egg, as would be expected (Neale *et al.*, 1986). This rather unexpected observation is typical of the type of unexpected and potentially important information provided by molecular genetics. Unfortunately many of the advances made in agricultural crops such as the identification of Quantitive Trait Loci for important traits await information on inheritance patterns in conifers, which is presently lacking.

Plant genetic engineering will undoubtedly be among the last of the techniques discussed in this paper to become tools in tree improvement programmes. This is because of two main facts. The first is technical problems with the expression of foreign genes in conifers. Only transient expression has so far been observed. Whether these will in fact be temporary problems or long term problems remains to be seen. Conifers are very sensitive to changes in the amount of DNA and a doubling of the DNA levels (polyploidy), or reducing it by half (haploidy), results in severe reductions in growth rate, unlike the response of angiosperms. Admittedly this is a rather large change of DNA levels in these cells. In Douglas-fir the addition of one additional chromosome results in a change in morphology, growth rate and reduction of flowering. The effect of inserting a single gene has yet to be demonstrated.

The second problem with genetic engineering will be the long time required for field testing of the engineered plant. Unlike agricultural crops where the life cycle of the plant requires only a few months, the time required to determine that there are no serious problems or side effects of the engineering process will take probably 15 to 20 years. Thus, a genetically engineered trait must be very beneficial to be useful after all the time required for testing. The ecological implications of biotechnology in forest ecosystems have recently been reviewed by Duchesne (1993).

The first paper in this series ended with a quotation from Faulkner (1981) saying that forest genetics could be likened to " . . . the use of the broadsword to crudely reduce the breeding base to a manageable size, then to use a scalpel to refine existing and develop new techniques . . ." for continued improvement. Certainly, when we think about the longer-term potential uses of biotechnology in forestry, we are approaching the level of the scalpel, if not the laser to refine our technique.

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Harvesting Coillte's Forests: The Right Tree at the Right Time

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Summary

Coillte Teoranta harvested approximately 1.4 million m^3 of timber in 1990. By 2010 this annual harvest volume will increase to 3.5 million m^3. This increased harvest volume, which largely will have to be exported, either as finished products or as round timber, has focused attention on the necessity for efficiency and rationalisation in the overall timber industry. The Department of Forestry, University College Dublin, in co-operation with Coillte, has developed a number of prototype planning procedures, designed as decision-support tools for forest management. Their main function is to illustrate the possible benefits to the company of the integration of operations research techniques in both operational and strategic planning procedures. The area that this paper focuses on is timber allocation and transportation. Past procedures, changes that have been made up to the present and proposed future developments are illustrated with the aid of hypothetical examples, using data from Coillte's data bases.

1. Introduction

Two developments have emphasised the importance of efficient timber harvesting and allocation procedures.

Firstly, in 1989 the state Forest Service was transformed into a commercial semi-state company, Coillte Teoranta. The long-term viability of the company requires the existence of a cost-efficient and profitable timber processing industry, capable of competing on export markets. The processing industry needs a timber producing industry which delivers raw material in the right form at the right time in the right place at the right price. As part of an industry-wide rationalisation process which is taking place, Coillte has targeted the areas of harvesting and transportation for efficiency improvements and cost reductions. One specific area where efficiency improvement possibilities have been identified is in the transportation of raw material from forests to processing locations. Both the reduction of transport distances, and the allocation of specific products to the appropriate mills should be targeted in any cost reduction strategies.

Secondly, as a result of past planting and management schedules, the annual timber harvest volume in Coillte's forests will increase from 1.4 million m^3 in 1990 to 3.5 million m^3 in 2010. This rapid increase necessitates improved planning and scheduling procedures in order to benefit fully from the improved flexibility and expanded processing alternatives which this expansion offers. Existing industries will increase production capacities and new operations will be introduced. In order to ensure a structured and organised approach to this expansion and introduction of new processing capacity, integrated management procedures and planning tools are required to examine the impacts of various strategic decisions both on the industry as a whole and on individual mills.

This paper presents an overview of work done in the Department of Forestry, University College Dublin on the development of a prototype integrated harvest scheduling and timber allocation decision support system for operational and strategic planning in Coillte Teoranta. The paper sets out the past, present and proposed future decision-making structures and highlights areas where the developed decision support system could be of use. The first two sections deal with the harvest and sales planning procedures as operated by the company till recently. Further sections will discuss developments, both implemented and proposed, to these planning processes.

2. Harvest Planning

The basis of Coillte's timber supply planning is a detailed sub-compartment forest inventory. This contains details on species, planting year, yield class, stocking etc. This attribute data, together with the associated spatial data, is stored and manipulated in Coillte's Geographic Information System (GIS) (Dodd, 1991).

A thinning regime and rotation length is prescribed for each sub-compartment by the forest manager. A Forest Investment Appraisal Package (FIAP) is available at this stage to evaluate a number of feasible management alternatives (Harper, 1988). The alternative which appears to best meet management objectives can then be selected.

The inventory data, thinning and rotation classifications, and yield models are used to produce a twenty year inventory forecast. The output of the inventory forecast then undergoes a smoothing process and production targets for the first five years are produced.

With the aid of Coillte's GIS, sub-compartments which are due for thinning or clearfell in the planning period are indicated. The forest manager then draws up sales proposals by grouping stands due for production into saleable lots. At the regional level, the regional manager will be assisted in this process by the regional marketing manager. The sales proposals are then input to the harvest forecasting procedure to produce a five year production forecast. The first year of the planning period is known as the harvest programme year. Further information regarding terrain conditions and timber quality, volume and size are collected for the programme year and a harvest schedule is produced.

3. Sales Planning

The harvest schedule is then handed over to sales and marketing personnel who are responsible for linking the supply and the demand. This process involves the balancing of the products that are wanted by the timber processing industry with what is available from the forests. Products are defined based on the timber quality and volume in each top diameter category. A price is then assigned to each product. Sales proposals are sub-divided into homogenous sales (usually one product per sale). Each sale is then assigned a method of sale and /or customer.

The combined harvest and sales planning procedures were basically sequential, with very little opportunity for back linkages and iterative processes, often resulting in inefficient use of timber resources. An

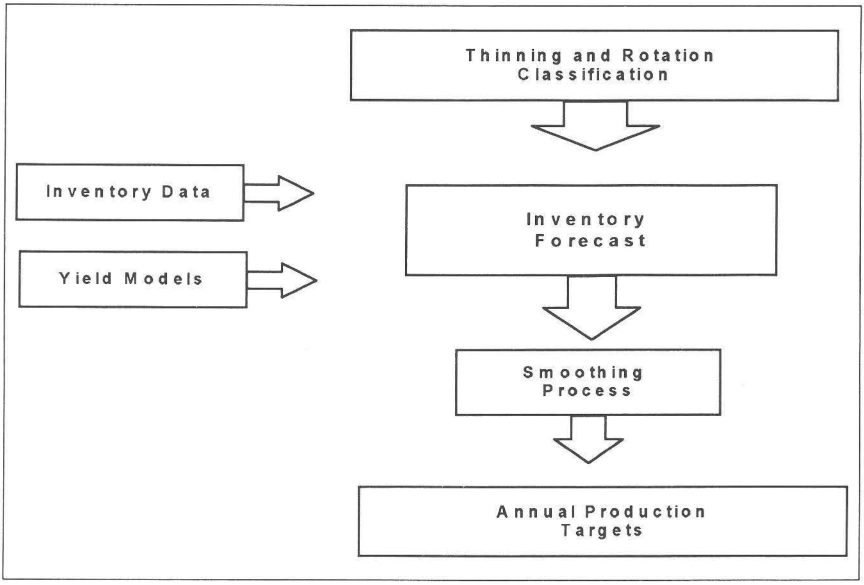

Figure 1. Data sources and procedures used in the setting of annual production targets.

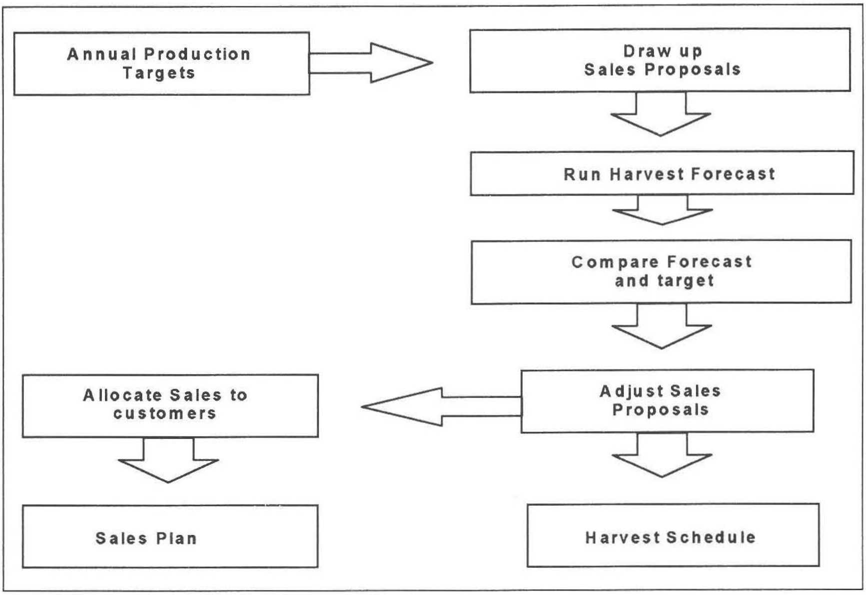

Figure 2. The steps in the decision process from production targets to harvest and sales plans.

overview of the planning process is given in figures 1 and 2. A detailed discussion of the procedure can be found in an article by O'Brien and Phillips (1991).

4. Present Situation

Two important improvements have been identified in the decision-making process (see figure 3 for a schematic overview). First of all, the process of reconciling actual production with production targets has been redesigned and the user has been given the opportunity to investigate large numbers of management alternatives with very little effort. In order to make this possible, two modifications were introduced. Firstly, the forecasting procedure was completely redesigned and expanded, incorporating up-to-date growth functions and assortment tables. Secondly, the forecasting module was integrated with the company's existing operational Forest Management Information System (FMIS) data bases. The result of these modifications makes it possible to advance or delay the harvesting of sales proposals by simply changing the production year in the data base, automatically adjusting harvest volumes and classes in the forecast accordingly.

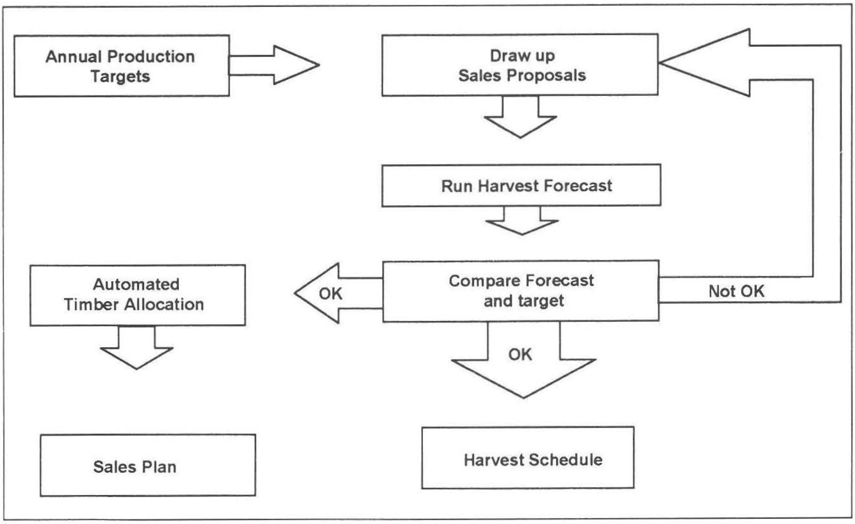

Figure 3. Modified decision process, including the iterative harvest forecast procedure and the proposed automated timber allocation procedure.

The second important area of improvement concerns the allocation and transportation of timber from forests to mills. The next sections of this article describe a prototype automated timber allocation procedure developed by the Forestry Department, UCD. Both the development work and the possible benefits of the procedure for the company are discussed. At the moment the procedure, together with a number of alternatives, is being evaluated for use during the annual sales allocation process. However, the procedure has been used in a number of cases as a tool for strategic decision-making within the company.

When examining Coillte's timber sales plan for 1991, the importance of the development of a systematic allocation procedure becomes apparent. The sales plan consists of 2674 sales in 245 forests, each sale consisting of up to 6 species and 5 assortments, giving a possible total of 30 supply categories per sale. Taking only the 20 largest sawmills and wood processing plants into account, each with up to 10 demand categories, the task of allocating the volumes in the supply categories of each sale according to the specific demands of the mills in each demand category in a cost effective manner, becomes impossible without the use of computerised Operations Research (OR) techniques (Nieuwenhuis, 1989).

The objective of the allocation procedure to be developed was the optimal allocation of the timber in the forests to the processing locations, constrained by supply and demand restrictions for each of the product categories considered. The term 'optimal allocation' can have a number of different meanings, depending on the angle of approach to the problem. Possibilities include: transport cost minimisation, profit maximisation, and harvest cost minimisation. The developed procedure minimises the transportation cost, as this was considered the most variable cost when linking forests and mills. Additional constraints may have to be introduced in relation to restrictions imposed by the transportation network, such as truck weight and size restrictions. A wide range of factors has to be considered in trying to optimise the transportation aspects of forest operations. The most important cost factor involved is the product of volume transported times the transport distance (i.e. m^3*mile or m^3*kilometre). By minimising the sum of all m^3*kilometre values for all allocated products in all sales, the main factor determining overall transport cost has been minimised. The impact of backloading on the overall transport cost is not taken into account by the model. The developed model consists of three parts: the Input procedure, the Allocation procedure, and the Output procedure (Williamson, 1991; Williamson and Nieuwenhuis, 1991).

4.1 Use of the allocation model for operational planning

4.1.1 Comparison of actual and optimal timber allocation strategies for 1990

To quantify the potential reduction in total transport distance and associated transport cost obtainable by using the timber allocation model, the "actual" and "optimal" allocation strategies for 1990 were examined. Summary results of the 1990 sales allocation, for transport distance, are presented in figure 4. A reduction in average transport distance from 79.2 km to 48.8 km was shown to be feasible, a 38 % improvement. This corresponds to a possible reduction in transport cost of up to IR£1,000,000. It has to be emphasised that the "optimal" allocation only is optimal in relation to the **transport distance.** Additional costs, and operational and tactical constraints such as timber quality, machine scheduling and site access, will make it impossible to implement this allocation strategy without modifications. The influence of these modifications on the overall cost structure can however be quantified and, as a result, informed management decisions with respect to the company's sales allocation and transport policy can be made.

4.1.2 Selection of suitable ports for export sales

Because of an over-supply of small timber, Coillte currently exports approximately 120,000m^3 of pulpwood per annum. Ports with their timber handling facilities and capacities were included in the network and a series of analyses was performed, using various export quality and quantity assumptions, to determine the best possible combinations of sale allocation and port selection to facilitate a range of export volumes and destinations.

4.1.3 Rail transportation of round timber

The use of rail transport for long distance movement of timber has been studied. The rail network, including loading and unloading facilities and linkages with the road network, has been integrated in the overall transport network. Because of uncertainties in relation to handling and associated costs, and the present infeasibility of introducing rail transport on a viable commercial scale, this aspect of the transport analysis was not studied in depth. It is envisaged, however, that rail transport will become a viable alternative in the near future.

4.2 Use of the allocation model for strategic planning

For strategic planning purposes, the level of detail does not need to be, and in most cases can not be, as great as for operational planning. Consequently the original model was modified slightly to allow it to be used to assist in strategic planning (Williamson and Nieuwenhuis, 1993). Medium to long-term timber forecasts were used as the timber supply data as opposed to actual timber sales. Timber supply data were available by 1 kilometre National Grid co-ordinates, but in order to reduce the problem to a manageable size, the timber supply data were aggregated to 10 kilometre National Grid squares. The timber supply was assumed to originate from the centre of each grid square. In addition, the timber supply was subdivided into only three products (i.e. pulp, pallet and sawlog).

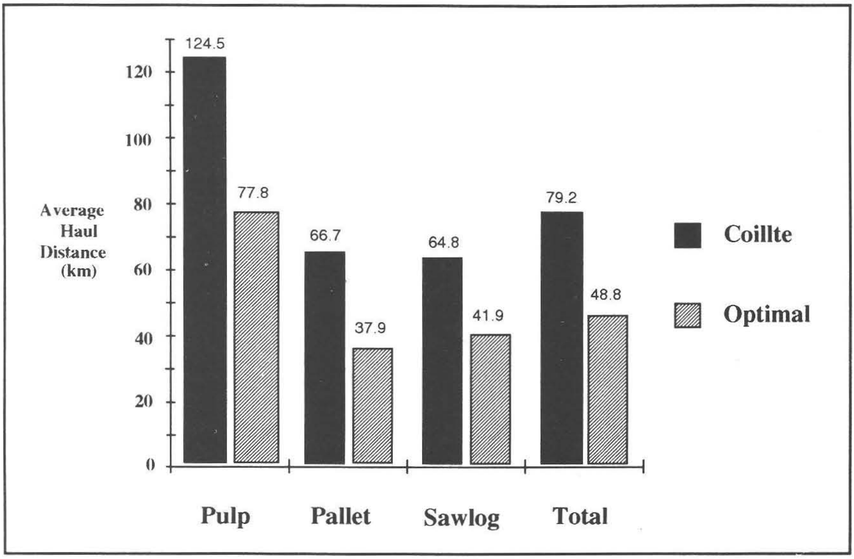

Figure 4. Actual and optimal average haul distances for 1990 allocations of pulp, pallet and sawlog. Total volume allocated is 957,534 m^3.

4.2.1 Location of New Timber Processing Industries

The possible introduction of any new timber processing industry into the country will make it necessary to investigate the influence of the location of these plants on the overall timber transport situation. Although the final decision on the location of such industries depends on many factors, such as land availability, infrastructure, grants, the type of production process, long-term timber production forecasts, processing capacity of the proposed plant and political pressures, the inclusion of transport analysis in the decision making process is important, both for existing industries and the planned mill. In conjunction with the spatial analysis capabilities of the GIS and with projected timber forecasts, a number of areas or zones where there will be concentrations of timber production in the future can be identified. In addition, by examining other factors such as proximity to ports and markets, a short list of possible processing plant locations can be produced. The allocation model can then be used to analyse the influence of the siting of such a plant, at each location, on the overall transport cost for the industry as a whole and on the cost changes for individual mills.

The results of an example transport analysis are presented in Figure 5. A pulpwood mill with a capacity of 150,000 m^3 was introduced at two possible locations: A and B. The influence of the location of the new mill on both the new mill's transport cost as well as the transport cost of existing mills, was analysed. The results show that location A is preferred, both with respect to the average transport distance of the existing industries and of the new mill. This advantage of location A with respect to transport costs has to be weighted against the other factors before the best location for a new timber processing industry can be determined.

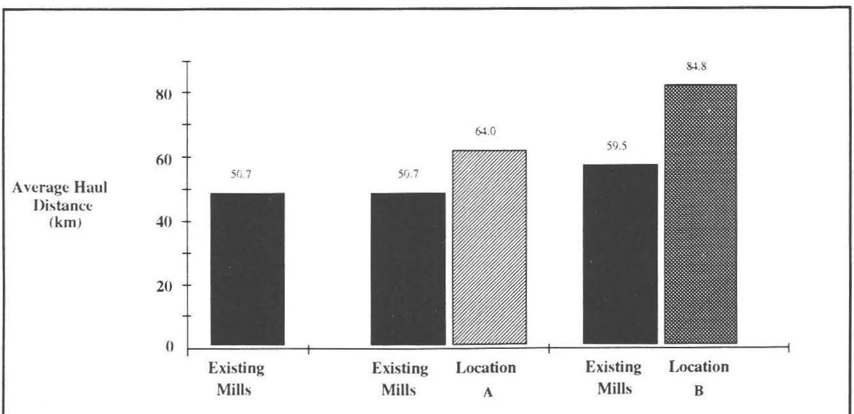

Figure 5. A comparison of average haul distances for two possible pulpmill locations.

4.2.2 Rationalisation of the Irish timber processing industry

The volume of Coillte's annual timber harvest is increasing each year. In 1990 Coillte harvested approximately 1.4 million m^3 of timber. By 2000 this annual harvest will increase to just over 2.6 million m^3, and further increase to 3.5 million m^3 by 2010. This increase in timber supply will require a corresponding increase in processing capacity and markets for the processed timber. A study was commissioned to evaluate the state of the Irish sawmilling industry and make recommendations for its future development. The resulting report concluded that there was a strong need to develop export markets and that Irish mills have under-utilised capacity which decreases their cost competitiveness. The report stressed the need to establish an Irish based export market consortium and consolidate and rationalise the sawmilling industry, if Irish mills are going to stay competitive in the export markets (Simons, 1991). Consequently, Coillte and the Irish Timber Council have been co-operating in the preparation of a programme for a structured approach to the expansion and rationalisation of the industry.

The developed timber allocation and transport analysis procedure could be of major use to the overall industry in the process of investigating changes in plant locations and capacities. The impact of the location of new timber processing industries on the transport cost of the overall industry has been discussed in the previous section. But other possibilities, such as changes in capacities of existing plants, can be analysed and quantified in relation to the effect on individual mills and, more importantly, on the overall displacement in the industry.

In an evaluation of the usefulness of the timber allocation procedure in this rationalisation process, it was used in an iterative manner to analyse the consequences of a number of demand/supply scenarios from a timber transportation point of view. The principle objective of the analysis was to investigate the sensitivity of timber transportation costs to processing capacity concentration. Results indicated that, depending on the mill location in relation to other mills and to timber supply, a relatively small change in mill capacity can have major impacts on optimal transport patterns (i.e. on the optimal catchment areas). However, the impact on the overall transport cost is in most cases relatively small. Because of the impact of supply and demand patterns on the industry as a whole, this information is of major significance when rationalisation decisions are made on the best location for processing capacity concentration. Although the rationalisation of the timber processing industry depends on many other factors, the benefits of performing such a transport analysis are that the effects of proposed decisions can be quantified. This allows an objective informed decision, as regards transportation costs, to be made. In addition, many of the other factors, assuming they are quantifiable, can be included in this type of analysis procedure.

5. Future Situation

At present the decision-making process is almost completely a sequential one, allowing for very little optimisation through iterative procedures. Any modifications that are made in the harvest forecast, using the new forecasting module, are done on a trial and error basis without the aid of a system to indicate the best course of action consistent with management objectives. In addition, the harvest schedule is drawn up rather independently from the sales plan.

Integration of these planning processes will allow for optimisation over time. An important consideration in the harvest scheduling process is the spatial distribution of the timber supply and demand. A study is being embarked upon to assess the feasibility of developing a system to assist in the temporal and spatial scheduling of timber harvests in an optimal fashion. See figure 6 for a schematic outline of the proposed decision steps.

Such a system has far reaching implications and would impact significantly on the work practices and procedures currently in place in the company.

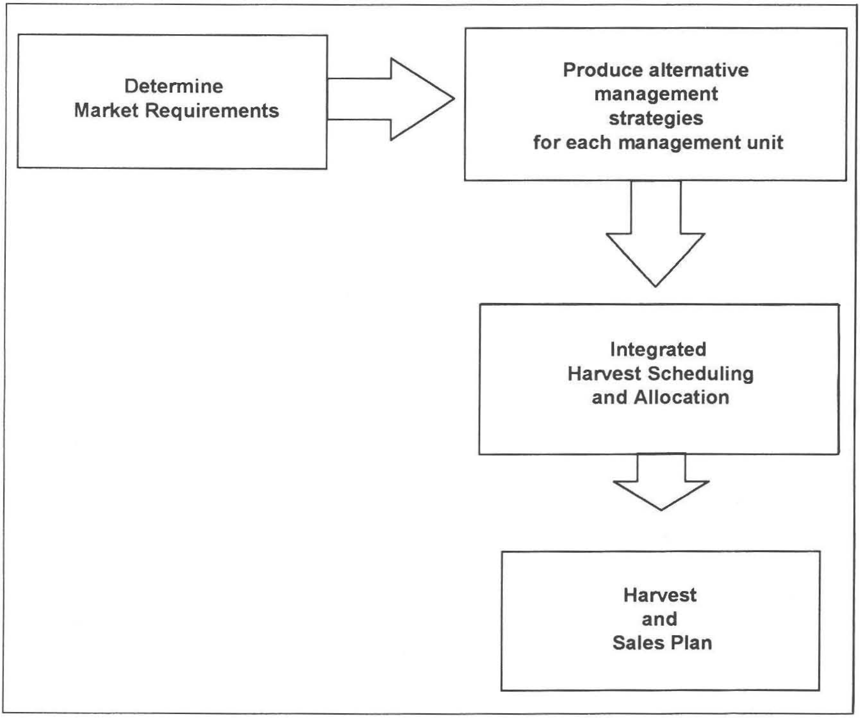

Figure 6. Proposed decision process, incorporating a fully integrated harvest scheduling and timber allocation procedure.

However, it is envisaged that the introduction of an integrated system will improve the company's capacity to supply the processing industry with the required timber at the right time at a competitive price.

The developed allocation procedure has demonstrated and quantified a number of benefits of computerised OR techniques in operational and strategic planning. It has contributed to an investigation and analysis of the company's current timber harvest planning and timber allocation procedures. It is envisaged that the allocation model will change considerably and will be replaced by a more comprehensive timber harvest planning and timber allocation decision support system. However, the present system has indicated the potential benefits of using OR techniques and that fact alone has made the development of the model a worthwhile and successful project.

ACKNOWLEDGEMENT

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Trees, Woods and Literature, 17

Thus happy in their change of life,
Were several years the man and wife,
When on a day, which proved their last,
Discoursing o'er old stories past,
They went by chance, amidst their talk,
To the churchyard, to fetch a walk;
When Baucis hastily cried out;
"My dear, I see your forehead sprout":
"Sprout", quoth the man, "what's this you tell us?
I hope you don't believe me jealous:
But yet, methinks, I feel it true;
And really, yours is budding too –
Nay, – now I cannot stir my foot:
It feels as if 'twere taking root."

Description would but tire my muse:
In short they both were turned to yews.
Old good-man Dobson of the Green
Remembers he the trees has seen;
And goes with folks to shew the sight:
On Sundays after evening prayer,
He gathers all the parish there;
Points out the place where either yew;
Here Baucis, there Philemon grew.
Till once a parson of our town,
To mend his barn, cut Baucis down;
At which, 'tis hard to be believed,
How much the other tree was grieved,
Grew scrubby, died a-top, was stunted:
So, the next parson stubbed and burnt it.

From *Baucis and Philemon (1709)*, by Jonathan Swift.

The full title refers us to Ovid's *Metamorphoses.* The following is the entry under Baucis in Lempriere's *Classical Dictionary* (11th Edition, 1820): *An old woman of Phrygia, who with her husband Philemon, lived in a small cottage, in a penurious manner, when Jupiter and Mercury travelled in disguise over Asia. The gods came to the cottage, where they received the* *best things it afforded; and Jupiter was so pleased with their hospitality, that he metamorphosed their dwelling into a magnificent temple, of which Baucis and her husband were made priests. After they had lived happy to an extreme old age, they died both at the same hour, according to their request to Jupiter, that one might not have the sorrow of following the other to the grave. Their bodies were changed into trees before the doors of the temple.*

Phrygia is part of present-day Turkey. Swift transposes the tale to Kent, in England; the gods become "two brother-hermits, saints by trade"; the temple a church with the old chimney growing into a steeple, and, as is proper to a churchyard, the trees become yews.

Jonathan Swift is best known as the author of *Gulliver's Travels,* an amusing but serious and impressive work, best read in a full and scholarly edition. He himself said that the book "will wonderfully mend the world".

Swift was born in Dublin in 1667. The identity of his father has been much discussed. Alternatives are a Dublin court clerk of English midlands origin (with one branch claiming descent from "Erick the Forester") i.e. Swift, or else one or other generation of a line of influential English statesmen and diplomats, i.e. Temple.

After education in Kilkenny and Trinity College, Dublin, he took orders in the Church of Ireland and served in Antrim and Meath before becoming embroiled in English politics as a pamphleteer in London. Finally, although expecting a mitre, he settled for appointment as Dean of St. Patrick's Cathedral, Dublin.

Swift's personal life has aroused much interest and speculation. He was closely involved with two women: Esther Johnston "Stella" whom he may have secretly married and who may have been his close relative, and Hester Vanhomrigh "Vanessa" who may have been his mistress.

He died in 1745 and is buried in St. Patrick's Cathedral, under his own famous epitaph, equally famously translated by W. B. Yeats:

Swift has sailed into his rest;
Savage indignation there
Cannot lacerate his breast.
Imitate him if you dare,
World-besotted traveller; he
Served human liberty.

(Literature consulted: list available on request.)

(Selection and note by Wood-Kerne)

OBITUARY

DAN McGLYNN
1910 – 1992

Dan McGlynn died in June 1992 at the age of 82. He was born near Lifford, Co Donegal and was one of a group of six trainees to enter Emo Park in November, 1932 under the instructor, Head-Forester Paddy Barry. This was the beginning of a long and very successful career in forestry until his retirement on the 1st March 1975.

Having completed his training at Emo, Dan was transferred to Dundrum Forest in 1934 as forest foreman. The following year saw the re-opening of Avondale House as a Forestry School and he was appointed Housemaster, but this posting lasted only a year until his transfer to Enniscorthy as Forester-in-Charge of Bree, Curracloe and Forth Forests. In June 1941, following an open competition, he was promoted to the grade of Assistant Junior Forestry Inspector. Two years later he became a Junior Forestry Inspector and was seconded to the Ministry of Supply, based in Galway to carry out an inventory of woodland resources in the western region. In 1944 he was back in Enniscorthy again as a District Inspector where he remained until August 1953 when he was appointed Divisional Inspector based in Bray. He was promoted to Senior Forestry Inspector in July 1964 and to Assistant Chief Forestry Inspector in November 1973. For a few years after retirement he acted in a consultative capacity for a sawmilling group and then devoted his time to social work which continued until shortly before his death.

Dan McGlynn played a very active and formative role in the development of modern forestry. A keen silviculturist he was always interested in cost effective methods of establishment and thinning but was adamant that these should not be at the expense of quality.

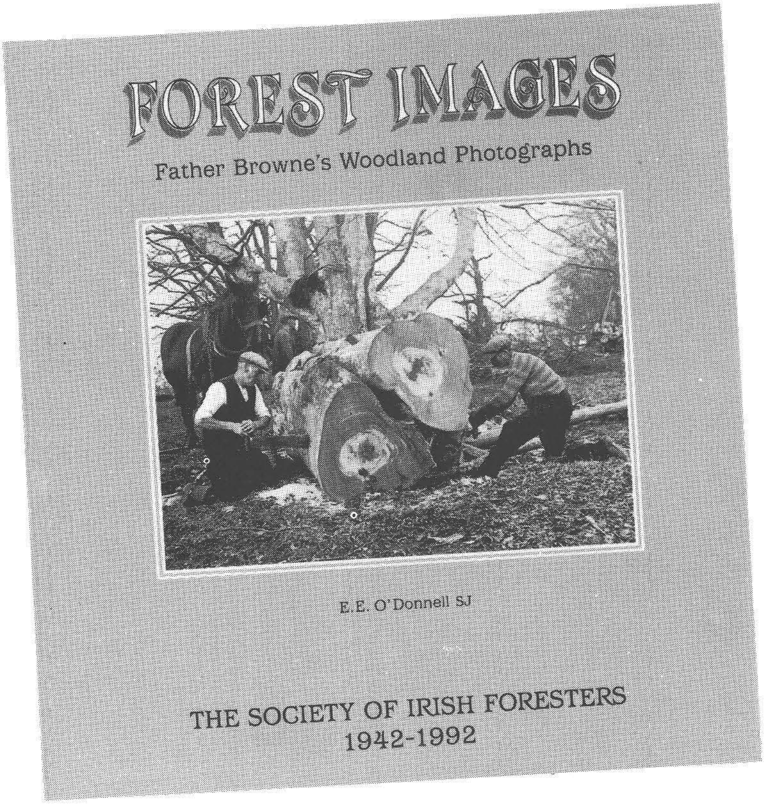
As one of the first foresters to become involved in work study, he was quick to realise its advantages in terms of standardisation of forest operations and cost control. He was chairman of the Standards Committee for more than a decade and will be remembered for his tremendous capacity for organisation, his sound judgement and his ability to arrive at a consensus on contentious issues.

His antipathy towards uneconomic undertakings often led him to express his displeasure in public at what passed for a national land use policy. He was highly critical of land reclamation for agriculture; a practice he considered to be not in the best national interest. He was less than enamoured of the large scale afforestation of blanket peat and often cautioned against it. Yet as research helped to resolve many of the problems of peatland afforestation he was foremost among senior management to seek out advice on new techniques. He warmly welcomed the involvement of private landowners in forestry both as a means of gaining access to better quality land for afforestation and as an opportunity to redress the imbalance of a large public ownership.

Dan was a very sociable person: he was good company and greatly enjoyed a game of cards. In latter years he liked to reminisce about the missed opportunities for a realistic land use policy or recall amusing incidents such as the instructions issued to trainees on entry to Emo Park in 1932. Each was required to provide himself with two suits; one for work and one for Sundays. No mention was made of a bicycle and this resulted in a three mile walk to Coolbanagher for eight o'clock each morning.

The Society of Irish Foresters will remember him as one of its staunchest supporters. He was a founder member of the Society and during his term as president he introduced the annual symposium which still remains a highlight of Society activities. Until his declining health in recent years he was a regular attendee and contributor at meetings. To his daughter Mary and sons Eamon and Colm we wish to extend our sympathy.

P. M. Joyce



FOREST IMAGES – FR. BROWNE'S WOODLAND PHOTOGRAPHS

In 1992 the Society of Irish Foresters celebrated the 50th anniversary of its founding. This occasion was marked by a number of special events. Among those was the publication of a book of photographs entitled *Forest Images – Fr. Browne's Woodland Photographs*.

Father Browne (1880-1960) was a Jesuit priest whose distinguished church career took him all over the world. At an early stage in his life he developed an interest in photography and as a result he always took a camera with him on his travels.

During his lifetime he amassed an incredible 42,000 negatives, thus providing a social history collection of incalculable value. Following his death in 1960 his collection lay in obscurity until rediscovered in 1988 by fellow Jesuit Fr. Eddie O'Donnell. Fr. Eddie has been responsible for the cataloguing and conservation of this unique collection.

From 1931 until 1957 Fr. Browne was based at Emo Co. Laois. During this period he took the opportunity to record on film a wide range of forestry and woodland activities. The complete forest cycle is to be found here starting with photographs of nursery operations and finishing in the sawmill. These beautiful photographs are evocative of an era in forestry now long gone.

The Society of Irish Foresters became aware of this forestry collection and decided that the publication of a book containing a selection of these photographs would be a fitting contribution towards the 50th anniversary celebrations. With the co-operation and help of the Jesuit order, and in particular Fr. Eddie O'Donnell, *Forest Images – Fr. Browne's Woodlands Photographs* was published in December 1992.

This is a beautiful hardback book printed in duotone on 170gsdm. art paper. It contains 52 carefully selected photographs with accompanying text.

Full credit is due to the editorial committee of Kevin J. Hutchinson, Niall O Carroll, Donal Magner and John Prior.

Copies of the book are available from most good bookshops or directly from the Society of Irish Foresters c/o 1 Dublin Road, Portlaoise, Co. Laois. Retail price is £16.95 or special members price £11.95 plus £2.50 p/p. A leather bound limited edition is also available at £60 plus £2.50 p/p.

Kevin J. Hutchinson.

Pictured at the Launch of
'Forest Images – Fr. Browne's Woodland Photographs'
(L to R): Fr. Eddie O'Donnell (Curator of the Fr. Browne Collection), Ted Farrell (President of Society of Irish Foresters), Kevin J. Hutchinson (Chairman of Editorial Committee), John Prior (Editorial Committee), O. V. Mooney who launched the book and Donal Magner (Editorial Committee).

ANNUAL STUDY TOUR 1993
6th – 18th October 1993
Oregon, USA

Background to Study Tour

In 1992 the Society celebrated its fiftieth anniversary. To mark the event a special Annual Study Tour was organised. The destination was the State of Oregon in the Pacific Northwest of the US, home of many of the exotic species used in Irish forestry.

Preparation and planning for the tour started in early 1990 and a comprehensive programme was arranged. When the departure date finally arrived, the main group assembled at Dublin Airport while other participants joined the tour at Shannon.

Undaunted by the thought of spending approximately twelve hours in the air, the group was soon on its way across the Atlantic on a Delta Airlines flight to Atlanta and from there to Portland via Seattle. Despite the long journey, the group enjoyed a pleasant trip.

On arrival at Portland Airport we were met and welcomed by our hosts, Wilbur (Wil) and Catherine Heath, and Larry and Marian Christiansen of Western Forest Tours Inc., and soon we were heading to the Ramada Inn in Beaverton, situated in the suburbs of Portland and our abode for the week that followed.

Introduction

The Pacific Northwest States of Washington and Oregon comprise an area of enormous variation in physiography, geology and climate. Elevations range from sea level to 4,450 m. Annual precipitation is as low as 200 mm or less in eastern Oregon whereas in the Coast Ranges, the Olympic Peninsula and the High Cascades it reaches over 3000 mm. The geology of the region is extremely complex. Much of the landscape has been shaped by volcanic activity, some of it very recent, but sedimentary and metamorphic rocks also abound, with some formations more than 400 million years old. Not surprisingly, the soils which are a product of these factors, as well as time and relief, also show considerable variation.

The climate of the region is broadly maritime and is characterized by:

1. mild temperatures with narrow diurnal fluctuation, frequent cloud cover;
2. wet, mild winters, relatively dry summers and a long frost-free period and
3. high precipitation, occurring mainly as rain, 75% to 85% of it in the October-March period.

The region has been divided by Franklin and Dyrness (1969), on whose work this introduction relies heavily, into 15 physiographic provinces. These are broad divisions within each of which, physiography, geology and soils are relatively homogeneous.

The principal field sites visited on the Study Tour fall into seven of these provinces. The principal features of each are described below.

Coast Ranges province:

The elevation of the main ridges in this province is between 450 m and

750 m although occasional peaks may be over 1,000 m. All rock formations are of the relatively recent, Tertiary period. In the area visited on the tour, both volcanic and sedimentary rocks occur. Siltstone and sandstone are found near Vernonia (October 8th). Eocene volcanic rocks, largely basalt, with some tuffs and breccias occur northeast of Tillamook (October 10th). Soils of the province are very variable. The most widespread soils vary from shallow lithosols and regosols to leached soils similar in morphology to brown podzolic soils.

The extreme coastal part of the province belongs to the *Picea sitchensis* Vegetation Zone. The natural habitat of Sitka spruce is only a few kilometres in width, except where it extends up river valleys. This zone has the mildest climate of any part of Oregon, characterized by annual rainfall in the range 2,000 to 3,000 mm, frequent fog and low cloud cover during the drier, summer months. The soils are amongst the best forest soils in the region, deep, relatively rich and fine textured. Under natural conditions, forest stands are dense and tall, dominated by western hemlock and western red cedar as well as Sitka spruce. Natural succession normally results in stands dominated by western hemlock, although on moist to wet sites, western red cedar and Sitka spruce will be present in the climax forest. Coastal lodgepole pine, known locally as "shore pine", occurs along the ocean.

Over most of the coast range, the principal forested region is the *Tsuga heterophylla* Vegetation Zone. This is the most extensive vegetation zone in Western Oregon and the most important in terms of timber production. Douglas fir is the dominant sub-climax species of this zone, with western red cedar and western hemlock comprising the natural climax vegetation. However, Douglas fir is a dominant, often the sole dominant, over large parts of the zone even in stands more than 400 years old. In addition to Douglas fir and western hemlock, western red cedar, grand fir and Sitka spruce (near the coast) are major forest tree species in the zone.

Precipitation levels are high (1,500 to 3,000 mm), most of it falling in winter. Although winter temperatures are lower than in the *Picea sitchensis* Zone, summer temperatures are only slightly higher and temperature extremes are rare. The soils of the *Tsuga heterophylla* Zone are generally moderately deep, fairly fertile and well drained.

Willamette Valley Province:

October 12, 13 and 16 were spent in the Willamette Valley. The valley is a broad, structural depression, oriented north-south and situated between the Coast Range and the Cascade Range. It is approximately 200 km long, from the Columbia River to Cottage Grove. It is characterized by broad alluvial flats, separated by groups of low hills. The valley is bordered on the west by a variety of sedimentary and volcanic rocks. Most of the valley floor is covered with thick, non-marine sedimentary deposits. Soils on the valley floor, derived from silty alluvial and lascustrine deposits, were formed under predominantly grassland vegetation. The climate of the valley is characterized by lower rainfall and higher temperatures than the Coast Range to the west.

Western Cascades and High Cascades Provinces:

The tour visited the Cascades on October 15 and 16. The Cascade Mountains in Oregon reach elevations of over 3,400 m (Mount Hood is 3,424 m). The rocks of these provinces are dominated by pyroclastic materials, some very young, and by basic igneous rocks. Glacial deposits are also widespread. Soils are very variable, but brown podzolics and regosols are among the most abundant. Soils derived from pyroclastic parent materials, such as tuff and breccias, are generally deep, fine textured and often imperfectly drained. Basalt and andesite give rise to poorly developed, often stony and well drained soils.

The Western Cascades fall within the *Tsuga heterophylla* Zone described above, to an elevation of about 550 m on the western slopes and to 1,125 m on the eastern slopes. Large areas of the province are in fact dominated by Douglas fir. At higher elevations, the sub-alpine forests consists first of *Abies amabilis*, western hemlock and noble fir. Above 1,700 m is the *Tsuga mertensiana* Zone which at first, is represented by continuous forest cover, then up to the tree line at a maximum of 2,000 m, as a mosaic of forest patches and shrubby or herbaceous sub-alpine communities.

The Cascade Range is a very effective barrier to the movement of both westerly maritime and north-easterly continental air masses. In the mountains, elevation has a dominating influence on local climate. With increasing elevation, precipitation increases, as does the proportion falling as snow. Temperature decreases markedly the higher one goes. On the western side, precipitation rises to 2,000 mm, falling off rapidly east of the Pacific Crest.

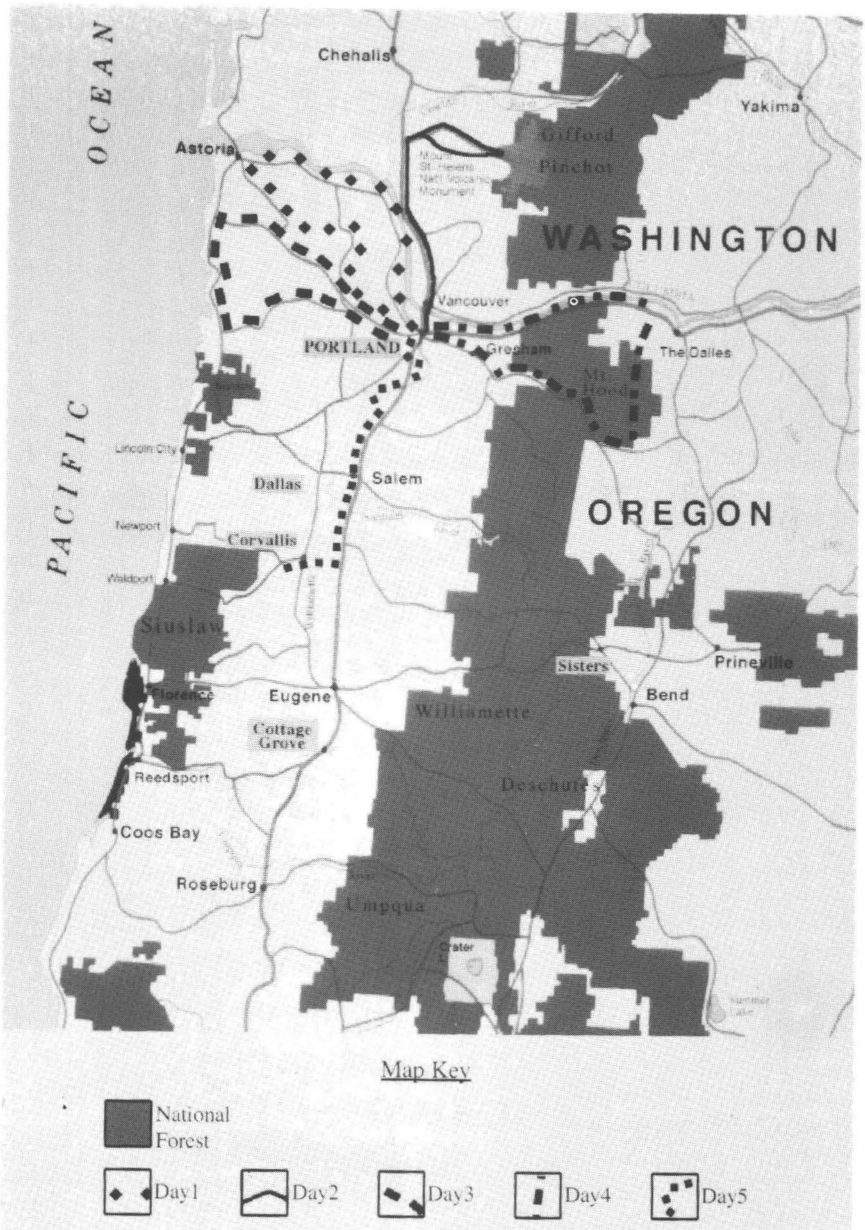
Southern Washington Cascades Province:

According to Franklin and Dyrness (1969), Mount St Helen's last erupted "100 to 150 years ago". Events have overtaken them and in many respects, their description of this part at least, of the Southern Washington Cascades is irrelevant. At least 90% of the province is made up of andesite and basalt flows with their associated breccias and tuffs. In the immediate vicinity of Mount St Helen's, visited on October 9th, this has been overlain with volcanic ash and pumice deposits from the eruption of the 18th of May, 1980. Soils derived from glacial materials are not so common in the province. In the area of pumice deposits, podzols and brown podzolics soils are most common.

The Mount St Helen's eruption devastated an area of 60,000 ha. It blew out a crater 640 m deep and dropped the summit's elevation from 2,948 m to 2,549 m. To put this decrease in elevation of almost 400 m in context, the summit of Little Sugar Loaf in Wicklow is 341 m above sea level, and that of Great Sugar Loaf 501 m. While it has been estimated that the explosion produced about one cubic kilometre of ejecta (airborne ash and pumice), it ranks historically, as a relatively small eruption. Krakatoa produced 18 cubic kilometres of ejecta when it erupted in 1883 and Tambora, in Indonesia, produced 80 cubic kilometres in 1815.

High Lava Plains:

This province, to the East of the Cascades, provided a dramatic contrast to



Location Map for Days 1 - 5

the rest of the tour itinerary. We arrived there on the afternoon of October 14th and left it about 24 hours later.

The province has a base elevation of about 1,200 m and is characterised by young lava flows and alluvial and lacustrine sediments. The region is very dry. Annual precipitation may be less than 300 mm and temperature extremes are much greater than in the west.

The area around Sisters is in the *Pinus ponderosa* Zone. *Pinus ponderosa* occupies drier sites than almost any other forest type in Oregon. Rooting is prolific on coarse textured soils utilising to the full the limited supplies of moisture in the soil. It is associated with a rich variety of species including inland lodgepole pine, seen on the tour, in pure stands in Deschutes National Forest.

Reference:

Franklin, Jerry F. and C. T. Dyrness 1969. Vegetation of Oregon and Washington. U.S.D.A. Forest Service Research Paper PNW-80, 216pp. Pacific Northwest Forest and Range Experimental Station, Portland, Oregon.

Ted Farrell

WEDNESDAY 7th OCTOBER

World Forestry Centre

After a late breakfast, we assembled in the hotel car park where the coach was ready to take the group to downtown Portland, visiting on-route the business district and the waterfront region. From here it was on to Washington Park, a 134 ha urban forest, where we stopped for a delightful picnic lunch. After lunch, the group made an informal visit to the International Rose Garden and the Hoyt Arboretum. The arboretum, perched on a ridge top of the Tuality Mountains in the western hills of Portland, has a collection of more than 700 species of trees and shrubs, including one of the nation's largest conifer collections.

The next stop was the World Forestry Centre, a centre for forestry education and a permanent collection of forestry exhibits. One of the highlights here, the Jesup Collection of Wood, has 505 full species represented. Morris K. Jesup (1830 – 1908), a banker, philanthropist and President of the American Museum of Natural History, developed and privately funded this elaborate collection. After a welcome rest at our hotel in Beaverton, we later returned to the Centre where, as guests of the Society of American Foresters

The Study Tour group at the World Forestry Centre, Portland, Oregon with our guides from Western Forestry tours.

The President, Dr. Ted Farrell and Mrs. Catherine Heath at the World Forestry Centre.

and the World Forestry Centre, we enjoyed cocktails and an elaborate banquet, honouring the first visit of the Society to the Pacific North West.

Overnight Beaverton.

John Fennessy

THURSDAY, 8th OCTOBER, DAY 1
Nyggard Logging Company

On the first day proper of the Study Tour we visited the chipping yard of the Nyggard Logging Company in Warrenton, Oregon. This firm, which operates the largest chipping facility in northern Oregon, specialises in chipping rough and "reject" timber in Warrenton, where it employs 60 people and has an annual intake of 350,000 U.S. tons of round timber.

The timber is first debarked (only 0.5% of bark is allowed in the finished chip) then chipped with rotary knives and finally screened to remove oversize chips which are rechipped to ensure a consistent size. The bark is sold to Weyerhaeuser Corporation at £7.50/U.S ton for use as hog fuel. The mill produces three categories of clean chips:

1. Douglas fir.
2. Hardwood (alder, maple & cherry).
3. White (spruce, hemlock and fir).

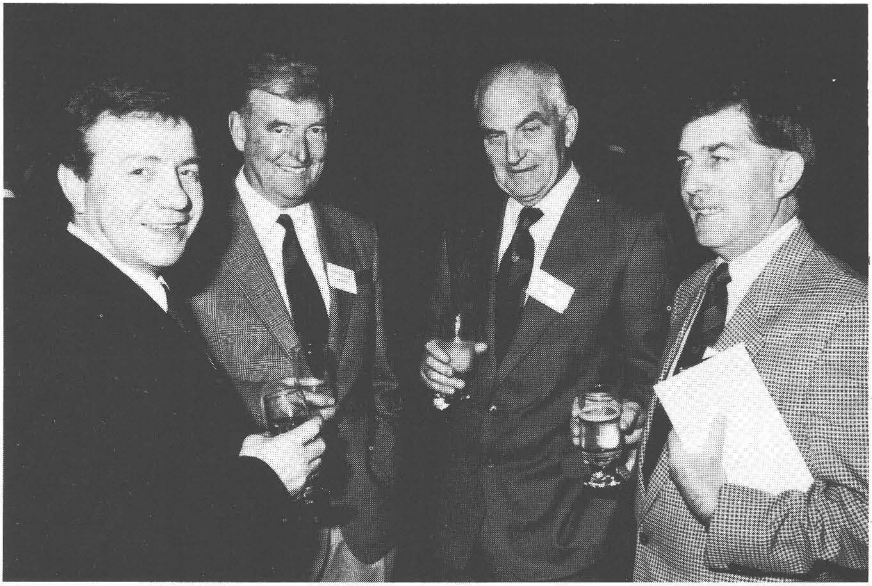
Nyggard purchases its round wood at £18/U.S ton for white (delivered) and £13/U.S. ton for hardwood (delivered). They purchase all sizes of material but as it has only a 30″ chipper, any logs or butts over 28″ diameter are split using an excavator mounted log splitter. Nyggard buys on a "green" ton basis and sells on a "bone dry" ton basis. On average one "green" ton produces a half "bone dry" ton. The current selling price of the chips is £53 per "bone dry" ton.

The mill's main customers are James River and the Weyerhaeuser plant at Lakeview, just across the Columbia river in the State of Washington. The chips are loaded directly on barges for export to Washington. They are used to produce newsprint at the Weyerhaeuser plant and computer paper and tissues at the James River plant which purchases a higher grade mix of chip i.e. 80% white, 15% hardwood and only 5% Douglas fir.

Weyerhaeuser Log-Export yard at Lakeview, Washington

In this 65 ha complex, the Weyerhaeuser Company operates a newsprint mill, two fibre board mills and a log export yard. A total of 4,000 are employed at the complex.

Our visit concentrated on the log export yard which has an annual throughput of 1.2 million U.S. tons of logs. Sixty five per cent of these logs are supplied from Weyerhaeuser's own forests in Oregon and Washington – mainly second



Pat O'Brien, Tom Purcell, Paddy Glennon and John Fennessy (Study Tour Convenor), at the World Forestry Centre.

growth forests or "tree farms" worked on a 55 to 60 year rotation.

On arrival at the yard (approx. 200 truck loads per day) the logs are debarked, measured (manually) and sorted into upwards of seventy different size categories using U.S. Forest Service log grades at a cost of 1.5 pence per log. The main reason why the timber is not sawn before export appears to be the very high price being paid by South-East Asian customers, e.g. quality logs of two cubic metres can command a price of £133 on the quayside at Lakeview.

The logs are exported to Japan, Taiwan, Korea and China, although Japan is by far the most important customer. The logs are mainly Douglas fir (70%) and hemlock (10%) with the balance comprising cedar, alder and spruce. Approx. 60% of their customers require the logs to be debarked prior to export. Highly mechanised systems enable large ships to be loaded quickly – one modern log transporter with a capacity of 155,000m^3 can be loaded in two days. The average sailing time to Japan is fourteen days.

During the past ten years the price trend for export logs had been upwards, with prices increasing significantly in the past eight months due to scarcity of export quality logs. In fact the log export yard is now operating at only one third capacity. The difficulty in obtaining suitable quality logs is due to federal restrictions on exports, environmental legislation which severely restricts harvesting and the small size of timber from second growth forests. The Weyerhaeuser Company fears this lucrative export trade may decline even further when Russia begins exporting from the vast forests of Siberia.

Overnight Beaverton (Portland).

Pat O'Sullivan

FRIDAY, 9th OCTOBER, DAY 2
Mount St. Helens Tree Farm

We had a 0700 hours departure from our hotel in Beaverton on a fine, bright and clear morning. We set off east-bound towards Portland ; in the distance stood Mount Hood, at 3424 m (11,235 feet) it dominates the skyline east of the city. After crossing the Willamette river we headed for the Columbia river which forms the boundary between the states of Oregon and Washington. We continued north on Interstate 5 through a countryside of mixed agriculture and forests. Among the fields were Douglas fir Christmas tree farms. Common too were plantations of cottonwood (poplar), grown to produce wood chips.

Travelling parallel with the Columbia we could see large log booms heading down-stream to log yards. At Kelso we had a welcome stop and an opportunity to purchase some film for the spectacular day that lay ahead. We were introduced to our guide for the day, Dick Bohlig, recently retired from the Weyerhaeuser Corporation. Having spent many years on the ground he had much valued practical experience to relate to us.

Off we set, and ten miles or so north of Kelso we left the freeway and climbed eastwards up through forests of mature Douglas fir. We passed areas of clear cut (clearfell) with slash (lop and top) piled and partially covered with sheets of plastic. This keeps the rain off so they can be burned during winter months. Reforestation generally takes place a year following clear cutting. Burning of slash is a controversial issue as locals complain about smoke pollution.

Continuing our journey we passed on through forests of Douglas fir interspersed with western red cedar, maple and red alder. The two commonest species of maple – big leaf and vine maple provided a colourful scene among the deep greens of the forest. Red alder grows very well naturally but is difficult to establish artificially. When it does establish itself, it forms a valuable source of wood chips.

We made a brief stop to see an aerial fertilising operation. Over 6000 ha (15,000 acres) were being treated with urea at 450 kg/ha (400 lbs/acre). The fertiliser had been railed to a landing in the forest using Weyerhaeuser's own rail line. It is filled into bags which hold 1.36 tonnes (3000 lbs) by a special attachment on the side of the wagon. The fertiliser is in pellet form for ease of spread. Application is on average once every eight years depending on foliar nitrogen levels. Research results indicate that a growth response of up to one third can be achieved using fertilisers.

Close-by at an elevation of 365 metres (1,200 feet) we saw a reforestation crop of Douglas fir planted in 1988 at 1000-1100 plants/ha (400-450/acre). The seed and planting stock (2+1 transplants) came from Weyerhaeuser's own seed orchard and nursery. Ground preparation on these sites involves burning slash, if heavy. If it is light and there is no need for burning a machine comes in and "kicks the slash about" to make direct planting easier. Apart from that no mechanical ground preparation is used. Planting begins around the end of January and goes on to early June. Contractors, paid by the thousand plants, are carefully supervised. Control of competing naturally regenerated red alder was done by spraying 2,4-D by helicopter. This operation is carried out during the dormant season. A feature of the plantation was the very high survival rate and low initial stocking used in comparison to Irish experience and practice. Natural regeneration is not widely practised as stocking levels tend to uneven compared with planted crops.

Inventory is done from the air, with stocking plots laid out on the ground. Productivity averages about 20 cubic metres/ha/year.

Further on we stopped at an 18 year old stand of Douglas fir. Four years ago a pre-commercial thinning was carried out. It reduced stocking down to 680 stems/ha (275 trees/acre). This operation is carried out by trained contractors who are paid by the acre. Cut stems are left on the ground. Various stages of pruning are carried out to a final height of 5.5 metres (18 feet). Again this is carried out using trained contractors.

Our final stop before lunch was in a 140-180 metre wide strip of 65 years old Douglas fir adjacent to the forest road. This crop was second growth, typical of what is being clearfelled at present. Beyond the strip the crop had been clearfelled and the area reforested. Regulations now stipulate that such strips of mature forest be left along certain scenic roads at clear cutting. Once the reforested crop reaches 4 years of age then this buffer zone will be cleared. Risk of windthrow is low as the soils are generally deep and free draining and provide a good rooting medium for Douglas fir. Throughout the forest area the roads are open to the public for recreational activity.

A welcome stop for lunch was made at Hemlock Creek. The day was glorious with clear views for miles over forests shaped by man by clear cutting and reforestation. Down in the valley below us a cable logging operation was in progress with a steady stream of trucks drawing away the extracted logs.

Mount St. Helens Eruption Area

After lunch we left for Mount St. Helens, travelling mile upon mile of forest road. The wide flowing Green river provided a change of scene. This is a popular fishing waterway having good salmon and steelhead (sea trout). Further on a monument by the roadside, overlooking the Green river, marks the extent of the blast area – 18 miles from the epicentre. It was on May 18th, 1980 that Mount St. Helens erupted violently. A severe earthquake triggered off one of the world's largest recorded landslide. During this avalanche more than 410 metres (1,300) feet of the mountain top cascaded into the river valley below. The Weyerhaeuser company lost 27,500 ha (68,000 acres) of forest in the devastation.

After things had settled a major salvage operation began. Much valuable timber was saved. Vegetation began to appear again within a month of the operation. Research plots were established to determine the effects of planting on areas with volcanic ash deposits. It was found that normal growth could be expected for conifer seedlings as long as the ash was scraped away so that the seedlings roots could be placed directly in the underlying mineral soil. Over a seven year period following the eruption Weyerhaeuser reforestated of the damaged areas. Over eighteen million trees were planted on 18,000 ha (45,000 acres). The species planted were those that had grown in the area prior to the eruption, Douglas fir and noble fir with some lodgepole pine and black cottonwood. The reforestation has been very successful with high survival and growth rates.

After travelling for many miles on forest roads to reach the viewing point over the eruption area we reached an impasse – the bus could go no further on the rough forest roads. After much deliberation among our hosts we were about to turn back until our President showed his true leadership qualities in leading a charge up the mountain. In glorious sunshine we walked, crawled and jeeped a good Irish mile to the viewing point. Several miles away to the south lay Mount St. Helens, with smoke still rising from where the blast occurred twelve years ago. One was struck with awe at the sheer magnitude of the devastation, and the huge expanse of country. As far as one could see was hill upon hill of forest. The very successful reforestation of the eruption zone is bringing a new greenness and life to an area that was formerly devastated. It was with reluctance that we had to return to the bus, then head back to Kelso via the River Toulte and picturesque Silver Lake.

Dinner With Weyerhaeuser

The Red Lion Inn at Kelso was the venue for a tastefully presented buffet evening meal thoroughly enjoyed by everyone. Will Heath from Western Forest Tours, our guides for the tour, introduced Dick Bohlig and his wife, Conor Boyd of Weyerhaeuser and John Keatley, land and timber manager Longview operations (Weyerhaeuser).

Ted Farrell spoke and said how pleased the Society was to have Weyerhaeuser as guests and for giving us such a great day – one we will remember for a long time. He presented our guests with "The Forests of Ireland" and Society ties.

There then followed an interesting question and answer session. Conor Boyd took the floor first saying that export customers were paying U.S. $190 per m^3 for logs, U.S. $50 higher than local mills. Japan is one of their major overseas customers for Douglas fir logs. There it is used in construction of traditional post and beam houses. The Japanese have found Douglas fir superior to any other imported species.

Weyerhaeuser originally bought their lands from various railway companies. These companies had been given vast stretches of land in the early pioneering days. Three hundred and sixty five thousand ha (9000,000 acres) of land, with a covering of old growth Douglas fir were bought for $17/ha ($7/acre). Today's prices for similar land would be about in the range of $30,000/ha ($12,000/acre).

John Keatley manages an area of some 160,000 ha (400,000 acres), with a team of 11 foresters. He was directly involved in the recovery of timber after the Mount St. Helens eruption. Replying to questions concerning low planting density, he said that research trials are presently looking at planting density and its effect on wood quality.

Trials have been done using containerised Douglas fir seedlings, but costs are very high compared to bare -rooted stock.

Growing of red alder commercially is at an early stage of development. There appears to be a future for the tree in furniture production and as a source of hardwood pulp. Germany is already importing some mature alder from the Pacific North West. They see it as an environmentally friendly species.

Environmental pressures have caused a marked decline in harvest volumes in Washington, Oregon and California from 101 m^3 million cubic metres in 1987 to 81 m^3 million currently. Nineteen ninety two figures will be in the range of 45 – 50 m^3 million.

Replying to a question regarding the reduction in North West timber exports to the E C, Conor Boyd said he wasn't worried unduly as their major customers are in the Pacific Rim countries.

Rounding off an interesting evening and a memorable day, Ted Farrell again thanked all concerned. He also stressed very firmly that management of forests should remain in the hands of foresters and not environmentalists. We are adequately trained to manage our timber resource in a proper and responsible manner.

Overnight Beaverton (Portland).

Richard D. Jack

SATURDAY, 10th OCTOBER, DAY 3
Trees, Cheese and Ocean Breeze

The group headed west from the Ramada Inn, Beaverton on Highway 8 to Forest Grove via Hillsboro – a traditional agricultural town, nowadays becoming increasingly popular as a dormitory town of Portland. We arrived at the Forest Grove District HQ of the Oregon Department of Forestry and already at 09.30 the temperature was over 10° C. Here we met Dave Johnson, District Forester of the Oregon Forest Service. Within the district is the 146,000 ha Tillamook State Forest known as the Tillamook Burn due to its four devastating fires – at six year intervals between 1933 and 1951 which destroyed 143,600 ha of mainly old growth forest. Only 2,400 ha of the original forest survived.

If the chilling devastation of Mount Helens was still a major topic of conversation after the previous day's tour, then the Tillamook Burn surely matched it in terms of scale of destruction and eventual rehabilitation which involved the Oregon Board of Forestry, Oregon citizens, industry, inmates from prison camps and the schools.

Most of the group had some experience of forest fires, and allowing for Dave's detailed description of the fire and an excellent video, it was still impossible to comprehend the enormity of these fires. For example the 1933 fire destroyed 80,000 ha of first growth Douglas fir in less than a day. Unlike Mount St. Helens, reforestation was more protracted. The six year cyclical fires played havoc both on salvage operations and attempts at reforestation. First, the area had to be protected and as 100,000 ha was owned by the private sector there was little interest in protection or rehabilitation. The State stepped in and acquired the land in 1940. Reforestation began in 1949. Today, the administrative bodies governing the forest are the Oregon Board of Forestry and the Oregon Department of Forestry.

As we drove west we could experience at first hand the results of the rehabilitation of the Tillamook Burn. The scale of reforestation across the 60 km journey was awe inspiring. The trees decreased in size as we moved from east to west beginning with mature Douglas fir – just outside Cottage Grove which were part of the first planting – ending in the east which was finally completed in 1970. Reforestation was a team effort. The Oregon State Forestry used their own employees and contractors. Some planting was even carried out by school children which became part of special school forests. Perhaps we might introduce this idea into the Irish educational system. Even inmates from the Smith Fork Inn prison camps played their part in the planting programme. Incidentally these inmates – now numbering 85 – are still used for planting and fire fighting.

The forests are now divided into a series of compartments with major firebreaks. These are supplemented by a secondary system including access roads. Firefighters now have 30 minute access to fire danger areas.

There are many different planting regimes including:

- conventional planting
- aerial seeding
- natural regeneration

As there was no ground cover, aerial seeding of Douglas fir using 0.8 kg seed per ha (3⁄4 pound of seed per acre) was carried out on 46,000 ha. Most of the planting however was carried out manually as it is today. Douglas fir is the main species covering 90% of the Burn. The Oregonians are at ease with Douglas – they have a Douglas culture. It is featured in their houses, hotels and number plates of cars. It is their State tree and vital to their economy. Alder is the most commonly planted broadleaf. While it has excellent potential for furniture its yield is less than a third of Douglas fir. Alder is also root rot free unlike Douglas fir. Almost 50% of some Douglas stands are now affected by *Heterobasidion annosum (Fomes annosus)*. The remaining species comprise western red cedar, western hemlock, noble fir, and Sitka spruce. Noble fir, surprisingly, has an excellent reputation as both a construction and furniture wood. At first glance stocking looks as heavy as ours but like the Weyerhaeuser plantations of the previous day stocking is only 1,000 trees per ha or 3 x 3 m spacing. However, 100% success rate at establishment gives it a uniformity which gives the impression of high stocking.

Dave Johnson acknowledged the views of some tour participants about possible poor form as a result of wide spacing and told the group that pruning is now being carried out to improve timber quality. Stocking is reduced to 500/ha during a pre commercial thinning (18-20 years) which is really a cleaning operation. Final stocking will be approximately 100 trees/ha.

Tillamook is close to Oregon's main population centres from Portland down through the Willamette valley. The demand for recreational facilities is huge and Dave sees this as an inherent part of the forest multi-use role. These include fishing, boating, camping, horse riding, hunting and motor cycling. Tillamook – an Indian name for land of many waters – offers these amenities in abundance.

As we moved south-westwards we saw how easy forestry and agriculture blend in the landscape along the

Wilson river even though the woods are predominantly coniferous. Here in the Tillamook valley we saw the neat farmsteads of Swiss settlers whose dairy herds supply the Tillamook creamery which produces the world famous Tillamook cheese.

We arrived at Tillamook at 11.30 a.m. and sampled some of these cheeses including spread cheeses such as Jolly Jack and their excellent cheddar which would give the best of Irish cheddar a good run for its money. Tillamook cheeses are the biggest sellers in the Pacific North West. This has all taken place relatively quickly because Tillamook County didn't even begin to be settled until the latter end of the last century.

After Tillamook, we travelled north on Highway 1001 – a coast road running from Canada to Mexico. We passed through Bay City, Brighton Wheeler and Nehalem Bay. We stopped at Manzanita Beach where we get our first real view of the Pacific. Here we saw our first old growth Sitka spruce, which is a protected species.

We lunched at Cannon Beach, Oregon State Park, which was established in 1932. The Sitka spruce grows right down to the beach and like Manzanita is protected.

After lunch we travelled a few miles north and then turned off Highway 101 to begin our journey back through the northern section of Tillamook. First we visited Klootchy Creek, home of the world's largest Sitka spruce. Any forester wishing to measure it would need a diameter tape of over 500 cm. Its circumference is 1,600 cm and when last measured for height it was 65.8 metres with a crown spread of 28 metres.

Later we stopped at Camp 18 logging museum where there is a permanent display of rail wagons and skylines.

As we drove back through northern Tillamook in the evening sun it was difficult to imagine that this forest in the north west is only twenty years old. While it has well over 90% Douglas fir and other conifer cover, foresters here made optimum use of birch and alder when planning the Tillamook landscape.

Overnight Beaverton (Portland).

Donal Magner

SUNDAY, 11th OCTOBER, DAY 4
Columbia River Gorge

As the only sea-level river flowing through the volcanic rock of the Cascade Mountains, the Columbia River is both a natural wonder and an important transportation corridor. Our first free day in Oregon was to be spent exploring the Columbia River Gorge.

When Lewis and Clark explored the Columbia River in 1805, they opened the way for further settlement.

For many years the Gorge has been the focus of public attention because of its unique natural features, its offering of a variety of opportunities for public recreation and its contribution to the Pacific North West. Recognising these interests, the 99th US Congress passed an Act creating the Columbia River Gorge National Scenic Area covering 115,000 ha. The Act was signed into law by President Reagan in November 1986.

After leaving Portland and travelling east along Interstate Route 84 we soon arrived at our first stop, Multnomah Falls, the second highest waterfall in the country with a drop of 189m. After a brief stay we were back on the coach again and climbing along Route 84, passing Bonneville Lock and Bonneville Dam and on past the Bridge of the Gods which takes its name from Native American legends. Geologists say that large landslides may have temporarily dammed the river here, giving rise to legends of a great stone arch built by the Gods for Indians to use in crossing the river.

Leaving the Columbia, and heading south along State Route 35, passing through apple and pear orchards we arrived at the small town of Parkdale for a lunch stop.

After a most pleasant buffet lunch provided by Marian and Catherine, from Western Forest Tours, the group headed for our final stop of the day – Timberline Lodge, a remarkable building on the slopes of Mount Hood. Towering above us we saw Mount Hood with its snowcovered peak, Oregon's tallest mountain. Timberline Lodge, a national historic landmark, is a huge stone and timber building, made of indigenous materials in the depression years of the early 1930's and employed hundreds of craftsmen in its construction. Perched at over 1800 m (6,000 ft) elevation on the side of Mount Hood, the Lodge is entirely handmade, from its massive, hand-hewn beams to its handwoven draperies. Today, the Lodge is operated as an exclusive hotel, catering for walkers in the summer months and for skiers in the winter.

Leaving Timberline Lodge in the late afternoon we returned to Portland via Interstate 26, travelling along the valley of the Sandy River with a stop, for dinner in Sandy, a small town close to the city of Portland.

Overnight Beaverton (Portland).

John Fennessy

MONDAY, 12th OCTOBER, DAY 5
Weyerhaeuser Forest Nursery

We left Beaverton heading south for the Willamette Valley. The bus joined Interstate 5 and we travelled south, left the motorway at Aurora, and headed for our first stop of the day at Weyerhaeuser's Aurora Forest nursery.

The nursery at Aurora is one of five belonging to Weyerhaeuser's western nursery division; the others being Klamath Falls and Turner in Oregon, Mima and Rochester in Washington. It was purchased in 1974 and comprises a total of 79 ha (195 acres) which includes four ha (nine acres) which are leased. Our hosts for this stop, Martin Treboser and Rod Miller explained that the nursery, is located along a main road with 800 metres frontage. At any one time they have 52 ha (128 acres) of beds producing a range of plants which include 1+0 seedlings, plug seedlings and miniplug seedlings for transplanting; 1+1 transplants which is the major stock type and 2+1 transplants for transplanting in visually sensitive areas – a practice they referred to as "greening up". The nursery soil is a sandy loam with a pH of 6.0.

The nursery is run on a three year fallow cycle that is, one year fallow, followed by a year in seedling production and another year in transplants.

1. Fallow year

Areas are left fallow for one year to allow time to treat weeds and soil pests and to build up soil fertility. The soil is sterilised to kill weed seeds and pests by fumigating with methyl bromide or chloropyckrin. The ground is covered with a 2mm polyethylene sheet until the fumigation is complete.

2. One year seedlings

After seed bed formation in winter and spring, sowing takes place in April. Precision sowing is used throughout. Species sown are primarily Douglas fir with noble fir, grand fir, western hemlock and Sitka spruce. Seeds are sown according to specific climate zone origin. Seed lots are rigourously logged and tagged. During the summer nitrogen is applied and water is continuously applied using an irrigation system with pipes located every six lines.

Because of the practice of leaving ground fallow combined with fumigation, weed control is kept to a minimum. Grasses provide the main problem and these are usually treated with Devrinol.

3. 2nd year transplants (1+1)

At the end of the first year seedlings are lifted, root cut and packed for lining out. Lining out is done using self-propelled machines. During the year transplants are subjected to a regime of root wrenching combined with restricted irrigation. This is repeated frequently to improve stem diameter at the root collar.

Where there is a threat of frost damage a minimum temperature of 0°C (32°F) is maintained by watering. At the end of December transplants are lifted and prepared for transport to the planting sites.

In the case of 2+0 plants these are left in the seedbeds and subjected to the same treatment as for 1+1 transplants with the addition of undercutting of the root system. These are also lifted in December.

Packing

Two fifteen man crews lift and place plants in bins which are then stored in the packing shed for a day. Over the packing period a total of 27 million units will be processed. A crew of 85 people will examine, grade, root prune and pack on average 400,000 – 500,000 plants per day. The procedure is as follows:

(i) plants are loaded onto conveyer belts from the bins

(ii) each plant is individually checked for root quality, root diameter and height, 1+1 transplants for reforestation sites must be 61 cms (24 inches) from root collar to tip, all plants must have a minimum root collar diameter (RCD) of 4mm, on average 10% of 2+0 and 30% of 1+1 are culled due to poor roots and RCD under 4mm

(iii) all plants are root-pruned as follows: groups of 15 trees are put onto a circular toothed table, roots facing outwards, where they are root pruned, this pruning will not affect the tap roots of plants, because previous wrenching in the seed beds or transplant lines will have produced a good fibrous root system which is not touched when extraneous roots are clipped off

(iv) plants are placed in bags, 160 in each but the bag must not weigh more than 23 kg (50 lbs), the bags are made of polyethylene on the inside and double paper on the outside, these bags will fit a frame on the planters back so there is a minimum of handling involved

(v) the bags of plants are now either transported to the planting site or held in cold storage, at –2°C (28°F).

Planting takes place from January to April on low elevation sites and into

May or early June where planting is being carried on up to the snowline. Of the 27,000,000 plants produced, approximately 50% are used by Weyerhaeuser. The remainder are either grown under contract or sold speculatively.

It is worth mentioning that the nursery, from office to packing sheds as well as the nursery proper was spotlessly clean. There were ample meeting rooms, canteen and shower facilities which were of the highest quality. I think this was reflected in the meticulous way in which plants were produced and the end result that we saw on successive days on establishment sites.

Finally we were shown a large area of western yew (*Taxus brevifolia*) plants produced from cuttings. Cuttings are rooted indoors and are grown-on outdoors for a period of three years. After this all plants are lifted and macerated. The resultant extract TAXOL is currently being studied as an anti-cancer agent and there are on-going clinical trials. Research and production of the product is a joint venture between Weyerhaeuser and Bristol-Myers Squibb, a large US pharmaceutical company.

Oregon Forestry Department's Seed Orchard

We left Weyerhaeuser's Aurora nursery and travelled west approximately 25 km to St. Paul, the site of Oregon Forestry Department's seed orchard.

The State orchard, sited on 65 ha (160 acres), has two main areas of operation, the production of seed from selected superior seed trees and the development of future improved seeds trees from grafted stock.

1. Seed Trees

The seed trees currently in the orchard are approximately 17 years old and were developed from seedlings. Two species, Douglas fir and western hemlock, predominate.

Douglas fir

The main emphasis in seed production is to produce site specific seed, as Douglas fir is a very site specific species with local variations occurring within very short distances. Elevation and latitude play an important role in determining performance.

Spring girdling of seed trees is carried out three times every six years. This has the effect of stimulating both male and female flowers into seed production. Calcium nitrate is applied every year at a rate of 450 kg/ha (400lb/acre).

Cone collection begins in August. Cones are hand picked, family by family, for around $20/bushel. The seed produced from Douglas fir cones is sold for $770/kg ($350/lb). It is estimated that each kilo yields 88,000 seeds which have a 90% germinative capacity.

Western hemlock

Western hemlock is planted mainly in coastal regions. Seed production is poor with usually 50 bushels of cones being produced each year. Western hemlock seed is sold for $3300/kg ($1500/lb), with an estimated 550,000 seeds/kg.

2. Grafting

Douglas fir scions are grafted onto specially developed rooting stock. It can take 20 years to develop rooting stock which will accept most grafts but even then rejection can occur. Scions come from either selected plantations or progeny trials. Grafting is carried out on stock plants on site and is a top rather than a side graft. Two grafts are made, one for analysis and one for production. The analysis graft is made to monitor possible rejection. As rejection of the grafted stock can still occur after 20 years this is a very important operation. Once it has been determined that the graft has been successful the seed tree is shifted using a tree spade and moved to a predetermined area in the seed orchard.

Leaving the State seed orchard we travelled down to Salem, Oregon's capital city and administrative centre, to lunch at the Willamette valley winery. Lunch was again an experience, set as it was, in a wooden two storey building in the centre of the vineyard. The winery has only recently been established – in the last 3-4 years – but already produces some decent, if expensive, red and white wines. The building is typical of many we saw in Oregon showing the many uses that Douglas fir can be put to. There was superb decking around and to the side of the building made from planed, preserative treated Douglas fir. Our host for lunch was Mike Miller. Mike, a former state forester for Oregon State, is the Executive Director for the Associated Oregon Loggers. He gave us some insight into the effect that the spotted owl has had on the logging industry in the State. The associated Oregon loggers encompasses 700 logging companies each of which employs on average 6/7 loggers per company. Originally these companies averaged 11/12 loggers per company so there has been a drop from around 8,500 loggers to between 4,200 – 5,000. He explained that the environmental impact of the spotted owl had serious implications for the lumber industry.

Starker Forest

After lunch we moved on to our final stop of the day to the Dan Farmer tree farm of "Starker Forest". We were met by Gary Blanchard, the Chief Forester of Starker's. Gary explained that Starker forest comprises 24,000 ha (60,000 acres) and has a management staff of seven foresters. It was started in 1936 when Therman J. Starker, who was in the first class of forestry graduates from Oregon State University, began buying parcels of land for \$2/ha (\$5/acre).

The management aim of the forest is to respace and thin the plantations on a rotation of 60 years. Respacing generally takes place at 15 years and the first commercial thinning at 25 years. There are three further thinnings at 35, 45, and 55 years before clearfell. The intention is to finish with 200-250 stems/ha(80-100 stems/acre) with a mean dbh of 46-50 cms (18-20 inches) and 2 rings/cm (5/6 rings/inch). Pruning is not carried out as part of the silvicultural practice. The clearfell will yield approximately 250 cubic metres/ha (20,000 board feet/acre) with a current price of \$100/cubic metre (\$500/1,000 board feet).

At the time of our visit they had completed a felling of 10 ha (25 acres) and were now heading into reforestation with its associated problems. Some of the reforestation costs were as follows:

Cut and burn – \$40-80/ha
(\$100- \$200/acre)

Plant 850-1000 plants/ha
(350/400 plants/acre)

Spray grass/light vegetation
\$125/ha (\$50/acre)

A second spray, using Roundup, will be required.

One of the problems they encounter

in establishment is the high temperatures experienced during and after planting. The forest is located at an elevation of 180 m (600 feet) with a rainfall of about 1300/annum (50 inches/annum). Always looking for alternative markets the foresters at Starkers have developed a small niche market for the sale of edible fungi – in this case "Chanterelle" (*Cantharellus cibarius*) which grows wild among the woods. As we were leaving we stopped to look at some broadleaved species interspersed among the Douglas fir. One in particular caught my attention – the golden chinquapin (*Chrysolepis chrysophylla*). Its fruit is very similar to that of the Spanish chestnut.

Overnight Corvalis.

Richard Clear

TUESDAY, 13TH OCTOBER, DAY 6
Oregon State University, College of Forestry

Professor George Brown, Dean of the College of Forestry of Oregon State University (OSU) at Corvalis welcomed the Society to the University. He outlined the main issues in Oregon forestry today:

- timber supply
- rural community stability and health
- integrated forest resource management
- value added manufacture

The total area of Oregon is 25.1 million ha, of which 10.9 million ha (43%) is covered by forest and of this area 7.9 million ha is commercially owned. About 63% is publicly owned by the US Forest Service and Bureau of Land Management. The remaining 37% is privately owned with industrial forest businesses accounting for 21% while the remaining 16% is owned by 25,000 non-industrial private owners.

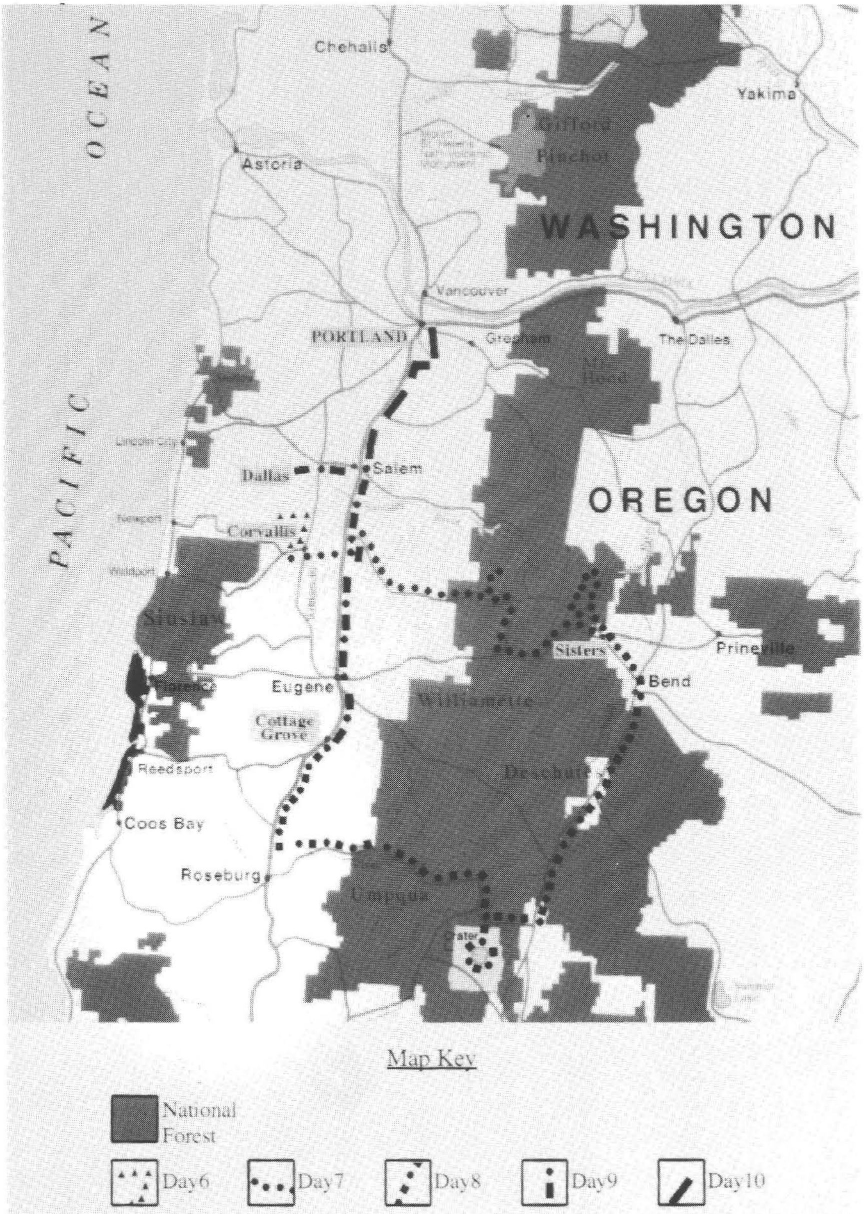
Over the period from 1977 to 1986 the annual harvest averaged 36.5 million cubic metres but this has declined in recent years. In 1989, 91,000 people were directly employed in the forest industry in the State. In the financial year 89-90 local taxes raised on the sale of public timber, the harvest of private timber and on property taxes associated with forest lands totalled $360 million.

The State has six main regions: (1) the Coast Range (2) the Willamette Lowland (3) the Cascade Mountains (4) the Klamath Mountains (5) the Columbia Plateau and (6) the Basin and Range Region. One quarter of the State is desert – to the east of the Cascade mountains.

The Cascade Mountains are of volcanic origin and the soils are derived from tuffs, breccia and pumices. These weather into deep, free draining soils. This region is the location of many of the finest old growth and second growth Douglas fir stands in the State. The Cascades include many of the highest peaks in North America such as Mount Hood (3424 m) and Mount Jefferson (3111 m).

The Willamette Lowland is a narrow strip of land wedged between the Cascade and Coast Ranges. The soils are alluvial in origin and are highly productive. It is the most important agricultural and industrial region in the State and over half of the population live there.

The Coast Range borders the Pacific ocean and is the lowest of Oregon's mountain ranges rising to a maximum



Location Map for Days 6 - 10

of 1249 m at Marys Peak. The Klamath Mountains are comprised of a number of different soils most of which are highly productive for forest growth.

Professor Brown went on to outline the Forest Research Laboratory (FRL) of OSU. The FRL is a public research organisation that has as its mission to 'Conduct well coordinated problem-solving research that provides knowledge for the integrated management of forest resources for multiple values and products which meets society's needs, with special attention to social and economic benefits'. He outlined four key ingredients for the success of a research programme:

- competence and credibility
- objectivity and reliability
- relevance
- the acceptance that research results affect decisions

The total budget for forestry research in 1989/90 was $11.5 million (£8.0 million). This budget was funded through two main sources: (1) appropriated funds (which support the permanent faculty) which accounted for 36% of funding (state general fund 15%, a harvest tax which is levied at the rate of 30 cents per 1000 board feet 17% of funding, and Federal funding 4%). (2) grant funds for fundamental research work which accounted for 64% of funding.

The research budget was divided among the following sectors:

- processing: 22%
- multiple land-use: 13%
- forest protection: 26%
- silviculture: 39%

Research results are communicated to users by a variety of mechanisms: through research publications, newsletters, workshops, symposia and conferences, through continuing education courses, research cooperators, through forestry graduates, personal contact and through forestry extension. The latter – getting research results to the users – is one of the major tasks of the FRL. There is a state-wide programme of forestry extension, there are eight full-time specialists at the FRL and a further thirteen agents in the counties. It is based on problem solving education and has a broad audience orientation with special county emphasis on the non-industrial private owner. This programme is a major source for research application, user feedback, and problem identification.

The campus of OSU is a major centre for forestry research. Apart from OSU (budget $11.5 million), there are staff from the Environmental Protection Agency (budget $5.4 million), US Department of the Interior, National Park Service, Cooperative Park Studies Unit (budget $ 0.6 million), USDI, Bureau of Land Management, Cooperative Research Unit (budget $1.8 million), US Department of Agriculture, Forest Service, Pacific Northwest Research Station (budget $6.0 million) engaged in forest research. The total investment in research in 1989 was $25.8 million.

The Cooperator Programme is another of the major tasks of the Forest Research Laboratory. In 1989/90 there were 285 formal cooperators and the work ranged from grants and contracts for research, to formal research cooperatives (seven in operation), through to in-kind support for the FRL.

The research programme is coordinated through a Statutory Advisory Committee and additional feedback and guidance comes from cooperators, resource management professionals, associations and resource organisations, user feedback, formal programme reviews, and Executive and legislative action.

After Professor Brown's presentation the Society was taken on a guided tour of the College laboratories.

The first stop on the tour was the Forestry Media Centre where the objective is to help improve teaching and to disseminate a forestry extension package. Its functions also include an instructional development programme which provides seminars and workshops on teaching and consults with individual faculty members. Students also have access to the centre. The Forestry Media Centre is an important part of the faculty and is an indication on the emphasis placed on acquiring good communication skills for faculty and graduates alike.

The College has a computer laboratory where we were given a hands-on demonstration of the GIS system. Satellite images on the GIS have been used to estimate forest volume and these have been found to correlate reasonably well with measured volume.

The Forest Products Laboratory is investigating shrinkage of wood and the variation in the moisture content of kiln dried wood. The latter can create problems especially where different species are dried together and used in composite products such as gluelam. Differential shrinkage can occur in use and result in surface checking in the beam.

In the Composite Wood Laboratory Dr. Philip Humphrey explained some of the work they are doing on modelling the hot pressing process of fibre board production in order to provide a tool that will aid in controlling the density of the board. He also gave a description of some of the newer composite wood products such as LVL (Laminated Veneer Lumber), parallam (being developed by McMillan Bloedell), OSB (Oriented Strand Board) and flakeboard (very similar to OSB). The overall objective in these products is to utilise relatively low value raw materials to produce a composite that has consistent strength and stability characteristics. He sees raw lumber being gradually replaced by composites as the supply of high quality lumber from virgin forests is replaced by wood from plantations of fast grown species with higher proportions of juvenile wood.

The Wood Engineering Laboratory is concerned mainly with testing wood strength and they have recently completed a strength testing programme on local softwoods to determine their suitability for the European market. They also have a programme of testing the suitability of Siberian larch for the US market. There is some import of Siberian lumber, with discussion in some areas of extensive imports to substitute for local supplies which are being tied up by environmental regulations. (The current estimate is that the harvest has been reduced by 20 to 25 million cubic metres because of the spotted owl controversy). There is also work on testing connectors for timber trusses and how these can be improved, and on wooden transmission poles.

McDonald Forest

After lunch in the nearby Avery Park we travelled a short distance by bus to the College McDonald Research Forest which comprises 5800 ha of mainly second-growth Douglas fir, much of it planted by the Civilian Conservation Corps (CCC) before the Second World War. There is a wide range of age classes as some of the areas were replanted several times. The forest is a important part of the teaching and research roles of the College; there are over 60 field experiments located there.

Being so close to Corvalis public relations is very important. Consultative meetings are held with local residents once a year and an explanatory brochure is distributed outlining the work in the forest. Recreation is an important use, with over 50,000 day visits each year. In addition to the these uses the forest provides a source of revenue for the College.

In the north end of the forest we visited a forest harvesting project. The objective was to investigate the possibility of shelterwood regeneration of Douglas fir in a stand that had been opened up by storms in previous years. One of the major of attractions of shelterwood regeneration is that it overcomes public hostility to clearfelling. Regenerating a light demanding species such as Douglas fir under shelter is difficult but on suitable south facing slopes it may be possible. The site was being thinned using a 50 feet Ross Tower skyline.

Dr. Ed Alrich outlined the three keys factors for efficient cable logging:

- planning
- crew training
- proper equipment

Cable logging has been found to be cheaper than skidding on sites with slopes greater than 40%. The cost of cable harvesting is from $15-20 per cubic metre. The maximum haulage length is 700-800 m with a 30 m side-haul distance on either side. One hundred and fifty to 250 cubic metres are typical amounts harvested in each set-up of the system with a maximum of up to 470 cubic metres per day. The maximum load on each haul is 15 cubic metres.

One of the noticeable features of harvesting in Oregon is the almost exclusive use of full tree extraction using either skidder or cable systems with little forwarding of shortwood. This is partly due to tradition and tree size but also to the approach of loggers in Oregon to harvesting where force is the order of the day – it is difficult to conceive of loggers using sophisticated forwarders or harvesters, although they are being used to a limited extent on some of the flatter sites.

The next stop was at a field trial examining spacings of Douglas fir from 1.5 x 1.5 m to 6.4 x 6.4 m. The trial has been installed in the past five years throughout the Pacific Northwest in order to provide a comprehensive database on the effect of spacing on the growth of the species in the region.

The final stop of the day was in a thinning trial where there was an intensive investigation on skyline logging on steep terrain. The trial was located in a second growth Douglas fir stand where the objectives were to make skyline logging more economic and to investigate the impact of different types of logging on soil compaction. The trial began in 1972 and has produced the largest database on thinning in the Pacific North West.

At the end of the day the Society were the guest of the College of Forestry at a barbecue dinner at Peavy Lodge in the McDonald Research Forest. Professor Brown wished the tour success in the coming days. The President Ted Farrell thanked Professor Brown and his staff for their time and hospitality in making our visit to the College and Research Forest such a success.

Eugene Hendrick

Christmas Tree Farm

After lunch some of the group visited Holiday Tree Farms, a few miles from Corvallis, and one of Oregon's largest. Established in 1955, it now carries an average inventory of five million trees and has an area of 1,200 ha. During our visit they were already well into their wreath making season. These were placed in cold stores.

The US Christmas tree market is now very competitive so production costs are kept to a minimum. This was evident in the use of Mexican workers in wreath making. Each had a minimum target of 50 wreaths per day. If a worker failed to reach this he/she was sent home. The farm produces mainly Douglas fir which was selling as low as $7.00 per tree, reflecting both the over-supply of Douglas fir and the US recession. They also grow noble fir, grand fir, white pine and Scots pine. Lately they have introduced Fraser fir and believe that it has excellent potential.

Holiday Tree Farms, despite its size is a family run business owned and managed by the Schudels. They also have a nursery where they grow all their own plants.

Spacing is 1.5 x 1.5 m and all trees are sheared each year, which to an Irish eye presents an artificial looking tree. However, this is what the customer wants and also ensures that despite irregular form at early stages of growth, trees can be sheared into a standardised shape. The rotation is 8 to 12 years – Douglas fir generally being a faster grower than noble fir.

Because of the scale of operation they make maximum use of helicopters in delivery of trees to central depots and in spraying. Helicopter rates were $425 per hour which is about half the Irish rate.

The Schudel family keep up to-date with new growing and production techniques, from tree provenances and ground preparation to chemical sprays and harvesting machinery. They adapt their own machinery if they cannot buy it and they believe that having their own nursery gives them the edge over their competitors. The motto of Dave Schudel is: "we don't just work here, we also study here".

Overnight Corvalis.

Donal Magner

WEDNESDAY, 14th OCTOBER, DAY 7

Willamette Valley Agriculture

We left our base in Corvallis and headed eastwards across the Cascade mountains. This area was in sharp contrast to what we had seen in N.W. Oregon. The soil is much lighter, rainfall is lower 150-180 mm/yr (6-7″/yr). Snowfall of 80-100 mm/yr (3″-4″/yr) makes up somewhat for the low rainfall. We passed through the Willamette valley which is mainly agricultural land. Rye grass is grown extensively and is famous world wide and is used in lawns.

The main towns here are Lebanon and Sweet Home, once home to 2,000

– 3,000 loggers. Most of the logging on neighbouring hills was done during World War II. The area is home to numerous sawmills and plywood plants. We stopped at Willamette National Forest Park which is mainly old-growth forest and good spotted owl habitat. Large areas of forest land are now tied up owing to the conservation of the species.

Road development costs are shared by the forest owners. Roads are used by the public and have to be maintained.

Foster Reservoir Big Tree

The first stop of the day was at a Douglas fir, typical of what the old growth forest contained. This specimen stood over 60 metres with a dbh of 380 cm. On our way to second stop we saw old growth forest of Douglas fir, noble fir and white pine. Old growth noble fir was used a lot in door frames, it is however, liable to shake or splitting caused by wind much more so than Douglas fir.

Skyline Logging Operation

The second stop of the day was at a skyline logging operation in a Federal forest at Deer Creek. The wood is sold by public tender. Logging takes place for ten to ten and a half months of the year, depending on weather conditions. The logging was being carried out by the Wymer Logging Company which does most of the logging for Willamette Industries Inc. (sawmills division).

The site was a staggered clearfell coupe of about 14 ha. Logging concessions follow contour lines but there environmental pressure to make these more irregular and less unsightly. The site was at elevation of 1,100 m with an annual rainfall of 400-500 mm/yr (15″ – 20″/yr) and a lot of snow. Felling is done 3 – 4 weeks in advance of extraction.

The team for the skyline operation was comprised as follows:

- hook tender – in-charge of operation
- skyline operator
- loader operator (John Deere grab and loader)
- sorter who segregates logs into up to nine different sizes
- chainsaw operator tidying up logs and cross cutting as necessary
- operator rigging and setting-up skyline
- two men chokering timber who also help setting up skyline

On very difficult terrain another man is added to the crew.

The full set-up time was about eight hours for a four man crew. A motorised carriage or skycar is used to reduce the number of set ups. To change to another extraction rack took about two hours for a four man team. The maximum rack length was 1,200 m with a side-haul of 400 m. The daily output was in the region of 200 cubic metres. The total price of the equipment on the site was about £500,000.

All timber measurement is done by an independent third party using the Columbia Logger Scale system which measures in board feet (200 board feet = one cubic metre of roundwood). Three log sizes are commonly used for Douglas fir: 10.5 and 6.2 metre (34 and 20 feet) lengths which are mainly used for pulpwood, and 4.3 metre (14 feet) lengths which are used for sawmilling. The cost of felling is about £1.70/cubic

Skyline logging at Deer Creek

metre which added to the cost of extraction and haulage to mill of £11.10 and £3.90/cubic metre respectively gives a total of £16.70/cubic metre.

The third stop was in a shelterwood cutting of a mixed stand of Douglas fir, noble fir and grand fir on Federal forest land. Some of the trees were retained to provide shelter and provide spotted owl habitat. Wide chain saw bars were used (914-1066 mm (36-42 inches)) and trees of over 42 inch butt diameter must be felled by two men for safety reasons. The fellers are paid about £10/hour.

After lunch we headed for Sisters which was our final destination for the day. We climbed up to 1370 m elevation (4,500 feet) passing through forests of spruce, lodgepole pine, white fir and noble fir, passing Lost Lake on the way. Here we say dead trees killed by the spruce bud-worm. These eventually fall to the ground and is not permitted by the state to remove dead trees. Spraying insecticide against the pest is now banned in 49 U.S. States. We passed through the Santiam Pass at 1468 m (4817 feet) to the eastern side of the Cascades. At lower elevations incense cedar and ponderosa pine predominate with stands of inland lodgepole pine. The rainfall in this region is 500 mm/year with a snowfall of 90 mm/year. Night time temperatures frequently fall as low as – 22°C.

The day ended when we arrived in Sisters to stay at the appropriately named "Ponderosa Inn".

Overnight Sisters.

Con Nyhan

THURSDAY, 15th OCTOBER, DAY 8
Willamette Industries Inc. Particle Board Factory, Bend

The plant was built in 1965 and employs 175 people, it is highly automated. It operates 350 days per year. The product is called KorPINE.

Sawdust and shavings from kiln dried fine, that is residues from windows and doors etc., is the raw material used, and it is stored undercover. The species mix most suitable for this process is pine/fir. Pine is preferred, due to too much resin in firs. Bark is not used due to discolouration of end product. Storage capacity of raw material is nine days, from 700 to 1,000 tons per day is used. $50 per dry ton is paid for raw material delivered in. The plant is operated seven days per week twenty four hours per day. The main source of energy is steam, all bark and sanded dust is blown into the furnace, in a similar process to burning natural gas.

In the main process, the raw material is screened, refined and blended with 7% wood resin to form a mat on caul plates. A pressure of 25 kg/cm^2 (350lbs per square inch) is applied at 160°C (320°F). Two lines 152 x 549 cm (5 x 18 feet) and 122 x 489 cm (4 x 16 feet) are used, producing 3.7 to 4.3 million linear metres (12 to 14 million feet) per month. There are four different thicknesses produced ranging from 6.4 to 28.6 mm (1/8 to 1 1/4 inches). After pressing the boards are sanded to a finish.

Michael O'Brien (extreme left) presenting a Society tie to Rod Moye of Wymer Logging, watched by John Fennessy, third from left and the President, Dr. Ted Farrell.

Strict quality control is applied at all stages. The main research laboratory is in Albany. The company has three more mills, one using pine and two using Douglas fir.

An electronic beam is used to produce a high gloss coating on 30% of the finished product. Seventy percent of the output is exported to Pacific Rim countries – South Korea, Japan and Taiwan, the remainder is sold on the home market. The main uses for the product are interior cabinets and furniture and the biggest market is DIY.

Salvage Logging of Lodgepole Pine

In the afternoon we visited a site where salvage logging of lodgepole pine, killed by bark beetle was underway. The operation on a very flat sandy site consisted of full tree harvesting using tree shears, flail delimbing and debarking and chipping. The chips are blown directly into large truck trailers for dispatch.

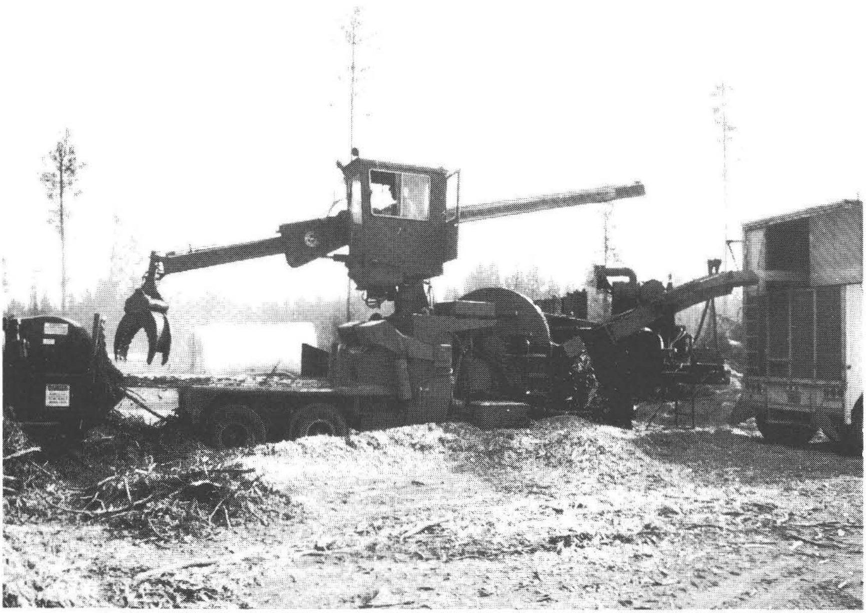
We made our way on through Deschutes National Forest to Crater Lake National Park. The main attraction, Crater Lake was formed when the Mount Mazama collapsed nearly 60 centuries ago. Leaving Crater Lake we travelled through Umpqua National forest to Cottage Grove.

Overnight Cottage Grove.

Tim O'Regan

FRIDAY, 16th OCTOBER DAY 9
Willamette Industries Inc.
Papermill, Albany

In the morning the Society visited a Willamette Industries Inc. paper mill



Salvage logging and chipping of lodgepole pine near Bend.

near Albany. The group was addressed in the office buildings by Mr. Keith Ivell – purchaser for the plant. He explained that the mill uses chips, hog fuel, and waste paper. Each day 100 – 120 truck loads of raw material are off-loaded at the mill, half fibre(chips) and half waste paper. The main species used are Douglas fir and western hemlock. Bark is used to generate steam.

The chip pile – a veritable mountain – spread over a vast area, amounted to two months supply. The factory was experiencing difficult times and ensuring continued supplies was proving more and more difficult due to environmental constraints greatly reducing logging activities in the State. Supplies are received from an 80 km (50 mile) radius and half are sourced from residues produced by the parent company. Moisture content is in the region of 50% depending on the season. Costs have tripled in the last few years due mainly to shortages – a bone dry ton costing approximately $100.

The group was split in two for a tour of the factory which uses the Kraft pulping process. The plant has three paper making machines. A computerised control room has recently been installed. The chips – a mixture of new and old - are first cooked under pressure in a mixture of water and sodium hydroxide. Uniformity of chip size is crucial for control of cooking and rejects end up as hog fuel. Cooking takes approximately half an hour. After cooking the chips are washed 3-4 times to remove lignin from the mix. When washing is finished the water – 99% of the total – is removed by initially scraping, then extruding onto a felt press, and finally by drying on a canister that is steam heated. The moisture content at the end of the process is 7%. The lignin removed is burned and chemicals are retrieved.

The paper made at the Albany plant is 'liner board grade' – the type used in cardboard boxes. Strength is imparted to the paper by aligning the fibres in different directions – achieved in practice by making the paper from three layers each with the fibres in a different direction. Control of directionality is achieved by the speed at which the 'mush' is fed onto the wire mesh for drying. 'Brown grocery bag' type paper is also produced.

Thirty eight to forty five million litres of water (10 to 12 million gallons) of water are used by the plant each day. Great emphasis is placed on recycling and the plant has its own treatment system. The plant has a second fibre operation which recycles OCC – old corrugated containers. It uses 500 tons of this material each day. The material is cleaned and passed to blenders and mixed with virgin fibre. The recycled fibres are weaker as each handling reduces the strength. The paper produced from these fibres cannot be turned as quickly on the drums and accordingly it has higher costs associated with it. However, OCC has 80 – 85% achievable efficiency. In the layered paper the top layer is 100% virgin fibre, the middle layer is 100% recycled fibre and bottom layer is virgin/recycled. All the production from the plant is presold.

The Chairman for the day, Mr. Paddy Glennon, complimented the people guiding the tours and thanked all involved for a very interesting morning.

Sawmill/Plywood Plant – Dallas

The Society visited a combined sawmill and plywood plant in the afternoon.

Bob Sloan set the scene for the visit. The original mill was built in 1905 and many changes had taken place since then. Much modernization was imminent – a new scanning system to be operational by Christmas.

Each plant uses approximately 250,000 tons of roundwood per year.

The group was divided in two and while one visited the sawmill the other visited the plywood plant. Schematic diagrams of both were provided before the tour commenced.

Sawmill

Almost everything going to the mill is butt reduced. Figures for recovery indicated that a figure of 59% was achieved – this did not include bark. The mill employs a grading system for its sawn lumber and figures given would indicates that 10% makes the best grade,that is, select. The next grade is known as two or better and 65% ends up in this category. The remainder is consigned to three and economy.

At the time of the visit prices for sawn lumber were going down. This was not a cause for concern as prices were heading for a level that was previously deemed to be healthy.

Plywood Plant

The guide for the plywood plant was Scott McIntyre. He first drew attention to the reserve which is retained in the event of a breakdown in the chop saw. The principal species used is Douglas fir with western hemlock comprising six to ten percent of the total. The chop saw cuts the logs into the correct lengths before they are dispatched to the steamer. Here the logs are exposed to temperatures of 100°C in the form of steam up to 18 hours to prepare them for peeling. Before they are fed to the rotary peeler a scanner finds the dead centre of the log. Once mounted a 51 cm (20 inch) log is reduced to a 9 cm (3.5 inch) stake in 10 seconds. The thin sheets of veneer are fed along a conveyor belt. A moisture scanner sorts the veneer into sapwood and heartwood. This is essential as each type requires a different drying schedule.

After drying, the sections pass through a very labour intensive process whereby sheet is placed successively on sheet. Numerous gluing operations also take place. Strength in all directions is imparted to the board by originating the sheets so as to ensure that the wood fibres lie in different directions. Finally the requisite number of sheets are in place and they are subjected to great force and heat which bonds them permanently together. Trimming of the edges leaves the product ready for grading and packing.

The plant produces a number of different grades of plywood. All the production is bonded with 'outdoor' glue. This is to prevent litigation/complaints in the event of improper use.

The Chairman thanked all those who had helped to make the day a success.

Overnight Salem.

Paddy O'Kelly

SATURDAY, 17th OCTOBER DAY 10

The Tour proper finished on Friday, Saturday was the first full free day and the morning was spent shopping at Clackamas Town Centre south of Portland. In the evening we moved to our hotel, the Shilo Inn, close to Portland Airport.

That night the Annual Society dinner was held at which the President Ted Farrell thanked all those who made the 1992 Study Tour such an outstanding success. Copies of The Forests of Ireland were presented to our hosts, Larry and Marian Christiansen,, and Wil and Catherine Heath. They in turn presented the Society with a copy of Oregon's Forests.

Study Tour participants

Denis Beirne, John Brady, Pacelli Breathnach, P.J. Bruton, Richard Clear, John Connelly, Maureen Cosgrave, Myles Cosgrave, Tony Crehan, Pat Crowley, Jim Crowley, Gerry Dolan, Joe Doyle, Charlie Farmer, Ted Farrell, John Fennessy, Gerry Fleming, Brigid Flynn, Lily Furlong, Paddy Glennon, Richard Griffin, Eugene Hendrick, George Hipwell, Liam Howe, Tom Hunt, Richard Jack, Harry Kerr, Donal Magner, Tony Mannion, Brian Monaghan, Eric Neyt, Noreen Nyhan, Con Nyhan, Tim O'Brien, Pat O'Brien, Michael O'Brien, Michael O'Donovan, Paddy O'Kelly, Tim O'Regan, Pat O'Sullivan, Denis O'Sullivan, Gerry Patterson, Tom Purcell, Peter Raftery, John Roycroft, Mossie Ryan.

Sponsorship

A portion of the cost of the Study Tour was provided by Coillte and the Forest Service. The Annual Society Dinner was sponsored by Smurfit Natural Resources.

COUNCIL REPORT 1992

1. COUNCIL MEETINGS

Six Council meetings were held during the year. Attendance by Councillors was as follows:

E. Farrell, L. Furlong, J. Fennessy, R. Jack, E. Hendrick, T/ O'Regan	6 meetings
P. O'Sullivan, N. O Carroll, J. O'Dowd	5 meetings
P. Breathnach, K. Hutchinson T. Wilson	4 meetings
A. van Wel	3 meetings
P. Carroll, J. Gilliland, A. Pfeifer	2 meetings

2. SOCIETY MEETINGS

The Annual Symposium was held in U.C.D. on 15th May 1992; the topic was "Sitka Spruce in the 21st Century". Attendance – approx. 110.

The Spring Meeting was held on 22nd May in Gosford Forest Park and Loughgall Horticultural Centre. Attendance – approx. 80. The Autumn Meeting was held on 4th September at Calverstown House and Ballynure House. Attendance – approx. 70. The Society also organised the Augustine Henry Memorial Lecture during National Tree Week and the Wood Ireland Exhibition on 18th-20th September. The Annual Study Tour visited the west coast of North America (Oregon and Washington) from 6th -19th October.

3. ANNUAL GENERAL MEETING

The 50th Annual General Meeting was held in the Agriculture Building, U.C.D., on 17th July 1992. The minutes of this meeting will be published in Irish Forestry.

4. SOCIETY PUBLICATIONS

Forest Images – Fr. Browne's Woodland Photographs was published in December 1992.

5. ELECTIONS

The positions of Vice-President, Technical Councillor (3) and Associate Councillor (1) for the period 1993 – 1994 were filled by election.

6. MEMBERSHIP

The Society now has 612 members enrolled in the following categories – Technical (444), Associate (125) and Student (43).

Signed: Pat O'Sullivan
Honorary Secretary
16th April 1993

ANNUAL GENERAL MEETING

Minutes of the 51st Annual General Meeting
13th May 1993
G-08, Agriculture Building, UCD

1. Minutes of 50th AGM

The minutes were taken as read. There being no amendments they were signed by the President.

1A. Matters arising from the minutes

Agenda item 5 (Council Motions I and II) – no submission on the issue of certification was received from the designated member

2. Council Report for 1992/3

The Council report was approved. It was proposed by P. M. Joyce and seconded by Eugene Hendrick.

3. Abstract of Accounts

The audited statement of accounts for year ended 31st December 1992 was adopted by the meeting. It was proposed by John Gilliland and seconded by Jim O'Dowd.

4. Results of 1992 Council Election

President: Eugene Hendrick
Vice-President: Gerhardt Gallagher
Secretary: Pat O'Sullivan
Treasurer: Richard Jack
Editor: Alistair Pfeifer
P. R. Officer: Jim O'Dowd
Business Editor: John Gilliland
Auditor: William Jack
N.I. Group Rep.: Trevor Wilson
Technical Councillors:
Ted Farrell, Niall O Carroll, Tim O'Regan
Associate Councillor: P. Glennon

The results, proposed by P. M. Joyce and seconded by John Connolly, were ratified. The incoming president, Eugene Hendrick, chaired the remainder of the meeting.

5. Council Motions

"That a Regional Group of the Society of Irish Foresters be established in U.C.D., Belfield". The motion proposed by Ted Farrrell and seconded by P. M. Joyce, was carried unanimously.

6. Constitutional Changes and Professional Standards

As a result of the recent changes in our Constitution, the Society must now define professional standards for its members and seek to promote the regulation of the forestry profession in Ireland. Ted Farrell suggested the Council should prepare a Statement of Ethics and a Code of Conduct for members. P. M. Joyce felt that some form of association with the Institute of Chartered Foresters (ICF)) would be of benefit to the Society. It was agreed that this would be considered by the incoming Council.

7. Policy Statements

The discussion concentrated on the two most recently prepared policy statements – "Forestry and Social Issues" and "Conservation of Semi-natural Oak Woodland". Fergal Mulloy felt that the title should be broadened to encompass other species. Niall O Carroll complimented the President on getting the Society to produce policy statements on such a wide range of issues and recommended that there would be one further editing of the papers prior to publication. It was agreed that this task would be assigned to Eugene Hendrick and Niall O Carroll. Fergal Mulloy suggested "Employment and Forestry" as a topic for a future policy paper.

8. Any Other Business

Forestry Courses

Ted Farrell recommended that the Society should assess and report on the quality and content of forestry courses being offered at various institutions around the country.

Archives Committee

Niall O Carroll outlined the purpose of this committee and asked members to donate any suitable unpublished material such as old photographs, minute books, notices of meetings, etc., to the Archives of the Society.

Meeting concluded.

Pat O'Sullivan,
Secretary.

SOCIETY OF IRISH FORESTERS – STATEMENT OF ACCOUNTS FOR YEAR ENDED 31ST DECEMBER 1992

1991	*RECEIPTS*		*1992*	*1991*	*PAYMENTS*		*1992*
8,573.03	To *Balance from last account*		15,859.79	116.07	By Stationery and Printing		1,125.31
	Subscriptions received			6,303.00	Printing of Journals		2,991.00
	Technical 1992	7,998.19		2,034.53	Postage		1,959.95
	Technical 1991	916.50		468.85	Expenses re Meetings		656.15
	Associate 1992	1,785.50		128.30	Bank charges		121.23
	Associate 1991	209.00		1,354.36	Secretarial expenses		1,484.10
	Student 1992	90.00		39.07	VAT		607.03
	Student 1991	20.00		0.00	Examination expenses		—
	Other arrears	490.50		143.57	Miscellaneous		208.52
	Advance payments	1,241.05		909.00	Insurance premium		900.00
14,709.09			12,750.74	204.06	Affiliations		147.36
	Interest on Investments				*Honoraria*		
784.47	Savings at Ulster Bank	1,008.43			Secretary	50.00	
8.38	Educational Building Society	8.53	1,016.96		Treasurer	50.00	
1,595.00	*Journal*		1,835.70		Editor	50.00	
	Grant for Book		5,000.00	200.00	Business Editor	50.00	200.00
	Book Sales		600.00		Father Brown Book		1,100.88
	Tie Sales		1,151.00		Purchase of Society Ties		1,375.78
40.88	Gains on sterling		17.50		Society display stand		1,998.45
49.75	Donation		13.50		U.S.A. visit		2,400.00
2,000.00	Wood Ireland						
					By *Balance*		
					Current Accounts	8,381.01	
					Savings Accounts	12,390.38	
					Educational Building Society	198.04	
				15,859.79			20,969.43
27,760.60			38,245.19	27,760.60			38,245.19

I have examined the above accounts, have compared with vouchers, and certify same to be correct, the balance to credit being IR£20,969.43 which is held in current accounts at the Ulster Bank (IR£9,901.25 less IR£1,520.24 uncashed cheques), Ulster Bank Savings Account 08778241 and the Educational Building Society Account 11304413. There is a holding of Prize Bonds Numbers R855061/080.

Signed: W. H. Jack, Hon. Auditor
28.4.93

EDUCATIONAL AWARD FUND

STATEMENT OF ACCOUNTS FOR YEAR ENDED 31st DECEMBER 1992

1991	*RECEIPTS*	*1992*	*1991*	*PAYMENTS*	*1992*
1,520.65	To *Balance from last account*	1,492.61	150.00	By Awards	0.00
121.96	To Interest	121.15	1,492.61	By *Balance*	1,613.76
1,642.61		1,613.76	1,642.61		1,613.76

I have examined the above accounts, have compared with vouchers, and certify same to be correct, the balance to credit being IR£1,613.76 which is held in the Trustee Savings Investment Bank Account 30013591.

Signed: W. C. Jack, Hon. Auditor
28.4.93

Notes to Assist Contributors

The following notes are designed to aid the speedy processing of contributions to the Journal.

1. Two copies of each paper should be sumitted in typescript, with double spacing and wide margins, correct spelling and punctuations expected.

2. Diagrams and illustrations should be clearly drawn in black ink on good quality paper. Captions should be written on the back of each illustration. Illustrations, wherever possible, should be drawn in an upright position (x axis narrower than y). The approximate position of diagrams and illustrations in the text should be indicated in the margin.

3. Tables should not be incorporated in the body of text, but should be submitted separately at the end (one table per page). Their approximate position in the text should be indicated in the margin.

4. Nomenclature, symbols and abbreviations should follow convention. The metric system should be used throughout.

5. References should be in the following form:

   GALLAGHER, G. and GILLESPIE, J. 1984. The economics of peatland afforestation. Proc. 7th Int. Peat Cong. Dublin. Vol. 3:271-285.

   KERRUISH, C. M. and SHEPHERD, K. R. 1983. Thinning practices in Australia. A review of silvicultural and harvesting trends. New Zealand Journal of Forest Science, 47:140-167.

   Forestry Abstracts may be used as a guide in the abbreviation of journal titles.

6. A short summary of the paper should be included. It should precede the main body of the text and not be more than 400 words.

7. Proofs will be sent to the senior author for correction. Proof corrections are costly and authors are requested, as far as possible, to confine alterations to the correction of printer's errors.

8. Reprints can be supplied as required by the author. The cost of reprints will be charged to the author at a standard rate per page. *Reprints must be ordered when returning corrected proofs to the editor.*

9. Submission of an article is understood to imply that the article is original and unpublished and is not being considered for publication elsewhere.

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