IRISH FORESTRY

JOURNAL of THE SOCIETY OF IRISH FORESTERS

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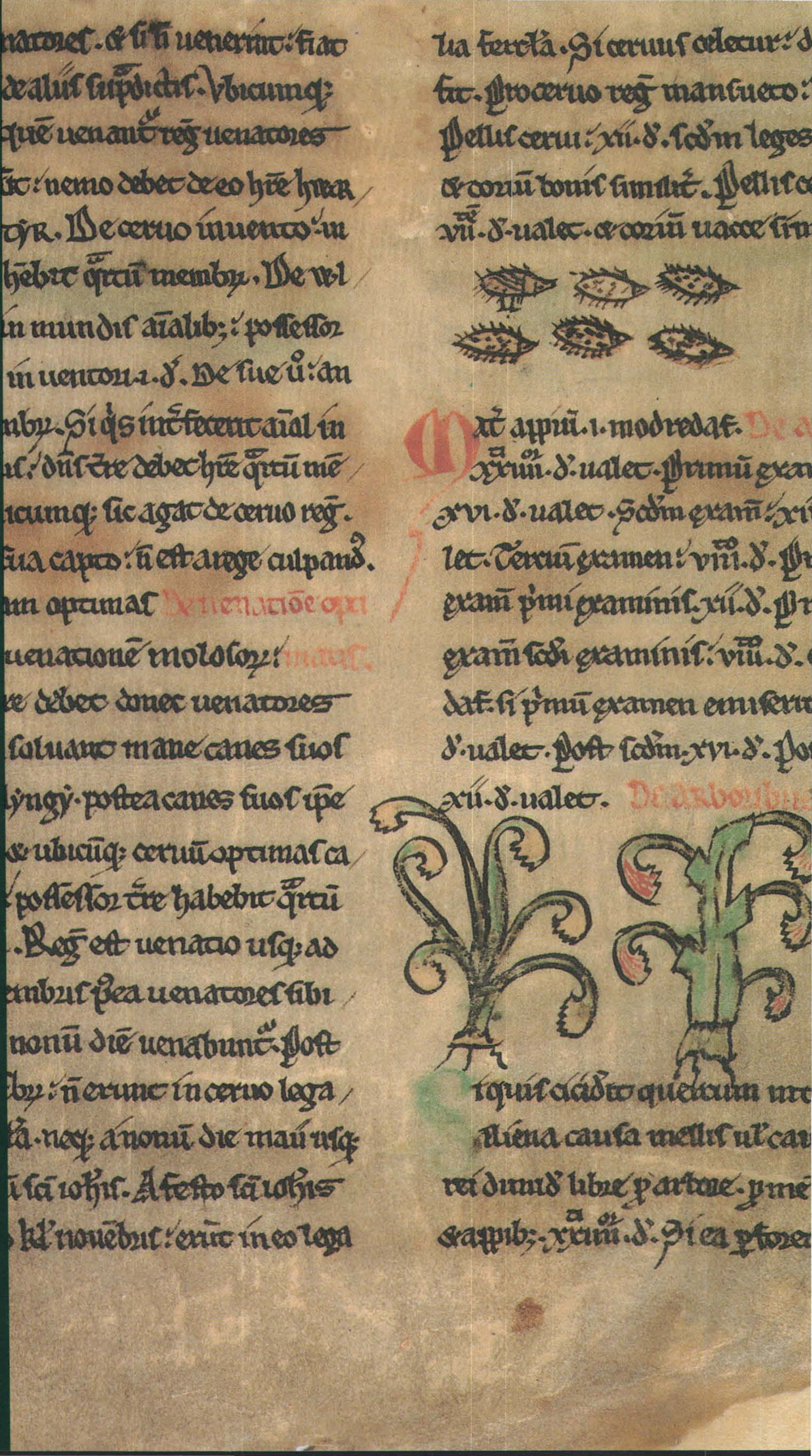

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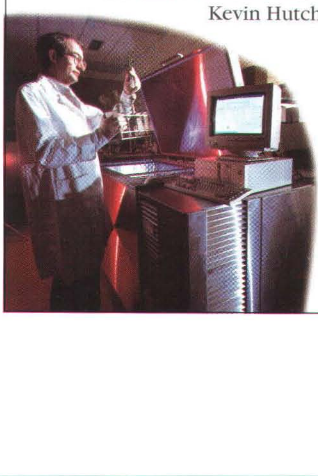

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Contents

Cover: Two trees which have been cut in different ways illustrate the section entitled *De arboribus* 'on trees' at folio 22^r of the thirteenth-century Welsh legal manuscript Peniarth 28. See *Trees in early Ireland* page

FOREST SERVICE

NEW AFFORESTATION GRANT AND PREMIUM RATES

The following grant and premium rates are effective in respect of areas planted from 1st October 1999.

		Afforestation Grant/Hectare	Maintenance Grant/Hectare	Total Grant/Hectare	% Increase
UNENCLOSED LAND		IR£1,600.00	IR£550.00	IR£2,150.00	40
ENCLOSED AND IMPROVED LAND	Non diverse conifers	IR£1,600.00	IR£550.00	IR£2,150.00	26
	20% diverse conifers	IR£1,700.00	IR£550.00	IR£2,250.00	25
	diverse conifers	IR£1,900.00	IR£600.00	IR£2,500.00	23
	approved broadleaf other than oak/beech 100% stocking	IR£3,000.00	IR£900.00	IR£3,900.00	30
	broadleaf - oak 75-100% stocking	IR£3,800.00	IR£1,200.00	IR£5,000.00	35
	broadleaf - beech 80-100% stocking	IR£4,000.00	IR£1,300.00	IR£5,300.00	33

		INCREASED PREMIUM RATES		Average % Increase
FARMERS - UNENCLOSED LAND		per hectare	IR£165.00	14
FARMERS - ENCLOSED AND IMPROVED LAND	non diverse conifers	per hectare	IR£265.00	29
	20% diverse conifers	per hectare	IR£308.00	32
	diverse conifers	per hectare	IR£328.00	33
	broadleaf - ash/sycamore	per hectare	IR£348.00	26
	broadleaf - oak/beech	per hectare	IR£373.00	27

In addition, a supplement of £10 and £20 per hectare will continue to be paid on areas greater than 6 hectares and 12 hectares respectively in relation to sites planted by or on behalf of farmers on enclosed land.

***STANDARD RATES FOR FARMER PREMIUMS ARE BEING INTRODUCED FOR THE THREE LAND CLASSIFICATION AREAS. THIS RESULTS IN HIGHER % INCREASES IN "SEVERELY HANDICAPPED" AREAS THAN IN "NON DISADVBANTAGED" AREAS**

NON FARMERS	conifers	per hectare	IR£135.00	17
	broadleaves	per hectare	IR£145.00	7

Discussions are continuing with the European Commission in relation to increased premium rates for farmers and non-farmers who planted prior to October 1999.

For more information please contact:

Forest Service, Johnstown Castle Estate, Co. Wexford.
Tel: 053 60 200 Lo call: 1890 200 223 Fax: 053 43834/5/6

Department of the Marine and Natural Resources
Roinn na Mara agus Acmhainní Nádúrtha

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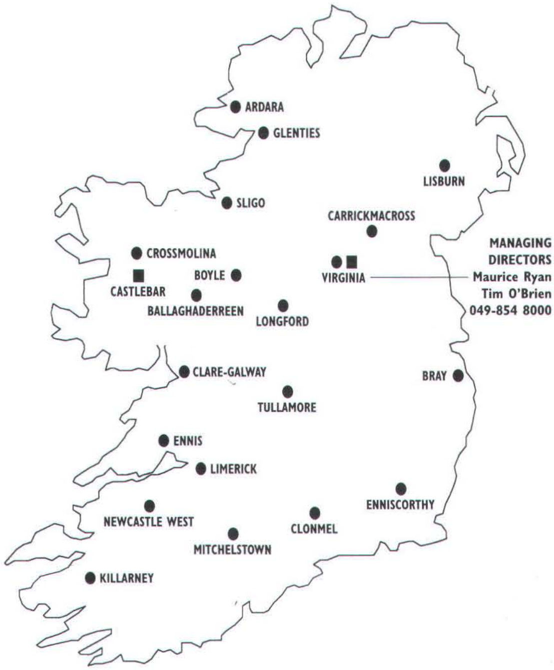

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The Society of Irish Foresters

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

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

There are three types of Society membership:

- Technical (MSIF): Persons who wish to promote the objectives of the Society and who, at the time of election, hold a degree or diploma in forestry from a recognised university, or who have successfully completed a full-time course at a forestry school recognised by the Society, or who hold the Foresters Certificate of the Society. Annual subscription IR£50.
- Associate: Persons not qualified for technical membership but who wish to promote the objectives of the Society. Annual subscription IR£30.
- Student: Persons studying forestry at universities, schools or colleges. Annual subscription IR£15.

In all cases, membership is subject to the approval of the Council of the Society. Enquiries regarding membership or Society activities should be made to The Society of Irish Foresters, 34 Upper Drumcondra Road, Dublin 9. Tel: +353-1-837 1400. Fax: +353-1-837 1321. E-mail: sif@tinet.ie

The non-membership subscription rate to *Irish Forestry* is IR£25 per volume world-wide (incl. P&P).

The Society of Irish Foresters is supported by the Forest Service, Department of the Marine and Natural Resources and the EU, under the Operational Programme for Agriculture, Rural Development and Forestry, 1994-1999.

Guidelines for Submissions

Authors are to observe the following guidelines when submitting material for publication in *Irish Forestry*:

- One complete copy must be submitted in typescript. Correct spelling, grammar and punctuation are expected. Nomenclature, symbols and abbreviations to follow established conventions, with the metric system used throughout.
- A computer disc containing text must be submitted. If applicable, a second disc containing computer generated tables, graphs and illustrations is also required. In both cases, clearly indicate the computer package used.
- Authors submitting scientific papers are requested to indicate whether they wish their material to be subjected to peer review. Papers submitted for peer review should include an abstract (max. 150 words) and a list of up to six key words before the main body of text. For general papers, a summary (max. 250 words) is required.
- References should read as follows.
  Gallagher, G. and Gillespie, J. 1984. The economics of peatland afforestation. *In:* Proc. 7th Int. Peat Conf. Dublin. Vol. 3:271-285.
  Kerruish, C.M. and Shepherd, K.R. 1983. Thinning practices in Australia. *New Zealand Journal of Forest Science* 47:140-167.
  Forestry Abstracts may be used as a guide in the abbreviation of journal titles.
- Communication relating to submissions will be made with the senior author. Prior to printing, a draft will be returned to the senior author for final proofing. Authors are requested to confine alterations at this late stage to the correction of typing errors.
- Submission of a paper is understood to imply that the paper is original and unpublished and is not being considered for publication elsewhere.

The above guidelines are designed to facilitate the speedy processing of material submitted for publication in *Irish Forestry*. Inadequate adherence to these guidelines may result in material being returned to the author for redrafting.

EDITORIAL

Forest certification schemes are now in place in a number of countries – the Forest Stewardship Council has recently certified both Forestry Commission and Northern Ireland Forest Service forests. In the Republic, certification is on the way. The objective of certification schemes is to independently verify that sustainable forest management is taking place and to establish a chain of custody for forest products from producer to consumer.

Forest certification has its origin in the desire of ENGOs to promote sustainable forest management in tropical and sub tropical forests. Forests in these regions have been overexploited for decades. Certification was seen as a means to promote sustainable forest management, through creating a demand for certified wood. While there have been some success stories these efforts have largely failed to halt the tide. In the meantime, the certification focus has shifted to the temperate and boreal forests of Europe and North America.

When certification was first proposed the reaction of foresters and forest owners alike was generally hostile. As the author of the paper in this journal asks, "why certification?" We did not need the imprimatur of a third party to tell us we were doing a good job. We had been practising sustained yield and careful resource management since the beginning of the 20th century. Unlike the tropics, forest cover was steadily increasing. Our forests were well managed and sustainable. However, forest products are traded internationally, in a highly competitive market. There was a market segment that wanted forest products and the forests from which they came to be certified by independent third parties. If the market demanded certified wood we had little choice but to respond.

But is it as simple as that? The market for certified forest products is difficult to measure. Certainly there is little or no evidence that certified forest products will command a higher price. Certification costs money, a cost that the grower will naturally try to recoup and pass down the chain. If this results in more expensive forest products then market share could be lost to competing materials such as steel and concrete – materials that are far more damaging to the environment in their manufacture than the equivalent wood products. There is also the danger of a proliferation of certification schemes, which may confuse the customer, leading to an erosion of confidence and lack of trust on the part of the consumer.

Despite these factors there has been a gradual change in attitude among foresters and woodland owners to certification. There is a realisation that the current schemes foster local involvement in the development of certification standards. They bring together growers, environmentalists and local communities. All current schemes favour the development of country-based standards that take into account national legislation, standards, and codes of practice, within the framework of sustainable forest management. The emphasis is on public consultation and continuous improvement. Forest management is taken in the broad sense, to include all forest functions.

Certification has the potential to play a powerful role in promoting the use of wood and wood products. However, it should not become an end in itself, or a development that will disadvantage the very entity it seeks to foster – sustainable forest management.

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

Submissions to be addressed to:

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Approaches to forestry investment in Ireland

Henry Phillips

Rathonorogh, Sligo

Abstract

The ultimate economic question about commercial forestry is 'what is it worth'? Confusion and misunderstanding surrounds the analysis of forestry investments. Forestry practitioners and private investors are unfamiliar with the terminology and techniques used. In the absence of a tradable market in forests in Ireland, it is generally recognised that discounted cash flow (DCF) is the most acceptable technique for the valuation of forestry investments. This is particularly appropriate to Ireland where the majority of investment concerns the establishment of new plantations. The various elements involved in carrying out a DCF analysis are discussed including risk elements – wind, disease, frost etc. – which up to now have to a large extent been ignored. Indicative returns based on economic analysis are given, together with published data.

Keywords: Discount rate, discounted cash flow, disease, fire risk, financial rotation, forestry investment, frost risk, internal rate of return, interest rate, markets, net present value, sustainable forest management, taxation, wind risk.

Introduction

The ultimate economic question about commercial forestry is 'what is it worth'? (Price, 1989). Forestry is a capital intensive investment. Capital is required for land purchase, crop establishment, roading and on-going operations and maintenance. In addition to the capital nature of the investment, forestry is unique in terms of the long delay before any revenue come on stream. Typically, under Irish conditions, rotation lengths for coniferous species vary from between thirty to sixty years.

To evaluate forestry investments there are a number of well-established techniques available. Most, but not all, take account of the two main distinguishing features of forestry that set it aside from most other investments – (a) the time scale involved and (b) the cash flow pattern of costs and revenues. The most widely used technique is discounted cash flow (DCF) which uses a discount rate to equalise or compare future costs and revenues in terms of today's costs and prices. Other techniques include historic cost and market value (Price, 1989). Ultimately however, forestry must be considered on a similar basis to any other type of business investment.

A lot of confusion and misunderstanding surrounds the analysis of forestry investments. Many forest practitioners and private investors are unfamiliar with the terminology and techniques used. Quite often returns are quoted which at first glance appear attractive but on closer examination are sometimes based on a wide number of over-simplistic assumptions and little analysis of the risks involved.

At the end of the day, the real value of a forestry investment is a combination of what price the purchaser is willing to pay and what price the investor is willing to dispose of the asset. The purchaser would prefer a low valuation and the seller would prefer a high valuation. In a free market, equilibrium would be established between the two. However, the market for forest sales in Ireland is only developing and we are confined to the use of the techniques referred to above to arrive at a valuation. It should be remembered that such valuations are *only indicative* and provide a *best estimate* which only time will reveal its validity.

Discounted Cash Flow

General

It is generally recognised that DCF is the most acceptable technique for the valuation of forestry investments (Fraser *et al.*, 1977). This is particularly appropriate to Ireland, where the majority of investment concerns the establishment of new plantations. The key feature of DCF analysis is that it is designed to assess the worth of a project taking account of the *timing* as well as the amount of cash flows. Underlying the technique is the assumption that investors behave in a rational manner and prefer returns sooner rather than later – time has a money value.

In DCF analysis, costs and revenues are equated to present day values through the use of discounting and discount rates. The basic formula is:

$$\mathbf{V_o = V_n / (1+ r)^n}$$

where

V_o	=	the value today (present value),
r	=	interest rate (expressed in decimal format),
n	=	the projected number of years from the present to cost or revenue occurrence,
V_n	=	value of the cost or revenue in n years time,
$1/(1 + r)^n$	=	the discount factor.

Interest Rates and Discount Rates

The interest rate charged to the project is logically the highest known rate that the money can earn elsewhere in the best alternative investment. This is sometimes referred to as the *'Guiding Rate'* and is also called the *Opportunity Cost* of money, since there is the opportunity to do something else with it.

To understand interest rates better, they can be considered as being composed of three elements: (a) the pure rate, (b) the expected inflation rate and (c) the risk rate. The pure rate is the equivalent of the interest rate net of inflation earned by risk free investments. This is typically the return on something like Government Bonds and is normally in the range of 2-4%. For long term investments like forestry, a view has to be taken as regards how inflation will average over the investment period. The investors can have their own opinion that may be either more optimistic or pessimistic than official government figures. The risk rate is that rate which describes the degree of risk associated with the investment. A high risk investment may have a high potential profit but it also has a high risk that one will lose everything. The risk rate varies from industry to industry. In general terms, forestry is considered either a low or medium risk.

The relationship between the interest and discount rate is:

Discount Rate = Interest Rate – Expected Inflation Rate
= Pure Rate + Risk Rate

The discount rate assumes that both costs and revenues increase at the same rate over the life of the investment. In doing this, the inflation rate is removed from the calculation and everything is expressed in terms of present value i.e. in today's money. If a cost or revenue item is expected to persistently inflate (or deflate) in price at a rate that differs from the average inflation rate, then it should be considered in the analysis and treated differently.

A lot of discussion and opposing views are expressed concerning what discount rate to use in the analysis of forestry investments. The rate chosen can determine the viability of a forest investment, be it either the purchase of land or the roading of a given property. A high discount rate favours short-term projects, while a low discount rate favours longer-term projects. High discount rates express a desire to receive money sooner rather than later.

Traditionally discount rates of between 3% and 5% have been used in relation to state forestry valuation in Ireland. Justification for the use of low discount rates include (a) unquantified non-wood benefits associated with the investment, (b) social aspects associated with investment in rural areas and (c) belief that the real rate of increase in timber prices will outstrip costs by anything from 0.5% to 1.5% on an annual basis.

In the private sector, higher discount rates are used, reflecting the natural desire for higher returns on investment and greater expectations. Typically discount rates of between 5% and 7% have been used.

Internal Rate of Return

The internal rate of return (IRR) of an investment is the discount rate at which discounted costs equal discounted revenues – the rate at which the present value (PV) equals zero. In simple terms the IRR is the earning power of the investment.

The IRR can give misleading results when the investment has a positive cash flow throughout its life, as can happen under the current grant and premium payments. In addition, the IRR does not allow for the inclusion of risk in the rate arrived at, as do present value calculations. Thus treatment of risk when using IRR must be either included in the inputs (prices, costs etc.), which is not always possible or alternatively, the IRR determined be reduced to account for risk.

Net Present Value (NPV)

The net present value of an investment is the sum of discounted revenues (DR) – including grants(s) and premiums where applicable – minus the sum of discounted costs (DC) – including land cost if appropriate. It represents the return over and above the discount rate used in the analysis. Typically DCF analysis produces a value for NPV. This value should however be treated with caution, as it is only indicative. A more prudent approach is to use NPV as an indicator for choosing between two or more possible options for investment, as for example a choice of species to plant. The use of DCF here will indicate the preferred option i.e. the one that is likely to yield a better return.

Risks

General

There is no such thing as a completely risk free investment. Governments have been known to fall, stock markets to crash, freak weather to devastate vast areas, banks to go bankrupt etc. The same applies to forestry. There are risks and it is important to state them clearly and where possible to account for them in any valuation we undertake.

Wind

Ireland is a windy country relative to most others in Western Europe. The incidence of high wind speeds and gales is well documented by the Meteorological Office. Wind coupled with wet mineral or organic soils predispose forest crops to windthrow, often cutting short the preferred rotation. On drier soil types wind can cause leader damage and breakage. Over the past five years an estimated 1m m^3 of timber has been windthrown in Ireland.

How do we account for the risk associated with wind? The most common method is to classify the crop rotation in terms of top height (Insley *et al.*, 1987). In Coillte (The Irish Forestry Board) crops are assigned a stability class with an associated rotation length defined in terms of top height. This is similar to the wind hazard classification adopted by the Forestry Commission (Anon, 1988).

The reduced rotation will incur a cost, as it is typically less than the financial optimum, if the crop had the ability to grow to maturity. This is relatively easy to quantify in terms of its effect on present value or IRR.

In terms of valuation, the top height site classification is critical. Both practitioners and potential investors have sometimes fallen into the trap of being overoptimistic in determining rotation lengths and have suffered the loss of revenue through windthrow and breakage. Conversely some practitioners have erred on the safe side and felled crops in anticipation of windthrow, many years prior to the onset of any damage. This too has a cost and reduces the value of the investment. An alternative approach to reducing the rotation length is to increase the discount rate used to allow for the additional risk associated with windthrow. This approach is more subjective and not recommended.

Finally in areas of high wind risk, it may be a better option to adopt a no-thinning regime. This will enable the crop to grow on further, but will reduce average tree size with consequent impact on revenues. A balance needs to be struck between revenue forgone by not thinning and the risk of losing revenue by opening up the crop to windthrow by thinning.

Fire

Ireland has a relatively short fire danger period compared to Mediterranean or Central European countries. Notwithstanding this, fire is a risk, particularly with young coniferous plantations up to thicket stage. The normal forest practices to reduce fire risk include the establishment and maintenance of firebreaks and vigilance during the fire danger period when burning on adjacent land can pose a threat. These costs should be included against the investment. In addition, it is possible to insure the plantation against fire. The premiums are relatively modest and it is prudent to include insurance in the cost schedule.

Frost

Spring and summer frosts can cause serious damage to a young plantation, resulting in the need for substantial filling-in or even replanting. This can in part be avoided by correct choice of species and provenance. However, based on national average replanting by Coillte over a ten year period, replanting due to frost damage will amount to less than 2% of the total area. Thus to account for the risk of frost damage, we need to include in our cost schedule a value for replanting in the region of 2% of total area. It must be stressed that this is a national average value and should be increased or decreased in areas where the risk is perceived to be higher or lower.

Disease

Ireland compared to other European countries is relatively disease free, due not only to its island status, but also to the enforcement of hygiene regulations on the importation of plant reproductive material and wood and wood products. There remains however a constant risk of disease, especially for our major coniferous species. The recent outbreak of the lesser-banded weevil in the north-west is a case in point.

Currently in mainland Europe there are a number of serious outbreaks of *Ips typographus*, *Lymantria monacha* etc., confined mainly though not exclusively to areas where crops are predisposed to disease, due to pollution or the effects of war, where normal sanitary operations have ceased, for example in Bosnia and Herzegovina.

With the establishment of coniferous crops on former agricultural land, there is an increased risk of butt rot (*Heterobasidion annosum*). The current practice of treating freshly cut stumps immediately after felling with a solution of urea will help reduce but will not eliminate the risk of infection completely.

It is impossible to evaluate the risk associated with disease and quantify it in a format suitable for inclusion in any investment valuation. Nonetheless, it should be borne in mind as a long-term risk associated with the investment. As a minimum, the recommended practices for protection against disease should be included in the valuation.

Markets

The following is a synopsis of the assessment carried out by the consultancy companies Deloitte & Touche and Jaakko Poyry in the preparation of the Government's strategic plan for forestry (Anon, 1996).

Global demand for industrial wood (wood for industry as opposed to wood for fuel) is now 1,600 m m^3/annum and is set to grow to over 2,000 m m^3/annum by the year 2015. Softwood will account for 67% of this demand growth, hardwood for 33%. The driving force will be increasing demand for pulp, paper and mechanical wood products (Anon, 1996).

There are two main deficit areas of wood in the world: Western Europe and the newly expanded areas in North-east Asia including Japan and China. The wood resources are situated at a distance from these areas. Possible influences on future wood supply to wood markets include:

- North American restrictions on wood cutting and more sustainable forest management which will reduce supplies to world markets;
- additional wood from South America which will mainly come from new plantations;
- increasing quantities of roundwood and sawnwood from the vast Russian resources;
- although Russia could stay as a low-cost country, the industry conditions and transportation would make the delivered cost fairly expensive; and
- the cost of wood from Western European resources would be fairly expensive.

Since this market analysis was undertaken, the Russian economy has collapsed and felling in Russia is now less than 50% of 1980 levels (Anon, 1997). Additional OSB, MDF and panel board capacity either has come on stream or is planned in the Baltics and Eastern Europe. The economies in South East Asia are in recession and there is additional pressure on wood producers to adopt and put in place sustainable forest management and certification procedures. This illustrates not only the dynamic nature of wood markets but also that any analysis is outdated the day it is produced

Ireland as an exporter of timber is very dependent upon what happens in the UK, which is its major export market. The timber produced in Ireland competes in the lower end of the market, where there is strong competition. Most analysts are of the opinion that this competition will increase over time with additional supplies coming on stream from traditional and non-traditional sources.

The impact of markets and price are interrelated. Wood is a globally traded commodity and cannot be looked upon solely in terms of the Irish market. Currently most forest valuations and analyses assume that the market (domestic and export) will be able to absorb/consume all of the wood assortments produced. This is very much dependent upon the development, growth and competitiveness of the sawmilling and small roundwood processing sector at home.

Price

Timber price has a major impact on any investment valuation. Over the years timber prices worldwide have kept pace with inflation and most analysts will agree that this scenario is likely to continue into the future. While prices have kept pace with inflation, they are subject to cyclical variations related to general world economy and growth/development of industry capacity. Ireland does not have a long tradition in forestry and reliable long term information on timber price is relatively scarce and rarely published.

In terms of private investment in forestry, there are a number of factors that will influence price at the local level. These include: (a) tree size, (b) road access (county and internal), (c) harvesting costs (ground conditions, haul distance etc.), (d) stem and wood quality – (species, straightness etc.), (e) distance to market, (f) lot size, and (g) supply and demand situation.

Each of these will impact to a greater or lesser degree on price. The most important are generally considered to be: (a) tree size, (b) access and (c) supply and demand. The most prudent approach in terms of valuation for a specific investment is to adjust general prices in relation to the distinguishing features of the timber coming from the investment.

For valuation of a forestry investment, using current timber prices is inappropriate and can give a very misleading result. This is due to the fact that current prices reflect the market at a single moment in time and do not take on board the cyclical nature of timber prices. Use of a long-term price series is more appropriate and is recommended. Current prices should normally only be used for valuation of mature plantations.

Timber Yields

Information on timber yields is necessary in order to estimate revenues. The traditional approach in Ireland is to use Forestry Commission (FC) yield tables (Anon, 1981) to predict future timber yields. The yield models included in FC Booklet 48 are extensive and cater for a range of yield classes, tree species, initial spacings and thinning treatments. These models are classified as static models and are only accurate if the prescription described is rigidly adhered to throughout the life of the crop.

Recent developments in yield modelling favour the use of dynamic models that can cater for variations in stocking and stand treatment over time. A dynamic model has been developed for Sitka spruce and plans are in place to develop models for Douglas fir, lodgepole pine, and Norway spruce (Broad, 1999). Based on a recent evaluation (Phillips, 1998a) of the model it as yet unsuitable for input to yield valuation.

Other Considerations

Taxation

The current taxation relating to investment in forestry is very favourable. An excellent summary of the taxation situation is provided by O'Hegarty (1997) upon which the following is based.

Income Tax: The occupation of woodlands, managed on a commercial basis and with a view to profits is exempt from income tax. Grant assistance and annual premiums are exempt from income tax.
Capital Gains Tax (CGT): Commercial woodlands occupied by individuals are exempt from CGT on the growing timber. The underlying land is not exempt but chargeable gains are restricted to the surplus over inflation adjusted cost. CGT is not applicable to a disposal on death.
Value Added Tax (VAT): Commercial forestry is regarded as agricultural production and exempt from VAT but the exemption may be waived.
Stamp Duty: Growing timber in commercial woodland is exempt from stamp duty but the underlying land is not exempt.
Capital Acquisitions (Inheritance and Gift) Tax (CAT): Commercial woodlands are subject to CAT on gifts to, or inheritance by individuals. In addition to specified exempt thresholds, relief is available to commercial woodlands as agricultural property.

Grant Schemes

Private forestry investment in Ireland is essentially driven by the generous grant schemes available to both farmer and non-farmer categories. Prior to the introduction of the Western Package scheme in the 1980s, private sector investment was negligible. Since the introduction of more generous incentives, mainly premium payments and increased grant levels, private investment has increased significantly. The downside is that the price of land for forestry has absorbed much of the increase in grant payments. Thus unless the investor owns the land, he/she is not in a position to benefit to the full from the increased grant payments.

Government Forest Strategy

Growing for the Future – A Strategic Plan for the Forestry Sector in Ireland (Anon, 1996) defines the national strategy for forestry. The case for continued and further investment in forestry was made on the basis of (a) a 'critical mass' size for the industry to enable it to compete and enjoy economies of scale, (b) real rate of return on investment, (c) future wood processing capacity and (d) employment. The strategy foresees:

annual planting levels of 25,000 ha to year 2000 and 20,000 ha to year 2030,
Wood output to increase from 2.2 m m^3 to 10 m m^3 by the year 2030,
each afforestation project to include a minimum of two species, and
Sitka spruce to be reduced to 60% of national average afforestation.

The overall forestry strategy provides an assurance to the private investor insofar that there is a strong government commitment to expand the current rate of afforestation and to put in place a range of measures that will benefit the sector and facilitate the private grower.

Cost Implications of Sustainable Forest Management

There can be no doubt but that in the immediate future there will be a requirement placed on owners of forests to manage their crops in accordance with the principles of sustainable forest management (SFM). In addition, there is every likelihood that timber certification will be required if forest products are to remain marketable. This has cost implications. First the cost of compliance with principles of sustainable forest management, second the cost of third party certification that SFM principles are being adhered to and finally the cost associated with the chain of custody.

Currently there are no reliable estimates of these additional costs for Ireland, as the process of SFM and certification is still under development. However, for the private forest owner, the costs are likely to be on average higher due to the level of fixed costs and lack of scale reductions for small forest areas. Some analysts quote a figure of between £2 to £5/ ha/year for compliance under Irish conditions and an additional cost of £2 to £3/m^3 for timber certification. While some costs will be absorbed by the industry, the likelihood is that the majority of costs will have to be borne by the forest owner.

Financial Maturity

Financial Rotation

There are many definitions of financial maturity in relation to forest crops. They can be categorised as being either (a) zero interest models or (b) interest rate models. The former have little application to forestry in Ireland and by their nature ignore the cost of time and capital. Of the models using interest rates there are three main definitions of financial maturity:

rotation of Maximum Net Present Value (MaxNPV)
rotation of Maximum Discounted Revenue (MaxDR)
rotation of Maximum Internal Rate of Return (MaxIRR).

The first two require the choice of discount rate. The third indirectly uses a discount rate, as the IRR is the discount rate at which the discounted revenue (DR) equals the discounted cost (DC) that is the Net Present Value (NPV) equals zero.

In practice MaxDR is easier to calculate and provides similar results to the rotation of maximum NPV (Johnston *et al.*, 1967).

The current practice in Ireland on rotation lengths for coniferous crops can be stated as to grow to rotation of maximum mean annual increment (MMAI) with the exception of Sitka spruce (*Picea sitchensis*) – less 20% MMAI; Norway spruce (*Picea abies*)-less 30% MMAI and coastal lodgepole pine (*Pinus contorta var latifolia*) – less 30% MMAI. The basis for this practice lies in an economic analysis undertaken in 1976 by the Forest and Wildlife Service. However, the analysis had a number of shortcomings in relation to (a) price information and (b) range of growth models available.

Recent economic analysis on rotation lengths (Phillips, 1998b & 1999) indicates that current practice is more or less in line with the theoretical financially optimum rotation for the major tree species. While there are differences, they are not generally so significant to warrant a change in rotation length apart from some minor exceptions. The situation for minor tree species Scots pine *(Pinus sylvestris*) and larch (*Larix spp*) for example, is different, and a reduction in rotation length is indicated. The scale of reduction varies from 5 to 15 years depending on species and yield class.

Technical Considerations

There are some technical considerations, particularly in relation to (a) the average final crop tree size and (b) timber quality from very fast grown crops that need to be taken into consideration. There is little point in having a recommended rotation length that results in a tree size that is not capable of being processed by industry.

Real Rate of Return

Indicative Returns

Economic analysis indicates that the real rate of return is mainly dependent upon (a) owner category – as this determines grant and premium levels and land cost, (b) site productivity and (c) crop management regime, including rotation length. The rate of return is extremely sensitive to the price of land, as this represents the major cost and is borne at the beginning of the investment period. Thus a land owner can in theory expect to achieve a real rate of return in the region of 8% to 12% depending on site productivity and management regime and assuming zero land cost. Where the investor has to purchase the land, then the expectation is for a real rate of return of between 4.5% to 7%, again dependent on site productivity and management regime.

A word of caution must be expressed in relation to these indicated returns. They are only 'best estimates' and are based on certain simplifying, yet prudent, assumptions.

Comparison with Published Returns

There is a lack of published information on the actual or estimated returns from investment in forestry in Ireland. Growing for the Future – A Strategic Plan for the Forestry Sector in Ireland (Anon, 1996) estimated the real rate of return in forestry (Sitka spruce) as 5% including land cost and exclusive of grants and subsidies. This figure[1] was amended to take account of Irish costs and changed to 4.3% which is close to the lower end of the range for non-farmer owner category.

In Britain on better quality land, with zero opportunity cost attributed, rates of return of 7% (Anon, 1986a) and 6.5% (Anon, 1986b) have been demonstrated. The Wood Production Outlook in Britain (Anon, 1977) concluded that rates of return were low and estimated an expected mean of 2.3% for the period 1977-81. Very favourable assumptions about land, labour and timber prices raised this to about 6%.

The Irish Forestry Unit Trust (IFUT) estimates (Lacey, 1998) the return from forestry as being within the range of 5% to 7%.

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Development and evaluation of a pre-harvest inventory and cross-cutting simulation procedure to maximise value recovery

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Abstract
The development and evaluation of a pre-harvest inventory and value maximisation decision-support system for sawmill wood procurement is described. The system allows procurement managers to select the most suitable stands for tendering and subsequently to maximise the value of the logs produced during harvesting operations. The developed system consists of a generic taper equation, a stand-specific dbh/height model, and a computer simulation programme which provides detailed information on the potential volume, log count and diameter distributions for different log assortment specifications. The system was developed using data from five Sitka spruce (*Picea sitchensis* (Bong.) Carr.) clearfell sites in west Munster. The system was evaluated using seven data sets, three validation sub-sets from data sets used for the development of the taper equation and the dbh/height model, and four data sets from new sites, including two Sitka spruce clearfells, a Sitka spruce thinning and a Norway spruce (*Picea abies* (L.) Karsten) clearfell. The evaluation process showed that the developed procedure produced accurate results for a wide range of stand types, as long as sufficiently large data sets are used.

Keywords: Cross-cutting simulation, dbh/height models, forest inventory, taper equations, value maximisation.

1. Introduction
The three cornerstones of profitability of harvesting and sawmill operations are maximisation of volume output, minimisation of costs and maximisation of value. Too often the emphasis has been on minimising production costs and maximising volume output, while raising product value recovery took a back seat (Murphy *et al.*, 1991).

In order for a sawmill wood procurement manager to select the most suitable stands for tendering and subsequently to maximise the value of the logs produced in harvesting operations, information is required, not only on the mean tree dimensions and total volume of the stand, but more importantly, on the potential volume, the number of logs and the diameter classes, for different assortment specifications. Information of this kind will greatly assist production planning in the mill. Knowledge of the consequences of adopting a particular cross-cutting strategy will also enable mills to identify the optimum combination of log products to be harvested from a stand, subject to operational constraints and the need to satisfy customer demands for sawn timber. With a greater insight into the yield potential of a crop in terms of actual products, tender prices could also more accurately reflect the value of individual stands to different mills. This would enable each mill to confidently target those sales most appropriate to its specific requirements.

At present, the information provided to sawmills on standing timber lots is considered by them to be inappropriate for their planning and procurement needs. Currently the conventional pre-harvest inventory typically provides estimates of mean diameter at breast height, mean volume and total volume, in addition to a breakdown of volume into assortment categories. In the absence of more informative pre-harvest information, the scope for efficiently exploiting the forest resource is limited. More specific and end use-oriented information relating to the yield of stands in terms of actual products would, subject to competition, enable mills to procure the stands and cut the logs that best meet their needs and that satisfy the demands of their customers.

Accordingly, a pre-harvest measurement and analysis procedure has been developed to provide an efficient means of obtaining, relaying and analysing information on standing timber to generate predictions of the volume, number and diameter class breakdown of potential log assortments. The inventory procedure was designed to enable the timber procurement manager to acquire, at reasonable expense, information that, when analysed, provides a comprehensive insight into the yield potential of the stand.

A research project was undertaken in conjunction with Palfab Limited, a medium-sized softwood sawmill that purchases over 90% of the logs it processes from standing sales. The research was directed towards finding solutions to the problems encountered by Palfab, and toward developing a system specific to the needs of the mill (Malone, 1998). In previous publications, the development and testing of the inventory procedure has been outlined and discussed (Nieuwenhuis and Malone, 1996 & 1999). This article will briefly summarise this development work, but will focus on the evaluation of the output of the inventory procedure for a wide range of stands and will compare these results with the optimal cross-cutting output as produced by a dynamic programming procedure which uses detailed stem measurements.

2. Development of Inventory Procedure

The purpose of the research was to develop a decision-support system, incorporating pre-harvest measurement and analysis procedures, to provide the timber procurement manager of a medium-sized sawmill with estimates of the volume, number and diameter class breakdown of log assortments that could potentially be cut from standing timber lots of mature Sitka spruce (*Picea sitchensis* (Bong.) Carr.). The tree section data used in the construction and testing of the inventory procedure consisted of 5,543 observations of diameter and height made on 246 stems, from five Sitka spruce stands (Table 1). The standing timber lots, selected by Palfab, were considered representative, with respect to mean dbh, mean tree volume and location, of those normally purchased by the mill.

An identical data collection procedure was followed in each stand. The diameter overbark at breast height was measured, in millimetres, for all sample trees using an electronic callipers. The point at which this measurement was taken was marked on the standing tree to provide a means of determining stump height. All trees were allocated a unique number to allow for future identification. The trees were subsequently felled and the stems delimbed to facilitate the measurement of diameter overbark. Measurements were taken, in millimetres, at 0.5 m intervals to a distance of 6.0 m from the butt and at 1.0 m intervals thereafter

Table 1. *Summary characteristics of the stands used for model development. All stands were Sitka spruce clearfell sales.*

Stand	*Forest*	*Planting year*	*Yield class* $m^3 ha^{-1} year^{-1}$	*Mean DBH cm*	*Number of sample trees*
1	Skibbereen	1958	24	27	54
2	Kenmare	1954	18	26	64
3	Killavullen	1956	18	23	38
4	Inchigeelagh	1956	22	32	59
5	Inchigeelagh	1956	22	30	31

Source: Coillte (The Irish Forestry Board)

to an approximate top diameter of 70 mm. In addition, the lengths, to the nearest centimetre, from the butt to the breast height diameter mark and to the tip were also recorded.

The data were subjectively divided into a development subset and a validation subset at stand level. This exercise was performed in such a way as to ensure that both subsets were representative of the original data with regard to the distribution of dbh and tree height values. The development subset was subsequently used to determine which independent variables to include in the candidate equations and to estimate the regression coefficients. The validation subset was used as independent data for evaluating the performance of the equations.

Four taper equations, identified from an extensive literature review, were selected for evaluation. Performance ranking, based upon values of bias and standard error of estimate, revealed an eight-variable taper equation (referred to as the Kozak 1992 equation in this paper, see Appendix for details) developed from modifications proposed by Newnham (1992) to the 'variable-form' equation of Kozak (1988) to be best overall (Malone, 1998).

Eight dbh-height models were chosen from the literature for preliminary testing. The three models that generated estimates of tree height with the least bias and minimum standard error of estimate were further investigated. The recommendation is to employ a combination of the Curtis 6 dbh-height model (Curtis, 1967) and ten height sample trees drawn by simple random sampling in conducting the pre-harvest inventory (see the Appendix for model details). Further investigations were carried out to finalise inventory procedures, primarily with respect to minimum height sample size(s) (McHugh, 1998). An interactive computer programme was developed to simulate the process by which stems are cross-cut into logs. The programme employs the generic taper equation to profile the stems of sample trees of known dbh and estimated height (using the dbh-height model and height sample trees) drawn from the stand. Using log specifications supplied by the user, the programme then simulates cut-to-length harvesting and produces forecast estimates of yield for each log-type in terms of the volume and number of pieces in each of a series of small-end diameter categories.

3. Evaluation of the Inventory Procedure

In order to determine the accuracy of the results from the inventory procedure (developed as described above), data from a wide range of stands were analysed. These data were processed by both the inventory procedure and by an optimal cross-cutting program which uses a dynamic programming algorithm (Nieuwenhuis, 1989). As this program uses detailed stem measurements and an optimisation procedure, the results produced by this process are assumed to be optimal (i.e. the best possible cross-cutting strategy). The results of the inventory and cross-cutting simulation procedure were evaluated against these optimal results.

Three of the five data sets used in the development phase of the project were of sufficient size to also allow for their use in the evaluation phase. The validation subsets of the datasets from Skibbereen (stand 1), Kenmare (stand 2) and Inchigeelagh (stand 4) contained circa 20 dbh sample trees and allowed for the random selection of 10 height sample trees.

Four additional data sets were also used in the evaluation process (Table 2). The original purpose of these data sets had been the testing of the developed inventory procedure over a wider range of stand types than that used during the development phase (McHugh, 1999). The sites included two Sitka spruce clearfells, a Sitka spruce thinning and a Norway spruce (*Picea abies* (L.) Karsten) clearfell. As these data had not been used in developing the inventory procedure, all observations from the four data sets were used in the evaluation.

Table 2. *Characteristics of the four additional stands used in the evaluation process.*

Stand	*Forest*	*Planting Year*	*Yield class* $m^3\ ha^{-1}\ year^{-1}$	*Mean DBH cm*	*Species and harvest type*	*Number of sample trees*
1	Kenmare	1958	18	24	Sitka spruce clearfell	38
2	Bandon	1953	20	27	Norway spruce clearfell	48
3	Ballingeary	1952	16	29	Sitka spruce clearfell	33
4	Dunmanway	1958	20	24	Sitka spruce thinning	47

Source: Coillte (The Irish Forestry Board)

In the evaluation process three potential assortments were specified: sawlog (length 5.5 m, minimum small end diameter (min. sed) 160 mm); pallet (length 2.5 m, min. sed 140 mm); and pulp (length 3.1 m, min. sed 70 mm).

3.1 The simulation process

The inventory data consisted of measurements on dbh sample trees and on height sample trees. These data were processed as follows:

1. The data from the ten randomly selected height sample trees, consisting of the dbh and height measurements, were inputted to the dbh/height regression model (i.e. the Curtis 6 model). The output consisted of the coefficients of the model's independent variables.
2. Data from the dbh sample trees, consisting of the dbh measurements of the remaining trees in the data set, were inputted to the dbh/height model as generated in step (1) and an estimate of the height of each tree was produced.
3. The combined data set, consisting of a dbh measurement and a height measurement or estimate for every tree, was inputted to the cross-cutting simulator, together with the assortment specifications. The simulator used the generic Kozak 1992 taper equation to estimate the diameter of the tree at any point along the stem. The output of the simulator consisted of detailed frequency tables, giving a breakdown of assortment

volumes and assortment log numbers by 2 cm diameter classes.

In order to be able to evaluate the individual impacts of the taper equation estimates and of the dbh/height equation estimates on the accuracy of the results, the simulator was also run using the actual height data of the stems, instead of the height estimates as produced by the dbh/height model. The difference between these results and the results from the optimisation procedure gave an indication of the performance of the generic taper equation. The results produced, when both the taper equation and the dbh/height equation were used, gave an indication of the overall performance of the simulator when compared with the optimal cross-cutting results. The results were also used to evaluate the performance of the dbh/height model when compared with the results where the actual heights were used.

3.2 The optimal cross-cutting process

As outlined in Section 2, the data used in the dynamic programming procedure consisted of detailed stem measurements. These data were reformatted to be compatible with the computer program. The procedure also required the identical assortment specifications as used in step 3 in section 3.1. The dynamic programming algorithm determined the optimal cross-cutting strategy for each stem. The output of the optimiser consisted of individual cross-cutting patterns for each stem. In addition, these individual results were combined into frequency tables that were compatible with the ones produced by the simulator.

3.3 The evaluation process

The output frequency tables produced by the simulator (both for the combination of taper equation and actual heights (Sim1) as well as for the combination of taper equation and dbh/height equation (Sim2)) and by the optimiser (Opt) were compared. First, the breakdown of total volume into assortment categories was examined on a cubic metre and on a percentage of total volume basis. Similarly, the breakdown of the total log count into the number of logs in each assortment category was analysed (both on a number and on a percentage of logs basis). This gave a clear indication of the capacity of the simulator to determine overall assortment estimates.

The next step was to evaluate the breakdown of the sawlog assortment volumes and log counts into the small end diameter (sed) categories. The capacity of the simulator to predict the correct sed frequency distributions within the general sawlog assortment is important, as this provides the wood procurement manager with the information needed to accurately value the stand and to predict the best possible combination of assortments to cut from the specific stand. As each site was evaluated separately, differences between single site estimates produced by the optimiser and by the simulator for each of the variables analysed were not statistically compared.

4. Results

4.1 The validation data sets

The results of the comparisons of the breakdown of total volume and total log count into assortment categories for the three validation data sets are presented in Tables 3 to 5. In these tables (as in subsequent tables) Sim1 results refer to simulator estimates where the taper equation was used with the actual tree heights; Sim2 results refer to estimates where the taper equation and the dbh/height model were used; Opt results refer to outputs from the optimisation procedure.

The simulator estimates for total volume and number of logs for the Skibbereen data set (Table 3) were too high (total volume was 14% higher and number of logs 11% higher than the optimal values), however the percentage breakdown into the assortments was very close (within 2%). Sim1 results were closer to the Opt values than the Sim2 results when actual estimates are considered, but there was no difference when percentages were used.

Table 3. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Skibbereen validation data set (19 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	1.10	1.37	9.84	12.31
Volume m^3	Sim2	1.01	1.61	10.48	13.10
	Opt	0.97	1.25	9.30	11.52
	Sim1	9	11	80	100
Volume %	Sim2	8	12	80	100
	Opt	9	12	79	100
	Sim1	26	22	33	81
# of logs	Sim2	24	25	33	82
	Opt	22	20	32	74
	Sim1	32	27	41	100
% of logs	Sim2	29	31	40	100
	Opt	32	29	39	100

Total volume and log estimates for the Kenmare data set (Table 4) of Sim1 were closer to Opt than the Sim2 estimates. The assortment results were close, both for the actual values as for the percentages. It was interesting to see the reduction in potential sawlog at the Kenmare site compared with Skibbereen (down from 79% of total volume to 72%), reflecting the smaller average tree size at Kenmare.

Table 4. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Kenmare validation data set (21 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	1.17	1.43	7.18	9.78
Volume m^3	Sim2	1.08	1.49	7.63	10.20
	Opt	1.06	1.56	6.78	9.40
	Sim1	12	15	73	100
Volume %	Sim2	10	15	75	100
	Opt	11	17	72	100
	Sim1	29	24	31	84
# of logs	Sim2	26	25	31	82
	Opt	27	27	31	85
	Sim1	34	29	37	100
Logs %	Sim2	32	30	38	100
	Opt	32	32	36	100

In the case of the Inchigeelagh data (Table 5), the Sim2 pulp estimates were accurate. However the sawlog estimates were too high, with too little pallet being estimated (sawlog 10% over-estimated by volume, 8% by number of logs). The Sim1 sawlog results are clearly closer to Opt than the Sim2 results, both for actual volume estimates as well as for the percentages. This was more than likely caused by the dbh/height equation, probably as a consequence of the dbh/height sample trees used to establish the regression coefficients not being representative of the stand.

Table 5. *Assortment breakdown of volume and number of logs, by quantity and percent, for the validation data set of Inchigeelagh (19 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	0.99	1.61	6.64	9.24
Volume (m^3)	Sim2	0.97	1.46	7.69	10.12
	Opt	0.96	1.49	6.74	9.18
	Sim1	11	17	72	100
Volume (%)	Sim2	10	14	76	100
	Opt	11	16	73	100
	Sim1	22	25	23	70
# of logs	Sim2	22	23	26	71
	Opt	22	23	24	69
	Sim1	31	36	33	100
Logs (%)	Sim2	31	32	37	100
	Opt	32	33	35	100

The sawlog frequency distributions for the three validation data sets are presented in Figures 1 to 3. Because of the limited number of stems in each data set, the distributions are not as smooth as would be expected with larger data sets. Overall there is a very close similarity between the estimates produced by the simulator and the optimal values from the detailed stem data, with the Inchigeelagh estimates especially accurate.

The average sawlog volumes for the three validation data sets, as produced by the three procedures, are presented in Table 6. It can be seen that all estimates for both the Sim1 and Sim2 procedures are higher than the actual values as produced by the optimiser. This is the result of an over-estimation of the volumes, based on data sets that are too small to produce accurate estimates. The estimated numbers of sawlogs are however very close to the actual values. The use of the dbh/height equations for the Sim2 estimates introduces a further deviation from the actual values compared to the Sim1 estimates.

Table 6. *Average sawlog volume (m^3 log^{-1}) for the three validation data sets, as estimated by the simulator and as calculated by the optimal cross-cutting procedure.*

Site	*Sim1*	*Sim2*	*Opt*
Skibbereen	0.298	0.317	0.291
Kenmare	0.232	0.246	0.219
Inchigeelagh	0.289	0.296	0.281

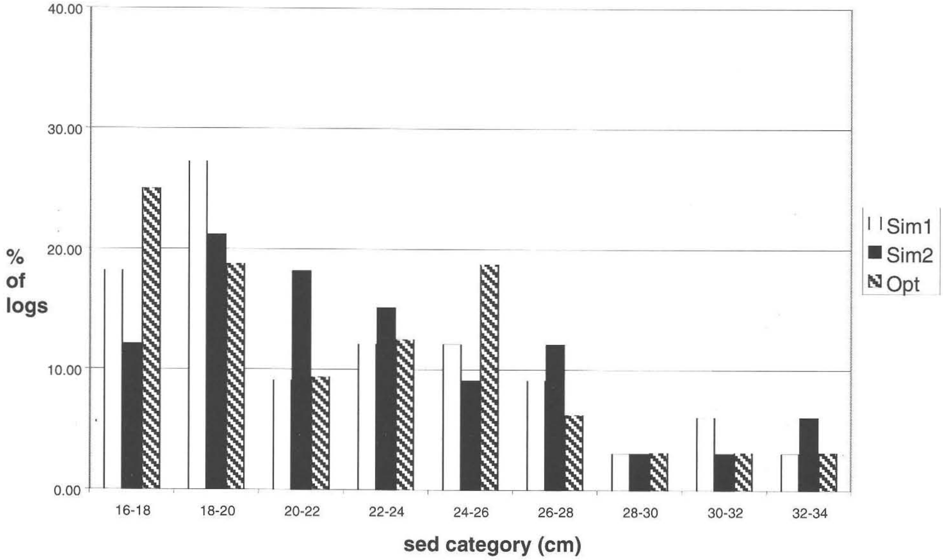

Figure 1. *Sawlog frequency distributions (in percent of number of logs) by small end diameter (sed) category for Skibbereen.*

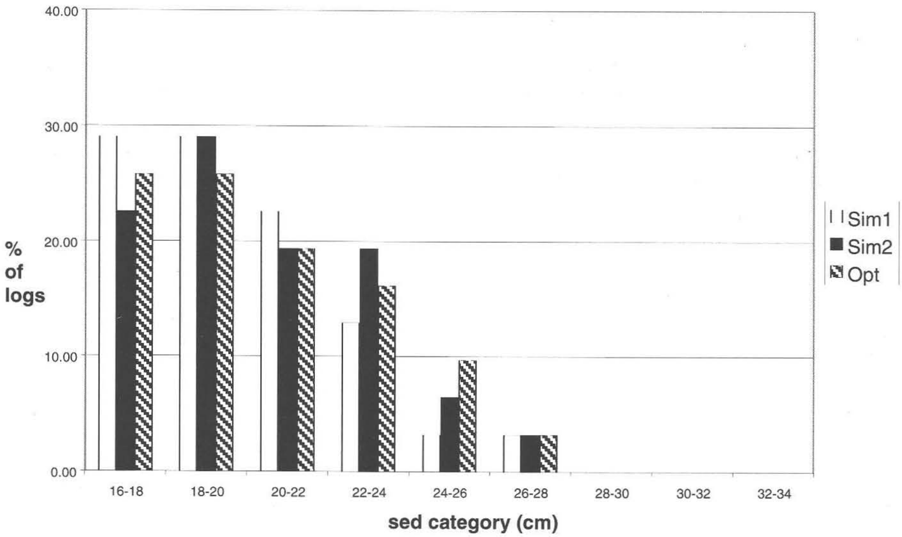

Figure 2. *Sawlog frequency distributions (in percent of number of logs) by small end diameter (sed) category for Kenmare.*

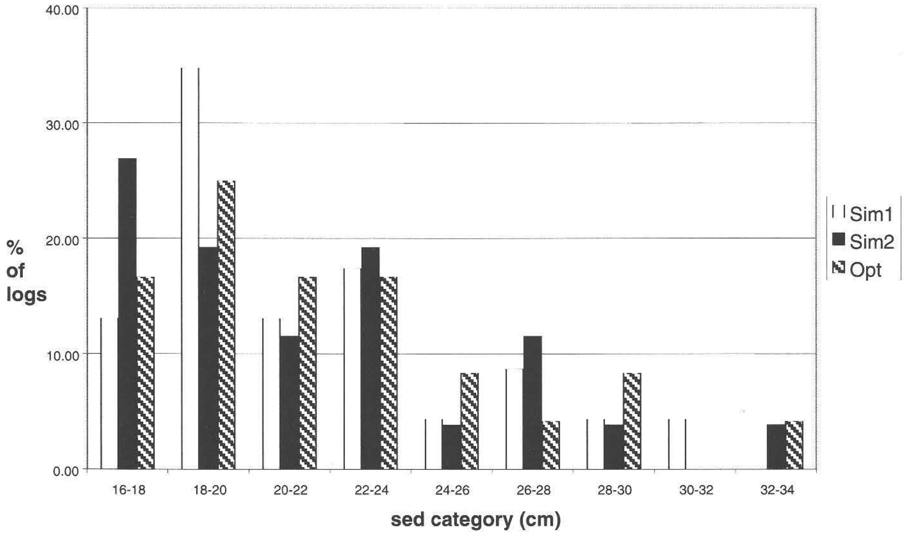

Figure 3. *Sawlog frequency distributions (in percent of number of logs) by small end diameter (sed) category for Inchigeelagh.*

4.2 The new sites

Data from four new sites were analysed. As these data were not used during the development of the simulation procedure, and as some of these stands were outside of the range of data used in the development of the taper equation, the objective was to evaluate how well the procedure would perform under these circumstances. The breakdown of the total volume and of the log count into the assortment categories for the four sites is presented in Tables 7 to 10.

The estimates of total volume by the simulator for the Kenmare site (Table 7) were too low (by 7.6% for Sim1 and 3.4% for Sim2) compared to the optimal value. However, the simulator estimates for percent volume breakdown, for total log count and for percentage breakdown of total log count into the assortments were accurate, especially for the sawlog category.

Both the sawlog volume and log count estimates as well as the sawlog percentage estimates for the Bandon site (Table 8) were over-estimated by the simulator by about 2 or 3%, while the pallet category was generally under-estimated.

Again the simulator over-estimated the sawlog component of the Ballingeary stand as shown in Table 9, in terms of both volume and number of logs. This is especially the case where both the taper equation and the dbh/height model were used (i.e. Sim2 results). This indicated that the height sample trees, used to establish the dbh/height relationship, did not fully represent the stand.

Table 7. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Kenmare validation data set (Sitka spruce clearfell, 38 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	2.36	2.67	13.78	18.81
Volume (m^3)	Sim2	2.36	3.15	14.16	19.67
	Opt	2.12	3.33	14.92	20.37
	Sim1	13	14	73	100
Volume (%)	Sim2	12	16	72	100
	Opt	11	16	73	100
	Sim1	64	47	53	164
# of logs	Sim2	60	52	53	165
	Opt	54	52	55	161
	Sim1	39	29	32	100
Logs (%)	Sim2	36	32	32	100
	Opt	34	32	34	100

Table 8. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Bandon validation data set (Norway spruce clearfell, 48 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	2.46	3.46	26.56	32.48
Volume (m^3)	Sim2	2.27	3.00	26.47	31.74
	Opt	2.25	3.77	25.05	31.07
	Sim1	7	11	82	100
Volume (%)	Sim2	7	10	83	100
	Opt	7	12	81	100
	Sim1	54	48	86	188
# of logs	Sim2	52	45	87	184
	Opt	52	55	83	190
	Sim1	29	25	46	100
Logs (%)	Sim2	28	25	47	100
	Opt	27	29	44	100

The estimates for percentage sawlog volume and percentage sawlog count for the Dunmanway thinning site were very accurate (Table 10). The assortment and total log count estimates of the simulator, specifically the Sim2 estimates, were very high compared to the optimal values, especially the pulp log count. This indicated that the combination of the generic taper equation (developed for clearfell sites) with the dbh/height model overestimated the upper dimensions of the stems at this thinning site.

Table 9. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Ballingeary validation data set (Sitka spruce clearfell, 33 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	1.69	2.20	16.98	20.87
Volume (m^3)	Sim2	1.54	2.01	17.64	21.19
	Opt	1.51	2.55	16.13	20.19
	Sim1	8	11	81	100
Volume (%)	Sim2	7	10	83	100
	Opt	7	13	80	100
	Sim1	37	32	52	121
# of logs	Sim2	36	30	55	121
	Opt	35	38	51	124
	Sim1	31	26	43	100
Logs (%)	Sim2	30	25	45	100
	Opt	28	31	41	100

Table 10. *Assortment breakdown of volume and number of logs, by quantity and percent, for the Dunmanway validation data set (Sitka spruce thinning, 47 trees).*

Units	*Procedure*	*Pulp*	*Pallet*	*Sawlog*	*Total*
	Sim1	2.80	3.22	14.16	20.18
Volume (m^3)	Sim2	3.04	2.88	15.02	20.94
	Opt	2.64	2.88	14.14	19.66
	Sim1	14	16	70	100
Volume (%)	Sim2	14	14	72	100
	Opt	13	15	72	100
	Sim1	72	56	66	194
# of logs	Sim2	80	53	71	204
	Opt	68	50	64	182
	Sim1	37	29	34	100
Logs (%)	Sim2	39	26	35	100
	Opt	38	27	35	100

The sawlog frequency tables for the four new data sets are presented in Figures 4 to 7. Overall there was a very close similarity between the estimates produced by the simulator and the optimal values produced using the detailed stem measurement data.

Both the Sim1 and Sim2 estimates for the 18-20 cm sed category (Figure 4, Kenmare data) were too high. The estimates for the Bandon Norway spruce stand (Figure 5) were very accurate over the full range of sed categories, while for the Ballingeary data (Figure 6) the only discrepancy in the estimates was a transfer of logs from the 18-20 cm sed category to the 20-22 cm category. The accuracy of the estimates for the Dunmanway thinning site (Figure 7) was remarkable, as this stand was outside of the range of stand types on which the procedure (i.e. the taper equation and the dbh/height model) was based.

The average sawlog volumes as estimated by the simulator and calculated by the optimiser for the four new sites are presented in Table 11. The Kenmare, Bandon and Ballingeary Sim2 estimates were all very accurate (within 2% of the real values), while the Sim2 estimate for the Dunmanway thinning operation was within 4% of the Opt value. It is interesting to note that the Sim2 estimates (i.e. estimates based on the use of both the taper equation and the dbh height equations) for Kenmare, Bandon and Ballingeary were more accurate than the ones based on the taper equation and actual height data (i.e. the Sim1 estimates). Only in the case of the Dunmanway thinning site were the Sim1 estimates more accurate than those produced using the Sim2 procedure.

Table 11. *Average sawlog volume (in m^3 log^{-1}) for the four new data sets, as estimated by the simulator and as calculated by the optimal cross-cutting procedure.*

Site	*Sim1*	*Sim2*	*Opt*
Kenmare	0.260	0.267	0.271
Bandon	0.309	0.304	0.302
Ballingeary	0.326	0.321	0.316
Dunmanway	0.215	0.212	0.221

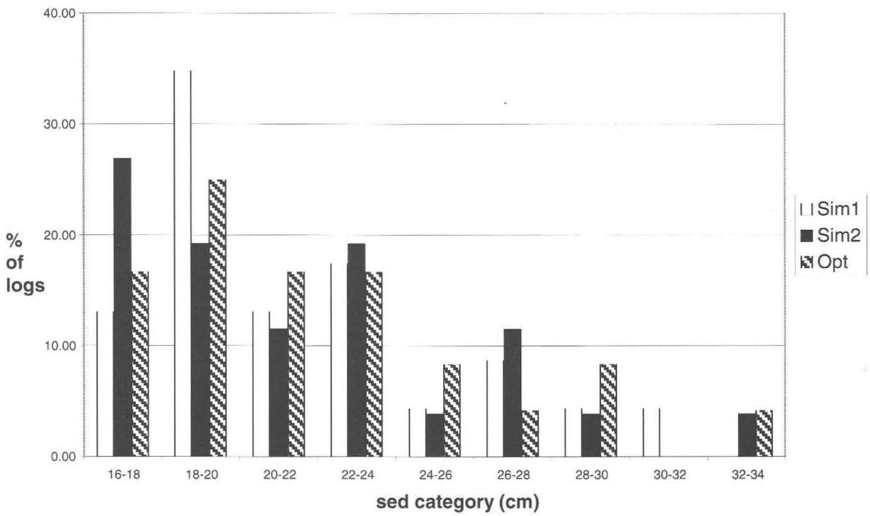

Figure 4. *Sawlog frequency distribution (in percent of number of logs) by small end diameter (sed) category for Kenmare (Sitka spruce clearfell).*

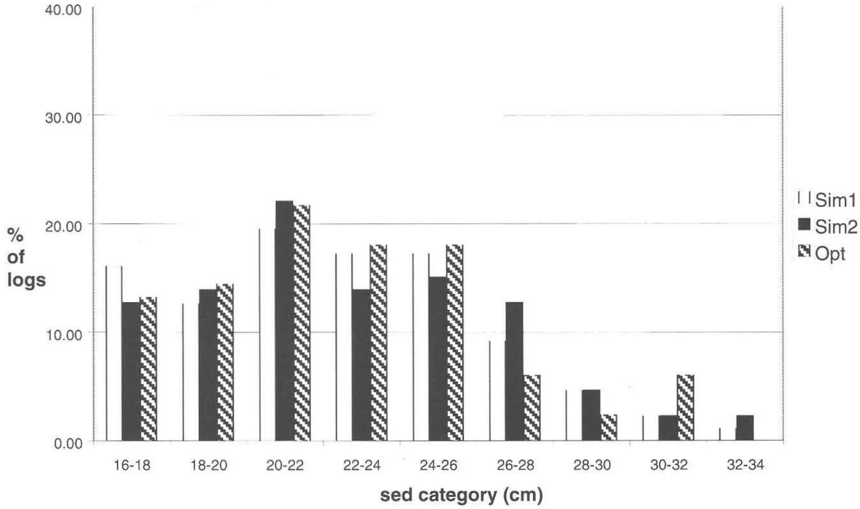

Figure 5. *Sawlog frequency distribution (in percent of number of logs) by small end diameter (sed) category for Bandon (Norway spruce clearfell).*

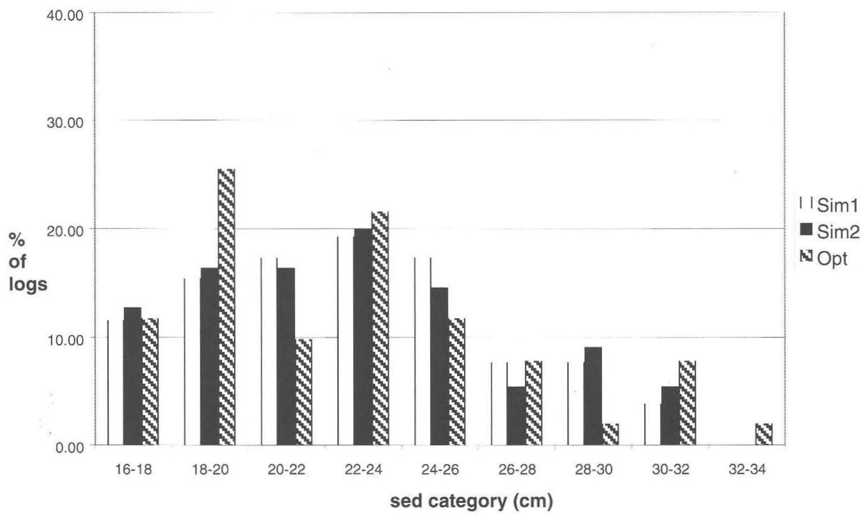

Figure 6. *Sawlog frequency distribution (in percent of number of logs) by small end diameter (sed) category for Ballingeary (Sitka spruce clearfell).*

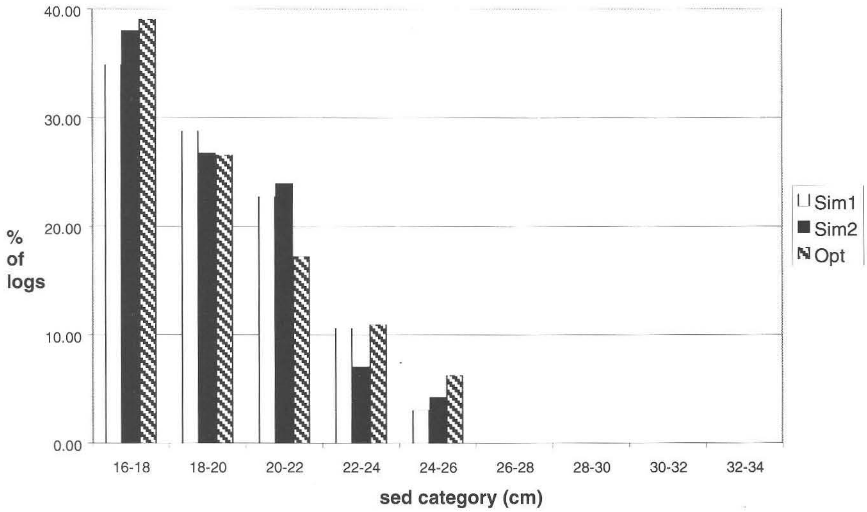

Figure 7. *Sawlog frequency distribution (in percent of number of logs) by small end diameter (sed) category for Dunmanway (Sitka spruce thinning).*

5. Discussion

This article describes the development and evaluation of a pre-harvest inventory and cross-cutting procedure for use in sawmill timber procurement. The system was designed to enable the procurement manager to identify the best combination of log types to harvest from Sitka spruce clearfell stands so as to accurately value the stand for tendering purposes and to maximise the value of the timber produced. The use of the procedure involves the collection of tree dbh and height data from a stand and the subsequent processing of these data, together with log assortment specification data, by the cross-cutting simulator. The combination of a generic taper equation and a site-specific dbh/height equation worked well with a sufficiently large dbh data set and with a dbh/height data set of 10 trees. The overall procedure allows for a cost-efficient data collection and stand valuation process.

The inventory and cross-cutting procedure was developed with data from five Sitka spruce stands in west Munster which were scheduled for clearfell and which were of the requisite size and quality for Palfab Limited, the sawmill involved in the study. The evaluation process has given some indication of the applicability of the procedure outside of these confines. The procedure produced accurate results for a wide range of stand types, including ones that were not part of the development and testing phase (i.e. the Norway spruce clearfell in Bandon and the Sitka spruce thinning in Dunmanway), if sufficiently large data sets were used. The validation data sets, consisting of only around 20 trees each, were clearly too small to produce very accurate estimates, even though they contained data from the same stands that were used in the model development process. The four new data sets, consisting of between 33 and 48 trees, on the other hand, produced very accurate estimates for volume, number of logs and average log size.

One factor that has been identified as contributing to the over-estimation of the volumes by the simulator is that the diameter estimates from the taper equation include fractions of millimetres, whereas the optimiser uses values truncated to the nearest millimetre. Especially in the case of the sawlog assortment (with its larger dimensions), this had a noticeable impact on the resulting volume calculations.

The use of a fixed dbh/height model generates a single height estimate per dbh class. This approach ignores the fact that, within a stand, height can vary for a given diameter. A more realistic description of the relationship between dbh and tree height within a managed stand would include variation in the values of height generated by the dbh/height model for a given diameter. This could be achieved with the use of probability density functions, as proposed by Schreuder and Hafley (1977) or the mixed models of Lappi (1991) and Uusitalo (1995).

Assessment of stem quality is not currently included in the inventory and cross-cutting procedures. The generally uniform, high quality stems within a well-managed Sitka spruce stand at the clearfell stage, resulting in a low proportion of downgrade, makes the cost of inclusion of detailed quality information during the inventory process unwarranted. However, the future inclusion of stem quality information in the cross-cutting simulation procedure would not cause any technical problems.

A further aspect which has kept the development and implementation of the procedure relatively simple is the omission of optimisation technology. Internationally, optimal stem cross-cutting is a key component of the process of maximising the value of logs produced in harvesting operations (Deadman and Goulding, 1979; Olsen *et al.*, 1991 & Uusitalo, 1995). However, in a situation where trees are of limited size, are comparatively low in value, where a limited number of log types are cut in any one stand, and where logs of a particular type are valued *en masse* regardless of variation in quality, the value of stem optimisation is limited. It seems unlikely that the additional costs associated with optimal cross-cutting, in terms of lost productivity arising from the need for intensive stem measurement at the stump, could, in the current situation, be justified by the increase that could be achieved in the value of timber recovered. However, the introduction of mechanised harvesters has the potential to change this. Harvester measurement systems are used extensively by Irish harvesting contractors for recording volume production figures. Modern measurement systems, such as the Ponnse *Opti* and Timberjack *3000*, also include (limited) stem optimisation capabilities. These systems predict the profile of each stem based upon the initial length of the stem fed into the head together with complete diameter measurements from trees of the same species previously processed in the stand. However, the functions used at present to predict stem profile are relatively simplistic. The introduction of sophisticated taper equations and dbh/height models (as developed in this project) in the harvester computer systems could greatly enhance their value maximisation capabilities.

It should be remembered however, that in Ireland the number of different types and lengths of logs that are cut in any one stand in the course of a harvesting operation is relatively small. As few as three permissible log lengths may be cut in the case of a clearfell operation. This lack of flexibility in the choice of logs to cut from a stem or stand limits the potential for achieving greater value recovery. However, a continuation in the recent spate of acquisitions within the sawmilling industry may change this. Individual stands may be purchased to supply timber to several sister mills, thus increasing the number of products cut in any one operation and, with it, the scope for improved utilisation of the timber resource. The optimal cross-cutting systems of modern harvesters, using accurate taper and dbh/height models, would greatly facilitate such an approach to harvesting.

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APPENDIX

Kozak 1992 taper equation:

$$\ln(d/D) = f\,\{\ln(X)\,X^6,\ \ln(X)\,X^2\,(D/H_s),\ \ln(X)\,X^3\,(D/H_s),\ \ln(X)\,X\,(D/H_s)^2,\ \ln(X)\,X^2\,(D/H_s)^2,\ \ln(X)\,(1/h),\ \ln(X)\,(H_s/\text{Ö}h),\ \ln(X)\,(H_s^2/Dh)\}$$

where:

X	=	$(H_s-h)/(H_s-H_{bh})$;
D	=	diameter at breast height;
d	=	diameter at height h;
H_s	=	total length of felled stem;
H_{bh}	=	distance from butt end to breast height mark (on felled tree);
h	=	distance from butt end at which diameter is estimated.

Curtis 6 dbh-height model:

$$\ln(H) = f\,\{1/D\}$$

where:

H	=	total height of standing tree;
D	=	diameter at breast height.

Seven thousand years of alternative history: the tree-ring story

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Augustine Henry Memorial Lecture,
5th March, 1997,
Royal Dublin Society.

Summary

Little dendrochronological information finds its way into forestry literature, despite the interest that it has for foresters. Using radiocarbon dating and correlation analysis a 7272-year oak tree ring chronology has been established for Ireland. Ring patterns of successively older timbers have been overlapped far back in time using the ring patterns of living trees which overlap those of historic timbers, back to archaeological timbers and eventually naturally-preserved, sub-fossil 'bog' timbers. Ring patterns and anomalously wide and narrow individual rings are used to verify and supplement the historic record. The relative abundance of oak timbers at different times provides valuable clues to levels of woodland use, human population patterns and trade. Past climatic environments can also be reconstructed using ring patterns. Dendrochronology provides tantalising evidence for the factual basis of a number of mythological events. Further development of the technique is likely to lead to improved understanding of past environments.

Foreword

People interested in trees tend to be fascinated by the process of tree-ring dating or dendrochronology. Studies involving tree-rings open up a whole new window on the past with the particular benefit of precise dating. It is the ability to date tree-rings precisely which opens up the possibility of adding new independent information to the existing historical record. However, it is ironic that little dendrochronological information finds its way into forestry literature. Most publications on the subject are aimed at archaeological, environmental and dendrochronological audiences. Perhaps this article will go some way to introducing foresters in Ireland to some of the possibilities offered by this quite remarkable method.

Introduction

In the 1960s a set of three circumstances gave rise to a serious study of Irish tree-rings.

1. From a purely scientific standpoint, there was a continuing controversy relating to the issue of radiocarbon calibration. It had been observed during the 1950s and early 1960s that radiocarbon dates on organic samples of known age - archaeological samples from regions with historical chronologies such as Egypt - tended to be too young by as much as several centuries in the period before 1000 BC. As a result Hans Suess in the United States had made a long series of radiocarbon measurements on wood

samples of known age from the American bristlecone pine (*Pinus aristata* and *P. longaeva*) tree-ring chronology as a calibration exercise (Suess, 1970). The bristlecone chronology had been constructed using the ring patterns of many of these extremely long-lived trees. Dendrochronologists were able to supply Suess with small blocks of tree-rings of precisely known age right back to 6000 BC. The problem was that the Suess calibration curve – which related dates in radiocarbon years to real dates in calendar years – contained short-term variations, so-called 'wiggles' which made interpretation of radiocarbon dates difficult. In addition, there were doubts about the validity of a high-altitude American calibration - the bristlecone pines grew at around 3000 m – and whether it could be used to calibrate radiocarbon dates in the Old World.

2. In the mid-1960s the University at Belfast had acquired a radiocarbon capability, and
3. it had been observed that large numbers of sub-fossil 'bog' oaks were being excavated as the result of land drainage and motorway construction in the north of Ireland.

As a result of these various factors, a decision was taken in the Palaeoecology Centre at Queen's University to investigate the possibility of building a 6000-year oak tree-ring chronology in Ireland and re-calibrating the radiocarbon timescale with low-altitude, Old World, tree-ring samples. Once that decision was taken there were only three possible routes forward. Either dendrochronology would be found not to work successfully in Ireland – an option which was all too believable in the late 1960s – or, it would be shown that dendrochronology would work as a method but it would not be possible to find oak timbers of all periods and the chronology building exercise would fall short of it's 6000-year objective, or, just possibly, a long chronology might be constructed. As things turned out, despite a number of difficulties, a 7272-year oak chronology was completed by 1982 (Pilcher *et al.*, 1984) and the Belfast, high-precision, radiocarbon calibration curve was published in 1986 (Pearson *et al.*, 1986). This combined completion of the tree-ring chronology and the radiocarbon calibration marked the fulfilment of the primary scientific objective. That work, of course, left the legacy of the long Irish oak chronology - at the time one of only a handful of such chronologies in the World - and its potential for archaeological dating and palaeo-environmental research.

Lessons learned in the course of building an oak dendrochronology in Ireland

In order to construct a long chronology along classic dendrochronological lines, it is necessary to overlap the ring patterns of samples from successively older timbers far back in time. This process starts with the ring patterns of living trees which overlap those of historic timbers, back to archaeological timbers and eventually naturally-preserved, sub-fossil 'bog' timbers. As modern timbers were acquired to test whether cross-dating was possible between the ring patterns of different trees, almost the first observation made related to the age of oaks. It became apparent that oak trees in Ireland were nothing like as old as people believed. There were widespread notions about oaks being many centuries old; these notions were not borne out by ring counts. Most oaks in Ireland occur on landed estates and were planted in the 18th or 19th centuries. Oaks surviving from the 17th century are notably rare, with only a handful having been observed in thirty years of study. Thus, the longest ring pattern for a living oak in Ireland, sample Q528 from Shanes Castle, Co Antrim, runs back only to AD 1649 (obviously it would be nice to prove this record wrong). An additional fact rapidly became apparent. It was observed that modern oaks (those grown since the early 18th century) on average exhibited rings twice as wide as ancient timbers. Initially it was thought that this might be due to the parkland nature of the modern trees – put narrow-ringed, forest-grown, oaks out in a parkland and they would grow bigger (?). However, it is now apparent that this is not the case and a more likely explanation for the larger size and faster growth of modern oaks is that they are imported stock, brought over from Britain or the continent to enhance the estates in which they were planted (Baillie and Brown, 1995).

However, none of these problems interfered with the issue of cross-dating ring patterns and building a modern oak chronology. A methodology was developed which allowed the dendrochronologists to reliably cross-march ring patterns to their correct relative felling dates using a combination of computer-correlation programs and visual matching. As a result, within a few years of starting, a well-replicated oak master chronology, which linked modern trees to historic building samples of the 17th or 18th centuries, was available back to AD 1380 (Baillie, 1974 & 1982). This chronology can be most easily visualised as a year-by-year record of mean oak growth, for Irish oak, for every year back to AD 1380. Immediately this chronology was completed several types of information could be exploited. First, new samples could be dated by matching their ring patterns against the pattern of the master chronology – a commercial service providing tree-ring dates for archaeologists and building historians became a practicality. Second, the details of the master chronology could be investigated at annual resolution. For example the growth ring for AD 1947 was always notably wide, whereas that for AD 1816 was always notably narrow; both were years of unusual climatic extremes – 1816 was notable for being known as the 'year without a summer' in the North Atlantic region. Clearly there was stored environmental information in the master ring pattern. This is graphically illustrated by going back to the growth rings for AD 1740-42. These show a catastrophic growth reduction which must be related to the anomalously cold year AD 1740 {the coldest year in the whole of Manley's (1974) 350-year Central England Temperature Record} and which coincides with the "last great demographic crisis of the pre-industrial era" (Post, 1985). Furthermore, the act of dating the wide selection of oak timbers which did become available showed some interesting trends in building activity. No buildings containing native oak timber could be found later than AD 1716, most later building in the 18th century used either hedgerow or sub-fossil timbers (low status housing) or imported pine, presumably from Scandinavia or the Americas (high status and industrial building). Of the buildings which did yield native oak timbers, a clear pattern of building dates began to emerge which reflected the social/political history of Ulster in the 17th century. No buildings were dated to the period of the AD 1640s, or to the later 1680s, whereas clusters of dates in the periods after AD 1658 and after AD 1690 coincided with flushes of 'plantation'. It appeared that the act of dating oaks provided facts consistent with the documentary historical framework.

Further back in time

The story of the construction of the Belfast long chronology is well documented elsewhere (Baillie, 1982 & 1995). Suffice to say the chronology building process broke down into the construction of long, robust sections of chronology and the subsequent linking of these robust sections. For example, the chronology for the last 2000 years was principally composed of four sections, namely:

1. a living-tree chronology spanning the present to 1649,
2. a late/post medieval chronology spanning c1350 to 1716,
3. a medieval Dublin chronology spanning 855 to 1306,
4. an Iron Age/Early Christian chronology spanning 13 BC to AD 896.

These robust sections reflected episodes of timber abundance separated by weak periods or 'gaps' where timbers were scarce to non-existent. Extensive sampling over thirty years has shown that this pattern is itself robust, in that the periods of abundance and weakness have not changed even with many more samples obtained. So, for example, the gap in the 14th century is closely related to the Black Death of 1347-50, with many oaks regenerating from the mid-century onwards. The depletion of Irish timbers across the 9th century was so severe that the link in the chronology actually exploited English ring patterns from sites in Exeter and London. This pattern of depletion/abundance is shown in Figure 1.

Exactly the same approach was used in constructing the prehistoric chronology. In this case the primary material consisted of several thousand naturally preserved oak trunks, mostly from the North of Ireland. Again it was found that long robust site chronologies could be constructed with relative ease. In retrospect it became clear that the bog oaks encountered in drainage were in no way random in occurrence. The oaks were survivals of a regenerating woodland that had colonised the surfaces of peat bogs for many centuries at a time. Thus groups of oaks, apparently sampled at random, would contain timbers whose ring patterns overlapped in time. In addition, the narrow growth rings associated

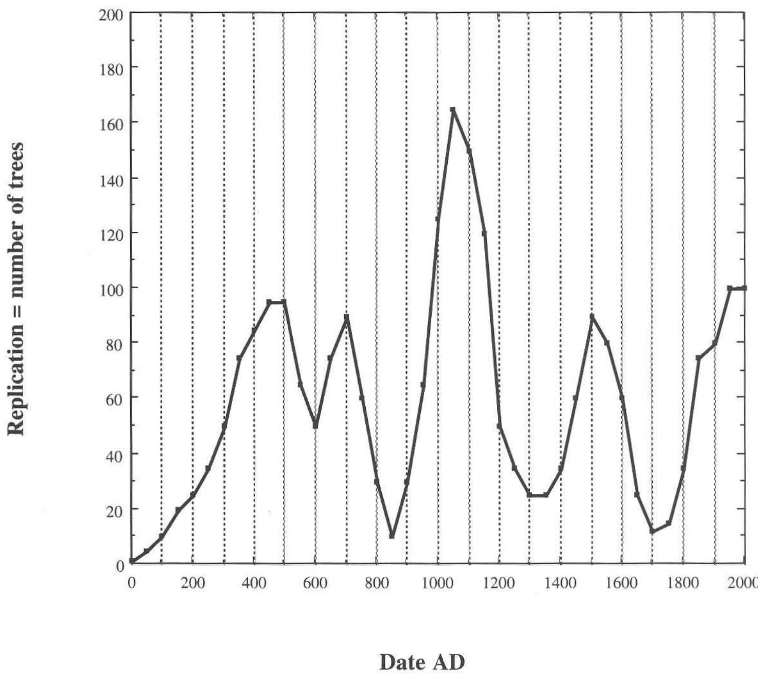

Figure 1: *Depletion/abundance of Irish oak timbers.*

with almost all ancient oak specimens in Ireland {mean ring width 1.0 mm over seven millennia (Baillie and Brown, 1995)} meant that oaks were relatively long lived (average age around 250 years with a small number of specimens up to almost 500 years). These timbers were therefore ideal for chronology building as the long ring patterns of contemporaneous trees could be overlapped with confidence to produce long site chronologies. With long, well-replicated, site chronologies being produced, the difficulty reduced to linking these robust chronological units across the periods of weak replication or gaps. Indeed, most of the overall 7000-year chronology was in existence by around 1977, though it took until 1982 to finally bridge the last gaps in the Irish chronology in the first and tenth centuries BC, again using English ring patterns.

This latter fact in itself indicates that long-distance cross matching was increasingly acceptable to dendrochronologists. When chronology building started in Europe it simply was not known over what geographical distances cross matching would apply. As chronologies were developed it became apparent that high correlations could be obtained between long sections of chronology from Ireland and Scotland, then England, then from England to Germany. Now it is clear that there is common signal in all of the regional chronologies from Ireland to Poland. This does not mean that one can date Polish or German trees using an Irish chronology – obviously Irish timbers should be dated against a local Irish chronology for the same species – but it is possible to isolate a highly stable year-by-year signal representative of European oak growth (a concept which would have been unthinkable before the chronologies were constructed).

Other applications

Once chronologies are available and dates are being produced with confidence (using replication as the ultimate check on the dating procedure), it becomes possible to accumulate information to develop broader pictures. Indeed, this was hinted at above when it was pointed out that the tree-ring dates for 17th century buildings in Ulster reflect the history of the period. As the chronologies were pushed further back in time problems were experienced in bridging the 14th century AD. It became apparent that what was being seen was a 'depletion/regeneration' phase, associated with the Black Death of 1347-50. Old trees were being cut down up to the mid 14th century; from the mid-century onwards oaks were regenerating. Thus the longest-lived oaks sampled from 16th and 17th century buildings in Eastern Ireland had all started growing just after 1350. This hiatus, which implies that either coppiced or marginal land went back to forest, possibly due to the lack of people to tend the woodland, was only bridged with timbers from the west of Ulster, where presumably the effects of the Black Death were different - but perhaps pressure on woodland in western areas was always less than in the east.

The interesting point about this observation of a depletion regeneration phase in the mid 14th century is that it can be paralleled with a building hiatus in Germany lasting from 1348 to around 1440. Something similar is seen in Greece. It is possible to suggest that dendrochronology alone would have raised the suggestion of a Europe-wide population decline in the mid 14th century even if history had not recorded the event (Baillie, 1995). This comment is made because, as we go further back in time, the historical record inevitably starts to thin. The hope must be that dendrochronology can either indicate some earlier events which history has failed to record or elaborate the record for other periods which are poorly recorded. An example of the latter relates to the accumulating picture of happenings around AD 800 where German dendrochronologists found difficulty in bridging one of their gaps. Now a gap can be due to numerous causes, but dendro dates can themselves provide clues. Just around 800 we find the greatest number of horizontal watermills being constructed in Ireland. As mills imply cereals, and lack of timbers implies human pressure, it is possible to suggest that this was a period on expanding human population. As oaks start to regenerate a century later the implication is that the human pressure has reduced - there may have been less humans. It is hints such as these which the dendrochronologists can supply to historian colleagues.

Trade

While most of the timbers recovered from buildings and archaeological sites are local in character, it is inevitable that some timbers will have moved as part of trade. In Britain it is now apparent that many Medieval oaks did not grow in these islands but were imported from the Baltic as part of Hansa trade with England and Flanders. One important example of the movement of timbers in the opposite direction is the finding by Neils Bonde (1998) from the Museum in Copenhagen that one of the famous Roskilde blockships, named Skuldelev 2, was actually of Irish origin. Indeed, so similar were the ring patterns from the boat to the master chronology constructed for the Dublin excavations that it is virtually certain that Skuldelev 2 was a Dublin boat. Thus, not only can dendrochronologists date oak timbers, they can is some instances locate their original area of growth. As more and more regional chronologies come on line examples such as this should multiply. One outstanding anomaly, which may have a trade explanation, relates to oaks from Hillsborough Courthouse, Co Down. The courthouse is late 18th century and originally had panelled oak pews. Several of the panels were sampled for analysis and it was clear that the trees were very straight grained and regularly grown. The panels provided a replicated ring pattern of some 300 years. However, extensive comparisons with available chronologies from all over northern Europe have singularly failed to produce significant correlations – the Hillsborough timbers don't match anything in Europe. Logic suggests that they may well be from eastern America. However, there are as yet no available oak chronologies from the eastern United States with which to compare the ring patterns.

Given this last example, it is worth stressing that the Hillsborough timbers are exceptional. Irish oak timbers have a very high success rate when it comes to dating. Structures have been dated from throughout Ireland, for example, horizontal watermills have been dated from north Antrim to west Cork.

Environmental reconstruction

It was always obvious that if dendrochronology worked as a dating method, and that oaks in Ireland were developing recognisably similar patterns of wide and narrow rings, then the tree-ring patterns must contain at least a partial record of the past environment. As indicated in the introduction, oaks do seem to respond negatively to cold conditions, as seen in 1816 and the early 1740s. A speculative extension of this line of thinking led to the discovery of what can be called 'narrowest ring events' in the Irish bog oak chronology. These are points in time when a significant proportion of bog oaks exhibit their narrowest rings. Since oaks are relatively long-lived, and as many factors could cause a narrowest ring, the occurrence of clusters of narrowest rings, in different trees, on different bogs, should indicate some notable environmental effects. The initial result of discovering a series of narrowest-ring dates was the apparent identification of significant volcanic dust-veil events at, for example, 2345 BC, 1628 BC, 1159 BC, 207 BC and AD 540. The dates are supplied by the tree-ring records. The link to volcanoes comes from dated layers of sulphuric acid found in the ice cores from Greenland (Baillie and Munro, 1988). This story was brought about because of the occurrence of other strands of evidence for notable volcanic activity at around these dates. Originally, an American dendrochronologist, Val LaMarche had indicated a frost ring related to volcanic activity at 1627 BC in his bristlecone pine record (LaMarche and Hirschboeck, 1984). Then Danish workers had indicated the presence of volcanic acid in ice-cores (Table 1) dated to AD 540±10, 210±10 BC, 1120±50 BC and 1644±20 BC (Hammer *et al.*, 1980; 1987).

Table 1: *Volcanic acid layer dates from Hammer et al. (1980 & 1987) and the original list of narrowest ring events in the Irish oak record (Baillie and Munro, 1988)*

Volcanic acid dates	Narrowest ring dates
540 ±10 AD	540 AD
50 ±10 BC	
210 ±30 BC	207 BC
260 ±30 BC	
1120 ±50 BC	1159 BC
1390 ±50 BC	
1644 ±20 BC	1628 BC
	2345 BC
2690 ±80 BC	
3150 ±90 BC	3195 BC
4400 ±100 BC	4370 BC

These observations suggested that the narrowest tree rings were related to volcanic events. This impression was added to when workers in Belfast dated the Icelandic eruption Hekla 4 to 2310±20 CalBC[1]. What was particularly interesting about these particular dates was their proximity to episodes of civilisation collapse/culture change/Dark Ages. For example, the Greek Dark Ages traditionally begin in the 12th century BC while it is possible to find authors who would suggest that the Dark Ages start in the early 6th century AD. Moreover, it is interesting that the conventional chronology in China suggests dynastic change at 1617 BC and 1122 BC, not far from the Irish narrowest ring dates (Baillie, 1995).

However, it is fair to say that there was always tension in the volcano story simply because most volcanologists do not believe that volcanic eruptions can collapse civilisations. Normally, in recent times at least, the effects of even quite large volcanic eruptions have been limited to two or three years. This tension was compounded as it became clear that the event at AD 540 was really quite exceptional in terms of the last two millennia. It's exceptional nature is best seen by the clarity with which it shows up in a wide grid of tree-ring chronologies from the north of Russia through Europe to North and South America. As exceptional events should have exceptional causes, and as the actual evidence for a major volcanic eruption at AD 540 was less than definitive, this raised the question whether the environmental downturn might have been caused by something other than a

[1] CalBC indicates calibrated radiocarbon dates compatible with historical dates.

volcano[1]. When to this query was added the observation of 'stones falling from the sky' in and around 207 BC (Forsyth, 1990), and references to comets at the start and end of the Shang dynasty (Sagan and Druyan, 1985), a rather more sinister scenario began to emerge for consideration (Baillie, 1999). Might the dust veils at the dates listed above actually have been due to Earth's interaction with cometary debris? This question, it turned out, had already been posed by several cometary astrophysicists, most notably Bailey, Clube and Napier (Bailey *et al.*, 1990; Clube and Napier, 1990). It cannot be without interest that Isaac Newton himself believed that the biblical Flood had been caused by a comet in 2349 BC, using Ussher's dating (Schechner Genuth, 1997). This latter section would be laughable were it not for the fact that Old Testament history, ancient Chinese history and much mythology all supports the bombardment from space scenario. For local interest, Arthur, who traditionally dies close to AD 540, is derived from Celtic mythology and is equated to CuChulinn. CuChulinn is a re-birth of the god Lugh whose attributes make him almost a direct description of a close comet. In brief, Lugh is described as coming up in the west, being as bright as the Sun and having a long arm and a fiery spear with which he delivers terrible blows. In the Arthur-related Grail legend, it is the blow by Lugh's spear which caused the 'Wasteland'. This use of mythology would also be laughable were it not for the recent finding by Courty (1998) of a soil layer in Syria, which contains a range of glassy balls and glazed over shards of archaeological debris which she dates to around 2350 BC {see also Peiser (1998) for evidence of a global disaster around 4000 years ago}.

The incredible thing about this story is that it has it's origins in some very narrow growth rings in oaks which grew rooted on the peat of Irish bogs. Suffice to say that if one turns to an article published by Britton in 1937 which includes some early decanting of information from the Irish annals, he notes that 'lakes overflowed' in Ireland in 2341 'BC' and 1629 'BC'. Trees suffer, lakes break out - how might the annalists have got it so right? In fact, if one wants to play games, and one goes back to the Annals of the Four Masters, produced by Michael O'Clery and his learned colleagues in the early 17th century, and annotated by O'Donovan (1848), one finds that in 'The Age of the World, 4020' i.e. in 1180 'BC' one Sirna acquires sovereignty of Ireland. Now Sirna is credited with reigning for either 150 years (Four Masters) or 20 years (O'Donovan, *op. cit.*) so that one could interpret this to mean that he either died "with a countless number of the men of Ireland" in 1030 'BC' or 1160 'BC'. As one of the other narrowest ring events spans 1159-1141 BC in the Irish tree-rings, obviously O'Donovan's interpretation would make for a more interesting story (it is important to stress that R.B. Warner would not allow this interpretation). If O'Donovan were correct then it would also be intriguing that, yet again, five rivers erupted in Sirna's reign. If lakes and rivers consistently break out around the time of the narrowest ring events, that hints at a consistent tectonic cause - or maybe it just got a lot wetter? The independent evidence provided by an unfinished dug-out boat, made from oak and found out in Lough Neagh, dating to AD 524±18 has already been connected with a rise of the level of the lough at that time (Baillie, 1995), a time close enough to AD 540 to hint at a similar cause to the earlier events.

[1] For the purposes of this article it is probably sensible to ignore super-eruptions. This class of volcano, exemplified by the eruption of Toba, Sumatra, some 74,000 years ago, could collapse civilisation. However, none have been observed during the Holocene (the last 10,000 years). The recent suggestion of a super-volcano in February AD 535 (Keys, 1999) is not supported by geological evidence. Had such an eruption occurred its effects would undoubtedly be seen globally in the tree-ring for AD 535 as the effects would have been immediate, global and devastating.

Conclusion

The successful construction of a seven millennia long Irish oak chronology means that there is now an absolute timescale against which historians, archaeologists and environmentalists can place their deductions. This year-by-year record can be interrogated in a number of different ways and the narrowest-ring work discussed above demonstrates the potential. Since all the rings in a dated specimen can be assigned to their calendar year of growth, dendrochronologists can study factors such as growth initiation phases (by dating the innermost rings of the trees). Episodes of widespread regeneration can become visible and results can be compared with those from other countries. At a local level, the fact that most bog oaks blew over (and were preserved by being buried in peat) means that attempts can be made to reconstruct episodes of increased storminess in the distant past. Similarly the occurrence of reaction wood (where a tree has been pushed over and attempts to right itself) or growth anomalies such as frost damage, or included sapwood, can allow the occurrence of severe environmental conditions to be reconstructed.

Overall, there is no restriction on the types of analyses. For example, the wood cellulose which grew in any year in the last seven millennia can be isolated for chemical or isotopic study. No-one knows what stories might emerge as such analyses proceed. Moreover, the absolute nature of dendrochronology means that information from any year in Irish oaks can be compared with deductions for that same year from trees from elsewhere around the globe. Finally, as I have pointed out elsewhere, oak trees seem to have been granted the gift of immortality - they can tell us their exact years of growth long after they are dead - and more importantly, they never lie - the stories they provide are independent of human history and much less biased. However, one other message seems clear from the work outlined above; when oak trees suffer humans also seem to suffer. It might serve us well to look after our Irish oaks.

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Trees in early Ireland

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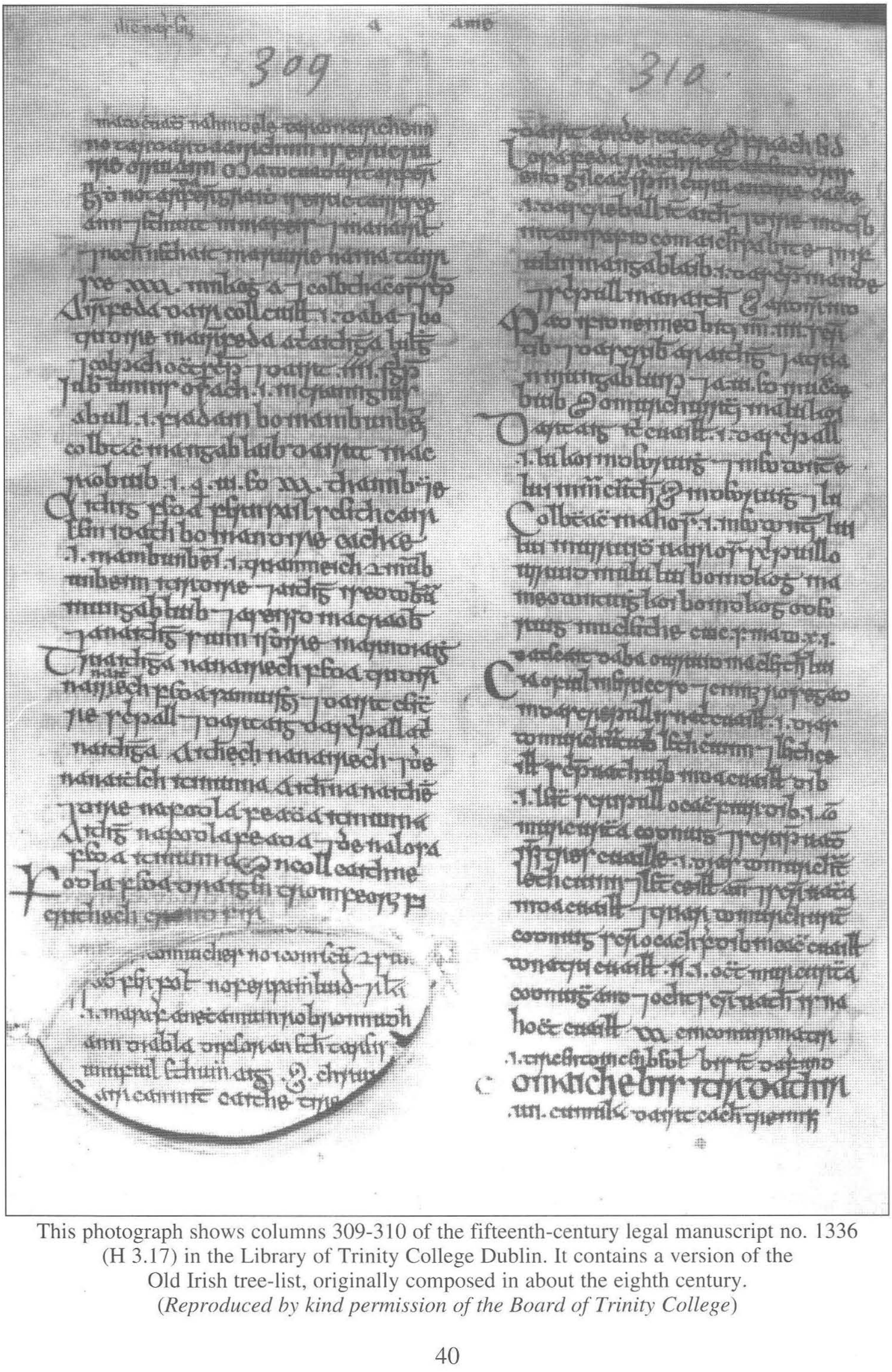
Summary
In this article an atempt is made to identify all the twenty-eight trees and shrubs which are listed and Old Irish law-text of about the eight century AD. There is also an account of trees which are mentioned in early Irish poetry and proverbs, as well as brief description of woods and woodland management in pre-Norman Ireland. The article concludes with a discussion of tree-references in early English, Scottish and Welsh sources.

Foreword
I am very honoured to be asked to give the annual Augustine Henry Memorial Lecture to the Society of Irish Foresters, and wish to express my gratitude to the President and Committee for this kind invitation. In the time at my disposal I intend to examine what the written sources in Irish and Latin tell us about the trees and woods of pre-Norman Ireland. I would like also to make some comparisons with the documentary evidence on this topic from early England, Scotland and Wales.

The literature of pre-Norman Ireland was rich and varied, and texts of many types survive: annals, histories, sagas, saints' lives, penitentials, religious verse, collections of proverbs, and law-texts. Of these, the law-texts provide the most detailed information on the trees of Ireland. These texts were mainly written between the seventh and ninth centuries AD, and describe a legal system ('Brehon law') which survived down to the end of the sixteenth century in those parts of Ireland still under Gaelic control. The law-texts cover a very wide range of legal topics and the wealth of information contained in them has been a godsend to the legal and social historian.

The Old Irish tree-list
The law-text which contains most information on trees is entitled *Bretha Comaithchesa* 'judgements of neighbourhood', and dates from about the eighth century. It deals with the various offences which a farmer is liable to commit against his neighbour, and includes a section on damage to trees and shrubs. Four different degrees of damage are distinguished: complete extirpation of the tree, cutting it off at the base, fork-cutting and branch-cutting. Obviously, damage to an especially valuable tree such as an oak or yew would be a more serious offence than to a less prized tree such as a birch or willow. For this reason, the twenty-eight principal trees and shrubs are divided in *Bretha Comaithchesa* into four classes of seven, based on their economic worth.



This photograph shows columns 309-310 of the fifteenth-century legal manuscript no. 1336 (H 3.17) in the Library of Trinity College Dublin. It contains a version of the Old Irish tree-list, originally composed in about the eighth century. (*Reproduced by kind permission of the Board of Trinity College*)

Class A

The most valuable class of seven is described as the "lords of the wood" (*airig fedo*).[1] I present here the Old Irish list with the equivalent English and scientific terms:

1. **Dair** 'oak' (*Quercus robur, Quercus petraea*)
2. **Coll** 'hazel' (*Corylus avellana*)
3. **Cuilenn** 'holly' (*Ilex aquifolium*)
4. **Ibar** 'yew' (*Taxus baccata*)
5. **Uinnius** 'ash' (*Fraxinus excelsior*)
6. **Ochtach** 'Scots pine' (*Pinus sylvestris*)
7. **Aball** 'wild apple-tree' (*Malus pumila*)

For any offence against one of the lords of the wood, the culprit must pay a penalty-fine (*díre*) equivalent to two milch cows and a three-year-old heifer. In addition, if the injury he has inflicted is merely branch-cutting, he must pay compensation (*aithgin*) of a yearling heifer; if it is fork-cutting, a two-year-old heifer is due, and if base-cutting, a milch cow. The text provides no information with regard to the compensation for extirpation. It is clear from the law-texts that damage to a tree belonging to another person was sometimes associated with the quest for honey or a swarm of bees. The seventh-century law-text *Bechbretha* 'bee-judgements' states that there is a heavier fine for damage to a tree during the period of growth than during the period of dormancy. The author was evidently aware that most types of tree are more likely to develop rot or disease if a cut is made during the growing season.

Dair 'oak'. A ninth-century legal commentary appended to *Bretha Comaithchesa* provides a useful summary of the reasons why the seven lords of the wood are so highly prized. The value of the oak is said to derive from "its acorns and its use for woodwork". There are many references in our sources to the importance of the acorn-crop (*mes*), particularly in relation to the fattening of pigs. A later legal commentator claims that a single oak can provide enough acorns to fatten one pig in a good year. This commentator describes the oak as *in Temair feda* "the Tara of the wood"on account of its size and eminence. The value of oak-timber is stressed in many texts. The sturdiest type of fencing described in *Bretha Comaithchesa* is the *dair-imbe* 'oak-fence'[1], and there are many references to a type of church called a *dairthech* (or *daurthach*) lit. 'oak-house'. Another use of the oak which is quite often mentioned in legal material is the provision of bark for the tanning of leather. If a person illegally removes enough bark from another person's oak to tan a pair of woman's sandals, he must give him a cow-hide. If he removes enough to tan a pair of man's sandals, he must give an ox-hide. In addition, he must cover the wound with a mixture of smooth clay, cow-dung and fresh milk until there has been the width of two fingers' new growth on all sides. This technique is similar to the modern one of painting an air-excluding preparation over the wound where a bough has been sawn off.

[1] It is interesting to note that a similar expression is used in the ancient Indian Laws of Manu. In this text, the trees which do not have (conspicuous) flowers are termed the "lords of the forest" (vanayas-patayas). Another Indian text entitled the Anūgitā names eight principal trees which are called "the princes among trees".

In none of our texts is a distinction made between the two species of oak, *Quercus robur* and *Q. petraea.* Finally, mention should be made of an intriguing reference in an undated scrap of vellum which has been inserted in the fourteenth-century Yellow Book of Lecan. It records an abundance of moths (*tuile féidlecán*) in West Connacht "so that they did not leave a leaf on an oak in the whole territory of O'Flaherty". This must be a reference to a plague of the moth *Tortrix viridana.*

Coll 'hazel'. In spite of its relatively small size, the hazel is included among the lords of the wood. The ninth-century legal commentary explains that this is because of its nuts and its rods. Hazel-nuts were an important element in the early Irish diet: the fact that they could be stored made them a particularly important foodstuff during the generally lean and hungry winters endured by the early Irish. Later legal commentary describes the hazel as *in briugu feda* "the hospitaller (food-provider) of the wood". It is clear from both the documentary and the archaeological evidence that the strong, pliable and quick-growing rods of the hazel were of the utmost importance in the construction of fences, enclosures and house-walls. The archaeologist Chris Lynn has described the ingenious method of house-construction employed at the seventh-century site at Deer Park Farm, Co Antrim. A double layer of wattling was used to build up a nearly circular structure. The rough side of each layer was turned inwards so that both the outside and inside walls had a smooth surface. Insulating material such as moss and feathers was packed in the cavity between the two layers.

Cuilenn 'holly'. Two reasons are given in the ninth-century commentary as to why the holly-tree is included among the lords of the wood. The first is obscure but may possibly refer to the use of holly as a winter-fodder for livestock. A legal gloss from about the twelfth century refers to a "hook or sickle for cutting ivy or holly", and another gloss intimates that both were fed to cattle. Writing in the late fourteenth century, a Catalan pilgrim to Saint Patrick's Purgatory in Co Donegal, Count John de Perilhos, says that "the beasts eat only grass instead of oats, and the leaves of the holly, which they roast a little on account of the prickles which are in the leaves".

The second use of the holly is the manufacture of chariot shafts. A later legal commentary refers to the holly as *in crann fuluchta fiannsa* "the tree of the open-air cooking-pit" because its hard wood is especially suitable for the manufacture of cooking-spits. Concealed spikes for trapping deer may also have been made from holly.

Ibar 'yew'. The ninth-century commentary attributes the yew's inclusion among the lords of the wood to "its noble artefacts". There is frequent mention of the use of yew-wood in the manufacture of domestic vessels, and a law-text on status includes the *saí ibrórachta* "expert in yew-work" as one of the categories of craftsman. In later legal commentary this tree is described as *int éochrann aicdide* "the yew-tree of artefacts".

Uinnius 'ash'. This tree is included among the lords of the wood, according to the ninth-century commentary, because it was used for furniture and spear-shafts. A king's chair seems to have been commonly made of ash, as it is referred to as "the support of a king's thigh". In other texts there are references to oars and yokes for oxen being made from ash. There was also an awareness that the presence of ash is a sign of good land: a law-text on land-classification refers to "hilly arable land... in which there are ashes in every second piece of ground". The author may have had in mind fertile hilly terrain with fields interspersed with ash-covered hills.

It is noteworthy that three out of the five venerated trees celebrated in verse in a Middle Irish collection of place-lore (*Dindshenchas*) are ash-trees – see under 'Venerated trees' below.

Ochtach 'Scots pine'. Because of the extinction of this tree in Ireland in later medieval times, it is particularly interesting to find that it is included among the lords of the wood in the eighth-century *Bretha Comaithchesa*. The ninth-century commentator explains that its inclusion is on account of "its resin in a bowl". Pine-resin was used to make pitch for caulking boats, preserving wood, etc. There are also a number of literary references to the use of pine-beams in house-building, and a gloss identifies the mast of a ship as being of pine. A Latin Life of Saint Samthann provides evidence of the increasing rarity of the pine. It describes how monastic builders spent four days in the woods of Connacht searching vainly for pines with which to build a refectory. Pines were eventually found, but only through the miraculous intervention of the saint.

The Old Irish word for 'pine', *ochtach*, can be shown to be etymologically connected with words for pine in other Indo-European languages such as Greek, Old High German and Lithuanian. In addition, a variant form of the word (*octgag*) is used in a seventh-century gloss to explain the Latin word *pinus* 'pine'. In about the tenth century another word for 'pine' – *giúis* – is first attested in the Irish language, and was applied both to the living tree and to bog-deal. It seems to be a loan-word of unknown origin, and its appearance in the language may indicate that pine was becoming so rare in Ireland that it had to be imported.

Aball 'wild apple-tree'. The ninth-century commentary attributes the inclusion of this tree among the lords of the wood to "its fruit and its bark". Even the small sour fruit of the wild apple would have been much appreciated by the early Irish during the late autumn and winter. There is also evidence in the texts of a distinction between the wild apple and sweeter cultivated strains. Thus the ninth-century Life of Saint Brigit refers to an abundant crop of sweet apples in a churchyard. A legal passage states that the penalty for destroying an apple tree belonging to a dignitary is a fine of ten milch cows. In addition the culprit must restore a tree of the same variety. This implies the existence of different varieties of apple. It seems impossible to be certain whether the early Irish cultivated apple derived solely from selected sweeter strains of the native apple, or whether there was also introduction of grafts or seeds from elsewhere. I suspect the latter, as we know that the technique of grafting apples, vines and other fruit-trees was well known to the Romans, and is likely to have been witnessed by Irish monks on the Continent. To my knowledge there is no early evidence in Irish sources of different varieties of cultivated apple. In the late 1940s, J. D. G. Lamb carried out a pioneering survey of the cultivated apple in Ireland – an enterprise continued in recent years by Michael Hennerty, Anita Hayes and other pomologists. Many of the distinctively Irish apple-varieties are associated with particular places, such as the Kerry Pippin, Blood of the Boyne or Ballyfatten. One variety of cider-apple has a descriptive Irish name, which suggests that its pedigree goes back at least a few centuries. It is the Cocagee, apparently an anglicisation of Irish *cac a' ghé* 'goose-shit'. This seems a very strange name for an apple, but may perhaps refer to the appearance of the pulped cider-apples before straining. A sixteenth-century glossary contains an otherwise unattested Irish word *nenadmin* which is explained as "the delicate juice of wild apple" and possibly refers to cider. The reference in ninth-century legal commentary to the value of the bark of the apple-tree is difficult to explain. John Tierney has suggested to me that it may refer to the use of the inner bark of the apple-tree to die cloth yellow. For magic apples, see under 'Venerated trees' below.

Class B

The seven trees of lesser value which are distinguished in the text are the "commoners of the wood" (*aithig fhedo*). The penalty-fine for damage to any of these trees is a milch cow. In addition the culprit must pay compensation. There is some inconsistency in the different versions, but it seems likely that the original text required the payment of another milch cow as compensation for base-cutting, a yearling heifer for fork-cutting, and a sheep for branch-cutting. If the tree is completely extirpated (*aurbe*), a payment of two milch cows and a three-year-old heifer is due.

1. **Fern** 'alder' (*Alnus glutinosa*)
2. **Sail** 'willow, sally' (*Salix caprea, Salix cinerea,* etc.)
3. **Scé** 'whitethorn, hawthorn' (*Crataegus monogyna*)
4. **Cáerthann** 'rowan, mountain ash' (*Sorbus aucuparia*)
5. **Beithe** 'birch' (*Betula pubescens, Betula pendula*)
6. **Lem** 'elm' (*Ulmus glabra*)
7. **Idath** 'wild cherry (?)' (*Prunus avium*)

Fern 'alder'. There are references in the texts to the use of alder-wood in the manufacture of shields, masts and tent-poles.

Sail 'willow'. Our texts make no distinction between the different species of willow. No doubt because of its lightness willow is quite often mentioned in the context of house-building. In general, early Irish dwelling-houses would have been impermanent structures, so there would not have been a need to use more durable timber. The wooden church, on the other hand, was made of oak (see above). There are also many references to the use of a twisted willow withe (*gat*) to tie up livestock. As in modern times, willow-rods would have been used for basket-making, wattling, etc.

Scé 'whitethorn'. The whitethorn is prominent in later Irish folklore, and there are many references to the magic properties of thorn-trees growing on fairy-mounds, but in early texts various other trees – particularly oak, hazel, yew and rowan – have more association with the supernatural. There is no mention in early texts of the whitethorn hedges which later became such a striking feature of the Irish landscape. Legal commentary from about the twelfth century includes haws (*scechóra*) among the wild fruit of minor economic importance. In spite of their insipid taste they were clearly of use as a source of nourishment in times of hunger.

Cáerthann 'rowan'. There is little information in our sources on the practical uses of the rowan, apart from the manufacture of spits for roasting meat. Legal commentary also indicates that its berries (*cáera*) were of minor economic value as food.

In literary material, on the other hand, the rowan features prominently. In verse, the beauty of its berries and flowers are extolled (see 'Trees in poetry and proverbs' below). A fine passage in the eighth-century tale *Táin Bó Fraích* describes how a rowan-branch contributed to Princess Findabair's falling in love with the warrior Fráech. Her father King Ailill and his retinue had gone to the river to bathe after a morning spent watching the hounds out hunting. The king spied a rowan-tree on the opposite bank of the river, laden with berries. He ordered Fráech to get a branch for him, as he thought its berries beautiful. Fráech did so, and swam back across the river holding the branch above the water. Findabair used to say afterwards that she had never seen anything as beautiful as Fráech crossing the river with his white body and beautiful hair, his well-shaped face, his very blue eyes, and the branch with its red berries between his throat and his white face.

There are also traditions of supernatural properties associated with this tree. For example, in one of the most extraordinary of the mythological cycle of tales, the Wooing of Étaín (*Tochmarc Étaíne*), the heroine Étaín was struck with a rowan wand by her husband's jealous first wife, the witch Fúamnach. As a result she was turned into a pool of water, which later became a beautiful fly.

Beithe 'birch'. As in the case of the rowan, the beauty of the birch-tree is frequently extolled in early Irish verse, but the relatively poor quality of its timber explains its inclusion among the trees of only secondary economic importance. *Beithe* 'birch' is the name for the first letter of the Ogam alphabet – an Irish script ultimately based on the Latin alphabet – which was mainly used for inscriptions on stone monuments from about the fifth to the seventh centuries. It is possible that the choice of *beithe* as the first letter was suggested by its resemblance to *Beta*, the name for the first letter of the Graeco-Roman alphabet. Tree-names are also used to denote other Ogam letters, such as *Coll* 'hazel' for *C*, *Dair* 'oak' for *D*, *Sail* 'willow' for *S*, etc. Hence in Irish grammatical writings the word *fid* 'tree' is used to mean 'letter'. Some later grammarians claimed that all Ogam letter-names referred to trees, but this is erroneous. For example, *Gort*, the name for *G*, is stated in later glosses to be the word for 'ivy', but it is in fact the common word for 'garden, field'.

Lem 'elm'. The palaeobotanical evidence indicates that the elm suffered a catastrophic decline during the first millennium – Frank Mitchell put it about 500 AD. It is significant therefore that it was still present in sufficient quantity to warrant inclusion among the "commoners of the wood" in the Old Irish tree-list. The word *lem* 'elm' is an occasional element in early Irish place-names, e.g. *Lemchaill* 'elm-wood', *Lemdruim* 'elm-hill', *Lemmag* 'elm-plain'.

It is well known that cattle are particularly partial to elm-leaves, and the Roman author Cato records that elm-leaves were routinely fed to cattle and sheep. An Irish text describes the elm as "sustenance of cattle" and "friend of cattle" so it is likely that the same practice was widespread in early Ireland. Indeed, the cutting of elm-branches for this purpose may have contributed to the decline of this tree.

There are some early Irish references to bark rope (*súainem rúisc*). No information is given with regard to the source of this bark. However, the Medieval Welsh law-texts refer to ropes made of elm-bark, so it is possible that this material was likewise used for rope-making in Ireland.

Idath 'wild cherry (?). My identification of the Old Irish tree-name *idath* (also spelled *idadh* or *fidat*) with wild cherry (*Prunus avium*) is uncertain. Stones of the wild cherry have been found in a number of excavations, most abundantly in the Late Bronze Age stratum at Ballinderry crannóg no. 2. The main textual evidence in favour of my suggestion is the reference to "berries of *idath*" in a ninth-century poem entitled the King and Hermit Dialogue. The context requires that these berries are edible. In his edition of this poem Gerard Murphy sought to identify them as the fruit of the bird cherry (*Prunus padus*) which is also native to Ireland. However, its fruit is about half the size of a wild cherry, as well as being dry and sour. It seems more likely, therefore, that *idath* refers to the wild cherry.

Stones which have been identified as belonging to the sweet cultivated cherry *Prunus cerasus* have recently been found in an eleventh-century pit at Winetavern Street, Dublin. In general, however, it seems that the cultivation of this fruit belongs to the period after the Anglo-Norman invasion of 1169. The Irish word for the cultivated cherry is *sirín* (also *silín*), a borrowing from Middle English *cherrie.*

Class C

The third class of seven distinguished in *Bretha Comaithchesa* is the "lower divisions of the wood" (*fodla fedo*). In general, the trees in this group are of approximately the same size as the "commoners of the wood", but somewhat less common. In one version of the tree-list the whitethorn is placed in the 'lower divisions' and its place in the 'commoners' is taken by the aspen.

The texts do not give a full account of the various fines due for damage to the 'lower divisions'. The penalty-fine is given in one text as a yearling heifer. Another text states that the compensation-fine for base-cutting is a two-year-old heifer. It also says that the fine for complete extirpation (*aurbe*) is the same as that due for a 'commoner': this may be a scribal error.

1. **Draigen** 'blackthorn' (*Prunus spinosa*)
2. **Trom** 'elder' (*Sambucus nigra*)
3. **Féorus** 'spindle-tree' (*Euonymus europaeus*)
4. **Findcholl** 'whitebeam (?)' (*Sorbus aria*)
5. **Caithne** 'arbutus, strawberry tree' (*Arbutus unedo*)
6. **Crithach** 'aspen' (*Populus tremula*)
7. **Crann fir** 'juniper (?)' (*Juniperus communis*)

Draigen 'blackthorn'. The blackthorn is often mentioned in early Irish texts, mainly in the context of its forbidding thorniness. However, it clearly also had some economic importance. According to *Bretha Comaithchesa*, twigs of blackthorn were used as an equivalent of barbed wire of modern times, and woven into a "thorny crest" (*cír draigin*) on the top of the field-fences.

Ninth-century legal commentary contains a most interesting reference to *draigen cumra* "sweet blackthorn" apparently in opposition to the wild blackthorn. From approximately the same period we have a reference to *áirni cumræ* "sweet sloes" in a Life of Saint Brigit. The same distinction is made explicitly in later commentary (from about the twelfth century) which contrasts the value of the wild sloe (*áirne fiadain*) with that of the sweet sloe (*áirne cumra*). These references suggest that some form of cultivated plum was present in Pre-Norman Ireland. The experts are not in agreement about the genetic history of the garden plum (*Prunus domestica*). Some authorities hold that the garden plum is a cross between the blackthorn and the wild cherry-plum (*Prunus cerasifera*) of southern Europe and neighbouring regions. However, in their *Domestication of plants in* *the Old World*, Zohary and Hopf argue that the blackthorn is unlikely to have made any contribution to the ancestry of the domestic plum. In their view, the garden plum was evolved from the cherry-plum by human selection of sweeter varieties, and their maintenance by grafting. If this is so, the likelihood is that the 'sweet blackthorn' of early Irish sources is an introduced species of plum. Stones of a bullace-type plum, *Prunus insititia*, have been found in an early eleventh-century pit at Fishamble Street, Dublin. It is however possible that these are from a consignment of imported fruit rather than from home-grown plums.

While on the topic of introduced fruit-trees, I should also for the sake of completeness note that the wild pear (*Pyrus pyraster*) is native to Britain but not to Ireland. There is no textual evidence of the presence of cultivated pears in Pre-Norman Ireland. The Irish word for 'pear', *péire*, is a borrowing from Norman French or Middle English.

Trom 'elder'. The elder-tree prefers nitrogen-rich soil and therefore tends to grow in places which have been enriched by human or animal faeces. The author of a ninth-century triad associated the elder with an accursed (i.e. abandoned) site: *Trí comartha láthraig mallachtan: tromm, tragna, nenaid* "three signs of a cursed place: elder, corncrake, nettle".

Féorus 'spindle-tree'. The main use of this widespread small tree seems to have been in the manufacture of spindles.

Findcholl 'whitebeam (?)'. The literal meaning of the compound *findcholl* is 'white hazel'. It must be admitted that – apart from leaf-shape – there is no particular resemblance between the whitebeam and the hazel. However, the white undersides of the leaves of this tree make it very conspicuous in early summer, so the first element of the compound fits well. Another slight argument in favour of this identification is the reference in an Old Irish tale to the use of *fidshlatta findchuill* "staves of white hazel" for belligerent purposes. The wood of the whitebeam is tough, heavy, springy and not liable to split. It would therefore make a formidable fighting cudgel.

An argument against this identification of *findcholl* is that its Welsh cognate *gwyngollen* (*gwyn* 'white' + *coll*(*en*) 'hazel') is valued at 15 pence in the record of a legal plea of about 1400 – this is the value of an ordinary hazel. Other trees, apart from the oak, yew, beech and sweet apple, have lower values. It seems, therefore, that the Welsh word corresponding to Old Irish *findcholl* refers to a variety of hazel, and not to any other species of tree. It is hardly a term for the filbert (*Corylus maxima*).

Caithne 'arbutus'. At the time of the composition of *Bretha Comaithchesa*, the arbutus must have been more widespread than its present restricted range in parts of Kerry and West Cork, with a few trees by Lough Gill in Co Sligo. In their study of the distribution of this tree in vol. 38 of the *Journal of Ecology*, Sealy and Webb note that "the northern limit of its Mediterranean and the eastern limit of its Atlantic distribution are determined apparently by winter temperature; the regions in which it can flourish and regenerate are almost entirely those in which the mean January temperature is above 40^0 F (4.5^0C)". It is therefore unlikely to have grown naturally in central or eastern Ireland.

There is some evidence from place-names that it was formerly present in the Dingle Peninsula in Co Kerry and in Co Clare. The Irish name of the village of Smerwick near Dingle is *Ard na Caithne*, which is likely to mean 'the hill of the arbutus'. There is also possible place-name evidence of its presence near Inchicronan Lough, Co Clare. In his article on "The forests of the counties of the Lower Shannon valley", Thomas Westropp marks a place called Derrynacaheny. In his discussion he does not provide an interpretation of this name, but it seems very likely to be *Doire na Caithne* 'the oak-wood of the arbutus', i.e. a wood which is predominantly of oak, but with some arbutus. One can compare other *Derry*-names in the vicinity: Derrynagullion (*Doire na gCuilleann*) 'the oak-wood of the hollies', Derrybehagh (*Doire Beitheach*) 'the oak-wood of the birches', Derryskeagh (*Doire Sceach*) 'the oak-wood of the whitethorns'.

I should also mention another place-name in Co Clare which has wrongly been thought to contain the element *caithne*. This is Quin (Irish *Cuinche*). In his *Irish Names of Places* vol. 2, Patrick Joyce suggested that *cuinche* is a collective from *caithne* meaning 'arbutus land'. The etymology of *cuinche* is unknown, but a connection with *caithne* is not possible.

Presumably on account of its rarity, the arbutus is replaced by *féithlenn* 'honeysuckle, woodbine' (*Lonicera periclymenum*) in three versions of the tree-list. This woody climber sometimes attains considerable dimensions, but it does not seem to have been of sufficient economic importance to warrant inclusion among the "lower divisions of the wood".

Crithach 'aspen'. The only native Irish poplar is the aspen. Its name *crithach* means 'the trembling or shivering one'.

Crann fir 'juniper (?)'. My identification of *crann fir* with the juniper is uncertain. The ninth-century King and Hermit Dialogue refers to *cáera fir*, which Gerard Murphy translates "berries of privet (?)". However, the context requires an edible berry, whereas those of the privet are inedible. In later times, the juniper was widely used for flavouring or medicinal purposes. A variety of names has been applied to this plant. In a list of medicines from the fourteenth or fifteenth century it is called *ibhur craigi* lit. 'rock yew'. Other more recent names include *iubhar beinne* lit. 'mountain yew', *bearnán Brighde* lit. 'the gapped one of Brigit', and *biora leacra* lit. 'spines of the rock'. A Scots Gaelic name is *giuthas na beinne* lit. 'mountain pine'. In many dialects, there seems to be an overlap between words for furze and for juniper. Thus in South Donegal *aiteanach* is applied to both plants, and juniper berries – formerly used to flavour poteen – are called *caora aiteanaigh*. In Scots Gaelic, the word *aitean* and its variant *aiteal* are given in dictionaries for 'juniper'. In Irish, the word *aiteal* seems confined to dictionaries.

In conclusion, the identification of *crann fir* with 'juniper' should not be accepted as certain without further evidence, either etymological or textual.

Class D

The least valuable of the twenty-eight trees and shrubs are the "bushes of the wood" (*losa fedo*). The three other classes of seven are fairly constant in the various manuscripts of *Bretha Comaithchesa*. In the case of the *losa fedo*, however, there is considerable variation between different manuscripts. I quote here the version in the oldest manuscript, Rawlinson B 487 in the Bodleian Library, Oxford. It lists six woody shrubs, along with the common fern bracken. Some other versions add an eighth member, *eidenn* 'ivy' (*Hedera helix*). In three manuscripts, either *raith* 'bracken' or *rait* 'bog-myrtle' is replaced by *lecla* 'rushes'.

1. **Raith** 'bracken' (*Pteridium aquilinum*)
2. **Rait** 'bog-myrtle' (*Myrica gale*)
3. **Aitenn** 'furze, gorse, whin' (*Ulex europaeus, Ulex gallii*)
4. **Dris** 'bramble' (*Rubus fruticosus* aggregate)
5. **Fróech** 'heather' (*Calluna vulgaris, Erica cinerea*)
6. **Gilcach** 'broom' (*Sarothamnus scoparius*)
7. **Spín** 'wild rose (?)' (*Rosa canina,* etc.)

According to *Bretha Comaithchesa*, the penalty-fine for damage to a shrub in this class is one sheep. A ninth-century legal commentator on this text recognises the absurdity of imposing a fine for minor damage to such plants and states that there is no penalty for cutting a single stem of any of the *losa fedo*. For destruction (*aurbe*) of the whole plant, however, this commentary fixes a fine of one yearling heifer.

All the plants in this class must have been viewed as being of minor economic value. Bracken was used for bedding, and an eighth-century tale mentions furze and heather as providing inferior grazing for livestock. Of the additional *losa fedo*, ivy was used for winter fodder, and rushes (*Juncus effusus* and other species) served as floor-covering, etc. Bramble and wild rose were no doubt valued mainly for their fruit.

Other trees and shrubs

Finally, a brief note should be made of those native trees and shrubs which do not appear in any of the four classes: buckthorn (*Rhamnus cathartica*), alder buckthorn (*Frangula alnus*), dogwood (*Cornus sanguinea*), guelder rose (*Viburnum opulus*), and privet (*Ligustrum vulgare*). If I am right in identifying (B7) *idath* as wild cherry, another omission is bird cherry (*Prunus padus*). Wild raspberry (*Rubus idaeus*) may for legal purposes have been regarded as belonging with (D4) bramble (*Rubus fruticosus*), and bilberry (*Vaccinium myrtillus*) with (D5) heather. Honeysuckle (*Lonicera periclymenum*) is usually absent, but replaces (C5) arbutus in some versions of the tree-list. In general the omitted species seem to be of little economic importance.

Venerated trees

Throughout the world, trees have excited feelings of wonder and reverence, and in many mythologies woods are peopled by a variety of divine, semi-divine or fairy beings. There is a long tradition among the Celtic peoples of veneration for trees. On the eastern extreme of the Celtic world, it is recorded that the Galatians conducted rituals at a *drunemeton*, which may mean 'oak-sanctuary, sacred oak-grove'. In Ireland, on the western extreme of the Celtic world, the emphasis seems to have been on individual venerated trees rather than on sacred groves. Such trees are referred to as *bile* or *fidnemed.* In some cases they were on monastic grounds. For example, the Annals of Ulster record the destruction by lightning in AD 996 of the monastery of Armagh, including its timber building, stone church, porch and '*fidnemed*'. Venerated trees may also grow on secular sites, and be a focus of local pride. Traditions concerning such trees are recorded in a Middle Irish collection of lore about places called the *Dindshenchas*. One poem celebrates five outstanding trees: *Éo Rossa* (a yew), *Bile Dathi* (an ash), *Éo Mugna* (an oak), *Cráeb Uisnig* (an ash) and *Bile Tortan* (an ash).

A tree's special status may make it the target of an enemy attack. The Annals of Ulster record that in 1099 the Cenél nÉogain chopped down the sacred tree of the Ulstermen, the *Cráeb Telcha* lit. 'the tree (branch) of the hill'. In 1111 the Ulstermen retaliated by felling the sacred trees (*biledha*) of the Cenél nÉogain at their inauguration site of Telach Óc. It is probable that some of these specially venerated trees continue a tradition of tree-worship going back to pre-Christian times.

As in Greek mythology, there are a number of references to magic apples in early Irish literature. In the tale *Echtrae Conli*, the hero Conle was one day sitting on the hill of Uisnech with his father, Conn of the hundred battles. A fairy woman appeared and tried to lure him to join her in the Land of Everlasting Youth. The king's druid chanted against the woman so that Conle was unable to see her. But before she left she threw an apple to him. He spent the next month without food or drink, sustained solely by the magic apple which did not diminish however much it was eaten. He longed for the woman. After a month she returned in a ship of glass. Conle leaped in beside her and the pair rowed away through the air and were never seen again.

Magic hazel-nuts also feature in early Irish literature. Nine hazel-trees grew above the spring of Segais where the Boyne river rises. Their fruit, flowers and leaves used to burst forth simultaneously. Their nuts were the *cna imais* 'nuts of inspiration', which used to fall into the river. The salmon of knowledge derived its poetic wisdom from eating these nuts.

Trees in poetry and proverbs

The beauty of trees is a familiar theme in Irish poetry. Some of the finest of such verse is to be found in material associated with the story of Suibne Geilt ('Mad Sweeney'). After being cursed by Saint Rónán, Suibne lost his reason and went to live in the trees. In a ninth-century poem attributed to him, his home in an ivy-covered tree-top is compared to a hermit's oratory. It is protected from the rain, but the sun, moon and stars are visible, and it is said to be "as bright as though one were in a garden". In later verse, probably from the twelfth century, Suibne is represented as praising the trees of Ireland in turn, starting with the oak and the hazel:

A dair dosach duilledach,
at ard ós cinn chruinn;
a chollháin, a chráebacháin,
a chomra chnó cuill.

'O bushy leafy oak,
you are high above every tree;
o little hazel, o branchy one,
o coffer of hazel-nuts'.

He then goes on to praise the alder and the blackthorn, and describes how everyone tries to shake down the apples of the apple-tree:

A aball, a ablachóc,
trén rot-chraithenn cách;
a cháerthainn, a cháeracháin,
is álainn do bláth.

'O apple-tree, o little apple-tree,
strongly does everyone shake you;
o rowan-tree, o berried one,
your blossom is beautiful'.

He praises the beauty of every high tangled branch of the proud and melodious birch, and extols the holly for sheltering him from the wind. But other trees arouse less positive feelings. He describes the ash as the 'baleful one' as it provides the handle for a warrior's weapon, and he castigates the bramble for tearing at his skin until its thorns are covered in blood. The noise made by the shivering leaves of the aspen fills him with dread as they remind him of a marauding band of raiders. He expresses hatred for the barren (i.e. acornless) oak-tree, which he compares with a milkless cow (*gamnach*):

Mo miscais i fidbadaib
(ní cheilim ar cách)
gamnach darach duilledach
ar sibal go gnáth.

'My hatred in woods
(I conceal it not from anyone)
is a barren leafy oak,
habitually swaying'.

In another poem of the same period there is a dialogue between Suibne and Saint Moling, in which the saint attempts to persuade the madman to abandon his wandering existence among the trees. The attractions of the life-style of each man are compared. Saint Moling observes that a leaf of the Psalter of Saint Kevin is beautiful, to which Suibne replies that a leaf of his yew-tree in Glenn Bolcáin is fairer to him. The saint then states that he is going to say Mass, to which the madman replies that he is going to leap a high leap over a fair-ivied tree. Eventually, however, Suibne found respite from his insanity, and died at the entrance to Saint Moling's church. He was buried with honour.

Trees also feature in various collections of proverbial and gnomic material. A ninth-century miscellany entitled 'The teachings of Cormac' contains the observation that "a wood is good at every season" (*maith fidbad cach ráithe*) and comments on the long-living nature of the yew-tree.

From approximately the same period, there are a number of references to trees in the collection known as *Trecheng Breth Féne*, edited by the great German scholar Kuno Meyer under the title 'The Triads of Ireland'. This collection consists of ideas and images arranged in threes. Thus in Triad 105 the shedding of leaves by a tree is compared with annual sheddings by deer and cattle. The text reads: *Trí bí focherdet marbdili: oss foceird a chongna, fid foceird a duille, cethra focerdat a mbrénfhinda* "three live ones which shed dead things: a deer which sheds its antlers, a tree which sheds its leaves, cattle which shed their coat (literally, their stinking hairs)". Another triad, no. 68, is rather difficult to translate, though the individual words are straightforward: *Trí bróin ata ferr fháilti: brón tréoit oc ithe messa, brón guirt apaig, brón feda fo mess* "three sorrows which are better than joy: the sorrow of a herd of pigs eating acorns, the sorrow of a ripe field of corn, the sorrow of a tree laden with fruit". Here the author compares the hush of a herd of feeding pigs with the heaviness of a ripe corn-stalk or a fruit-laden bough. All three phenomena are evidently regarded as having the appearance of sorrow, but are in fact "better than joy", because they provide food, whether fat roast pig, bread or fruit.

Woodland in early Ireland

The evidence of the law-texts and other sources indicates that there would have been many trees in a typical early Irish landscape. Because of their importance as a source of timber, firewood, charcoal, fruit, etc. trees – as we have seen above – were afforded strict legal protection. The picture portrayed by the texts is of farmland interspersed with individual trees and small woods. Many of these woods would have been privately owned, but it is emphasised in the law-texts that all law-abiding freemen in the community enjoyed limited rights in private woods. These include such privileges as picking berries, collecting enough firewood to cook a meal, gathering a fistful of hazelnuts, cutting rods for carrying away a dead body, and other minor concessions.

It takes only a generation's neglect to turn farmland into woodland, and it is likely that after the great plagues among people and livestock in the mid-seventh century, there would have been considerable expansion of tree-cover. In general, however, the documentary evidence of the early Irish period indicates that large woods were rare and confined to poor land. The author of a ninth-century series of geographical triads clearly regarded large woods as unusual in the Ireland of his day. He lists the three wildernesses of Ireland (*trí díthreib Éirenn*) as *Fid Mór hi Cúailngi* "the great wood in Cooley" (Co Louth), *Fid Déicsen hi Tuirtre* "the wood of Déicsiu in Tuirtre" (probably on the slopes of Slieve Gallion, Co Tyrone) and *Fid Moithre hi Connachtaib* "the wood of Moithre in Connacht". In addition to these three, there is a reference in another ninth-century text to a great wood (*Fid Mór*) to the west of the Sperrin mountains.

There has been much debate on the location of *Silva Vocluti* 'Wood of Fochluth', mentioned by Saint Patrick in his Confession as being "near the Western Sea". The Patrician scholar Ludwig Bieler placed it near Killala in Co Mayo, but without providing definite proof.

Woodland management

Our sources provide us with relatively little information on the ways in which woodland was managed by the early Irish. It is clear however that privately owned woods would normally have been surrounded by a ditch or wall. A law-text on land-values emphasizes that the worth of a wood is increased if there is access by road.

A passage in the twelfth-century tale *Cath Ruis na Ríg* provides evidence of the use of the 'coppice with standards' method of woodland-management, whereby a few large trees are allowed to grow to maturity while the underwood is regularly coppiced to yield a crop of rods every decade or so. The author makes a vivid comparison between an army in which all the lesser warriors have been slain – leaving only the great champions – and an oak-wood in the middle of a plain in which all the underwood (*cáel*) has been removed, with only the great oaks remaining.

Timber and wood-cutting implements

Legal commentary distinguishes three categories of wood: firewood (*connad*), rods (*cáelach*) and timber (*clárach*). A standard beam (*clár n-inraic*) is legally defined as twelve feet in length, two feet across and one foot in thickness. An eighth-century law-text on social status lists the various wood-cutting implements which a prosperous landowner would be expected to possess: a small axe (*eipit*), a large axe (*biáil*), a billhook (*fidbae*), a saw (*tuiresc*), an adze (*tál*) and an auger (*tarathar*). There is also mention in other texts of a wedge (*gend*) for splitting wood.

The small axe is primarily for chopping wood for the fire, and is also referred to as a *túag connaid* "firewood axe". It is clear from the annals that the easily-concealed small axe was sometimes used to carry out murders. Thus the annals of Connacht record that in the year 1243, a man named Giolla gan Ionathar Ua Miadhaigh tricked Hugo de Lacy into inspecting a moat at Durrow, Co Louth. As Hugo was stooping down to measure the ground Giolla gan Ionathar despatched him with a *túag connaid* which he had hidden under his armpit. Similar murders with a firewood axe are recorded in 1232 and 1424.

The large axe was clearly a prized possession in an early Irish household. A ninth-century triad lists the three which are most valuable in a house as "oxen, men, axes". The penalty-fine for stealing or destroying somebody else's axe is a two-year-old heifer. Another law-text provides a detailed description of a proper axe, and specifies that the axehead should be manufactured with three heatings: red heat, white heat and the heat of tempering. The cutting-edge of the iron blade should be so hard that it is not dented by oak or yew i.e. the toughest woods which would be encountered. Some of the terminology used in this passage is obscure, but it seems that the author envisages an axehead of six inches in width with a cutting edge of three inches. The socket in which the wooden handle (*samthach*) is fixed is two inches in breadth. There is little mention of the saw in our sources, except in the context of small-scale carpentry, and it is clear that the normal tree-felling implement is the axe. The legal implications of accidents during the cutting of trees or branches are discussed in the law-text *Bretha Étgid*. The tree-cutter is liable to pay a fine and medical expenses for any injuries which he causes if he neglects to shout a warning beforehand. A later commentator on this passage further states that he must drive away any livestock which are grazing nearby, and ensure that there are no sleeping, deaf or witless people within the danger-zone.

Because of the enormous importance of rods (see under *coll* 'hazel' above) in the early Irish economy, it is not surprising that the billhook is classed along with the large axe as the two principal 'irons of husbandry'. A law-text provides an account of the design and dimensions of a proper billhook. The socket is a fist in diameter, and the curved blade is about six inches long. The metal is one third of an inch thick at the beak (*corr*), half an inch at the middle of the blade, and an inch at the handle. There is a cutting edge on one side of the blade only, but there may have been a short spike (*frithchorr*) at the back of the blade. This would have been employed to pull branches towards the user.

References to trees in early English and Scottish sources

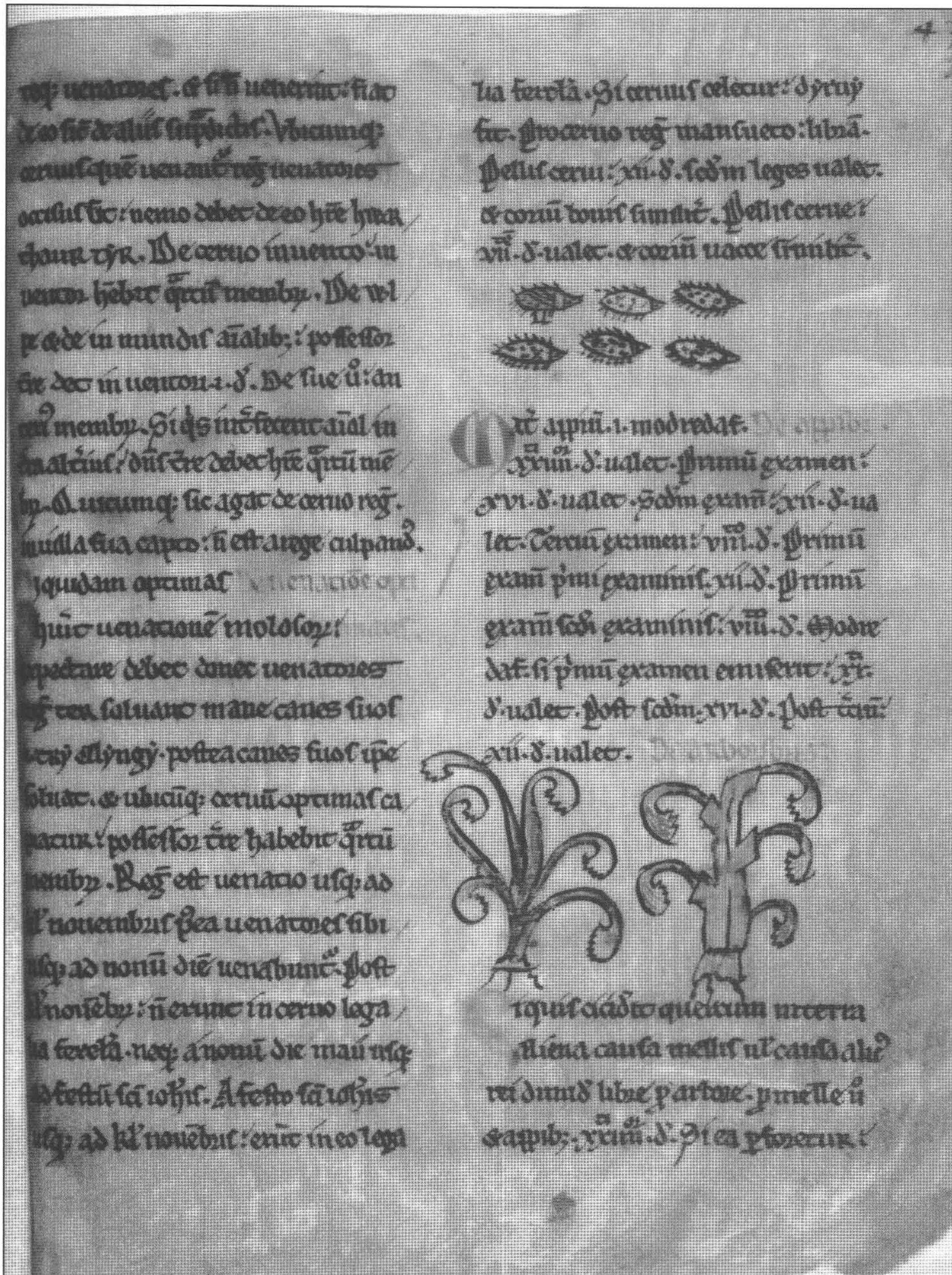
Apart from the arbutus, the trees and shrubs in the Old Irish tree-list are native also to Britain. A number of other trees are native to Britain but not to Ireland, such as the beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), maple (*Acer campestre*) and small-leaved lime (*Tilia cordata*). The documentary evidence on early English trees has been assembled by Oliver Rackham in his marvellously readable and informative books *Trees and woodland in the British landscape* and *The history of the countryside.* Unlike their Irish counterparts, the early English law-texts provide little general information on trees. The great richness of the English material lies in the preservation of detailed early records of the trees, woods and other physical features of specific areas. Appended to charters from between c. 600 and 1080 AD, about 840 Anglo-Saxon 'perambulations' survive which describe the exact boundaries of named areas of land. Rackham notes that 766 individual trees of seventeen species are mentioned in these documents. Specific local evidence of this type is very rare in early Irish sources. An exception is to be found in the ninth-century Book of Armagh where a careful record is made of the boundaries of the fifth part of an estate belonging to a man named Caíchán in the territory of Calraige (Calry, Co Sligo). As in the case of the Anglo-Saxon perambulations, trees are used to mark some of the boundaries of this piece of land. For example, one landmark is given as the Great Oak-wood (*Daire Mór*) and another as the Slope of the Nine Trees *(Ucht Noí nOmne)*.

The Scottish *Leges Forestarum* 'laws of the forests' date from the twelfth and thirteenth centuries. A forest is a more or less wooded area under the control of the king or one of his barons. The *Leges Forestarum* lay down fines and penalties for grazing-trespass by domestic animals within the forest. For example, if the king's forester catches goats in the forest, it is lawful for him on three occasions to hang one of them by the horns in the trees. On the fourth offence, he must kill one of the goats and leave its entrails there as a sign of the trespass. This document also deals with the killing of deer within the forest under various circumstances, and specifies what fines are to be paid to the king. There are a number of references to trees. If the oaks of the forest provide an abundance of acorns in a particular year, the forester is required to summon pig-owners from both town and country to bring their pigs there. For every ten pigs which come to the forest, the king gets the best one among them, and the forester gets a young pig. The *Leges Forestarum* deal also with the forester's duty of exacting fines from those who cut trees in the forest. A distinction is made between fruit-bearing trees and those which do not bear fruit, but there is no list of species. If the forester finds anyone cutting an oak, he must evaluate the tree and exact six pledges from the culprit. If the offence is repeated, the number of pledges is doubled. Imprisonment is the penalty for a third offence.

Tree-lists in Medieval Welsh texts

From the point of view of information on trees, Medieval Welsh documents have the most affinity with those of Ireland. A text entitled *Cad Goddau* in the fourteenth-century collection of poetry called the Book of Taliesin describes a battle involving trees and shrubs of different species against a common foe. In a recent study, Marged Haycock has suggested that it is a parody of the descriptions of warriors in Welsh heroic literature. This text can be compared with Suibne Geilt's account of trees (mentioned under 'Trees in poetry and proverbs' above) as each tree in *Cad Goddau* is given a personality of its own. There is also a good deal in common between the tree-lists found in Irish and Welsh law-texts, though the Welsh texts are considerably later, dating mainly from the thirteenth and fourteenth centuries. I concentrate here on the version of the tree-list in *Llyfr Iorwerth* from Gwynedd (North Wales), as it provides the most detailed treatment of the legal consequences of damage to another person's trees. Law-books from South Wales, *Llyfr Blegywryd* and *Llyfr Cyfnerth*, have similar lists, with some additional material. There are also Latin versions of the tree-list, one of which (Recension A) shares features of both *Llyfr Iorwerth* and *Llyfr Blegywryd.* In general, the fines for offences against trees seem somewhat lower in Welsh law that in Irish law.

Derwen 'oak'. The value of an oak (*derwen*, cognate with Irish *dair*) is 120 pence, which is the equivalent of two milch cows. The total fine payable for cutting down an oak in



Two trees which have been cut in different ways illustrate the section entitled *De arboribus* 'on trees' at folio 22[r] of the thirteenth-century Welsh legal manuscript Peniarth 28. The section begins *Si quis ciciderit quercu...*"if anyone shall have felled an oak …". (*Reproduced by kind permission of the Trustees of the National Library of Wales, Aberystwyth*)

Irish law would be three milch cows and a three-year-old heifer (see above). As in the Irish law-text, a distinction is made between fork-cutting and branch-cutting. If the oak is forked with two main trunks of equal thickness or growth, a fine of 60 pence is payable for each trunk. A fine of 30 pence is payable for a cross-branch which reaches to the heart of the tree. No fine is payable to the owner of the oak if top branches are cut, but the culprit must pay a special fine (*camlwrw*) to the king. In the Latin version of the Welsh tree-list in the thirteenth-century manuscript Peniarth 28, this passage is accompanied by an illustration of two trees, possibly oaks. They are reproduced with this article by kind permission of the Trustees of the National Library of Wales. In his book on *Welsh woods and forests,* William Linnard suggests that the one on the left has been coppiced at the base, whereas the one on the right has been lopped at various heights.

Welsh law also distinguishes a special category of oak-damage called *twll* 'cutting into, perforation', for which the different versions assign fines of 24, 30, 40 or 60 pence (with in some cases an additional fine to the king). This type of damage is associated with the theft of honey from a bee-colony which has taken up residence in a cavity in the oak. The Welsh text assigns the derisory value of 4 pence to a rotten oak (*kegyn derwen*) which produces no acorns. One can compare Suibne Geilt's contemptuous reference to the barren oak (*gamnach darach*) which has been discussed above.

Collen 'hazel'. *Llyfr Iorwerth* assigns a value of 24 pence to a hazel-grove (*collwyn*). If an individual tree (*collen*, cognate with Irish *coll*) is cut from a hazel-grove, only 4 pence are to be paid. Other versions do not assign values to a hazel as part of a grove, but simply state that a fine of 15 pence is due for the destruction of a hazel.

Afallen 'apple-tree'. The Welsh law-texts generally make a distinction between the sweet apple-tree (*afallen ber*) and the crab apple-tree (*afallen sur*). According to *Llyfr Iorwerth,* a graft (*ymp*) of a sweet apple-tree is worth 4 pence until the winter after it is grafted. Thereafter its value increases by 2 pence each season until it bears fruit. It is then worth 60 pence. The crab apple-tree, on the other hand, is only worth 4 pence until it bears fruit; it then acquires the value of 30 pence. The distinction in the Welsh texts between the sweet and sour apple is not made in the Old Irish tree-list. It is however mentioned in other Irish texts (see under *aball* 'apple-tree' above). Welsh *afallen* is cognate with Irish *aball.*

Ywen 'yew'. *Llyfr Iorwerth* assigns the yew a value of 25 pence. *Llyfr Blegywryd* and *Llyfr Cyfnerth,* on the other hand, make a distinction between a woodland yew (*ywen coed*) worth 15 pence and a churchyard yew (*ywen sant*) worth one pound (= 240 pence). The same distinction is made in Recension D of the Latin version.

Other trees. *Llyfr Iorwerth* states that any tree which has been planted for shelter in a garden or beside a house is worth 24 pence. In other situations, the ash (*on*), alder (*gwern*), willow (*helyg*) and other 'non-fruiting' trees (without fruit of dietary importance) are given a value of only 4 pence.

The blackthorn (*draenen,* cognate with Irish *draigen*) is not specifically mentioned in *Llyfr Iorwerth.* However, in *Llyfr Blegywryd* and the Latin versions it is valued at 7½ pence, and in *Llyfr Cyfnerth* it is valued at 8½ pence. Another tree which is omitted from *Llyfr Iorwerth* is *ffawyden* 'beech'. In his *Welsh woods and forests,* William Linnard explains that this is because the beech had not been introduced to North Wales at the period of the texts. In *Llyfr Blegywryd* and *Lfyfr Cyfnerth* from South Wales, the beech is given a value of 60 pence, as is the case in Latin Redaction D.

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Why engage in forest certification? – a Swedish perspective

Ake Granqvist

Stora Enso Forest

Paper presented at the Annual Symposium of the Society of Irish Foresters, Newbridge, Co Kildare, March 1999

Summary
Sweden has a long history of forest regulation and sustained production of wood. Public debate on forestry issues began in the late 1950s with the advent of large scale mechanisation. By the early 1980s environmental non-governmental organisations (ENGOs) had emerged and were beginning to have an impact on forest legislation. They began to have real impact when they succeeded in convincing some large customers to seek wood products from sustainably managed forests. New silvicultural and nature conservation strategies have been developed and are outlined which take into account customer concerns. The means of communication of the new strategies are outlined including the role of certification.

Background
The landholdings of all major Swedish forest industry companies are FSC certified today. How come that more than half of the total FSC certified forest area in the world is situated in Sweden?

To understand this, you need to be aware of developments in Sweden over the past 50 years, even over the whole of the 20th century. Sweden passed its first modern forest act in 1903. The act stipulated that forest must be regenerated after final felling. Over the intervening years forest legislation was developed further. These developments have resulted in a doubling of standing volume over the century, from 1,500 m m^3 to 3,000 m m^3 – despite a wood harvest of some 6,000 m m^3 over the same period. These figures demonstrate a truly sustainable resource, from the wood production point of view.

Public debate on forestry issues, emergence and impact of ENGOs
The mechanisation of the forestry operations started in the late 1950s. Large clearfelled areas were created by heavy, immobile equipment. The public debate about devastating the forest resources emerged. Over the following four decades the debate continued, with the main issues being:

- 60s – clearfelling
- 70s – chemical spraying (herbicides)
- 80s – nature conservation, biodiversity
- 90s – large scale forestry, leaving nothing untouched.

Over this period critics of the industry developed strategies to change forest practices. Around 1970 we faced action from small environmental groups, who chained themselves to our equipment to prevent us from using it. They also turned to the public to influence opinion. Around 1980 the environmentalists began organising themselves in ENGOs. They also started to make politicians write new laws that restricted forest operations. Still they did not achieve what they wanted in terms of changed forestry practices. They found the key to success when they went to the market and convinced some major customers to ask for wood products to be sourced from sustainably managed forests. At that time, the ENGOs had created international networks. They promulgated lots of information about misbehaviour in the forests, which was easily and rapidly spread among different organisations. Computerisation did of course contribute to this.

From the industry's perspective this development, whereby customers became increasingly concerned about environmental issues relating to our raw material supply, was good. Earlier, when small groups of activists directed limited actions at a specific company, it was 'unfair' for the company which was the target. Nowadays, all companies play on the same pitch in a defined market.

Industry response to environmental issues

What strategies did the industry chose to handle the debate? My personal interpretation of the attitudes of the industry in the decades since 1950 is as follows:

- 60s – ignored the opposition,
- 70s – said "we are the professionals, you don't understand forestry",
- 80s – started to listen, learn and cooperate,
- 90s – engaged in joint development of ecological engineering.

The forest industry in Sweden was an easy target for the environmental movement as there was a direct link from the central European wood market to large land holdings in Sweden. The main forest companies in Sweden own 38% of the productive forests in the country. From an international perspective this is unique. Normally industry depends to a greater extent on wood supply sources outside their own forests. This was the main reason for the Swedish forest industry being so sensitive in their forest operations to the concerns of the environmental movement. The direct link from the customer, through the marketing organisation to the industry and hence to large land holdings made the ENGO's efforts effective.

New silvicultural and nature conservation strategies

The forests of Stora Enso in Sweden are concentrated in the central part of the country. Forests in the area have been used for 500 years, as a source of fuel for mining and for iron processing operations. They have been cut again and again, and their biological diversity is definitely affected by that.

Stora Enso Forest Sweden is responsible for:

- the wood supply to the company's mills in Sweden (14 m m^3/annum),
- management of the company's forests in Sweden.

Around 1990, we realised that it was time to reconsider our forestry operations due to the public debate. We knew that:

- sound forestry is environmentally friendly,
- forestry is one of the few sustainable industries,
- we had to review our strategies,
- we had to become proactive instead of reactive in operations and debate.

To achieve this we had to change attitudes, listen to and learn from our critics, cooperate with them and, most importantly, take the initiative. This was the start of the development of our new silvicultural and nature conservation strategies.

The silviculture department in cooperation with the corporate research functions and different external scientists developed the silviculture strategy.

The nature conservation strategy had to be developed through a process whereby our external critics as well as external scientists were invited to participate. To improve our own ability to address these issues and to improve our communication with the outside world, an ecologist was recruited in 1991. He was the first ecologist to be employed by a Swedish forest company, but not the last. Today all major forest companies in Sweden have ecologists employed on their staffs.

The first step was to design a development project where we could discuss all the relevant aspects of a new nature conservation strategy from different perspectives. The ecologist was made project leader. Project group members were assigned from the silviculture department as well as from the Ludvika forest management district where the project area was located. The location of the area (Grangärde, 70 km south of Falun) was chosen because the properties of the area are typical of the company's forest holdings. The size of the project area was 14,000 ha, of which Stora Enso owned 10,000 ha.

To address all relevant non-timber production questions a reference working group of people from outside of the company was recruited. I refer to them as 'scientific environmentalists', as they were scientists (who covered different fields) who were at the same time engaged in the environmental movement. These were specialists in interpretation of aerial infra-red images, landscape ecology, botany, ornithology, lichens and mosses. One represented the hunter's association. The working group met in the project area to solve all the practical problems that arose while developing the strategy. There were, of course, a number of contacts with other scientists during the project.

Three important results arose from the work of the reference group. First, we learned a lot about nature conservation; the group made us understand the fundamental importance of forest fire in our ecosystems. Second, they helped us to find smarter and more cost-effective solutions to different problems than those we found ourselves. Finally, as part of the process, they told their networks what was happening, people outside the company realised that something big was happening.

The new nature conservation goal that was formulated was that the company would preserve the biological diversity at the landscape level (5,000-25,000 hectares). Formerly lots of discussions and energy were spent on trying to rescue every single species on every area to be harvested. We realised in the project that this is not the way that nature works. A forest fire is completely devastating for the individuals of a species that happen to be in an area on fire. Earlier we did not consider the time factor to the extent necessary to understand how species move around in the landscape over time. This finding was fundamental to creating the new goal.

Once the goal was spelled out, we had to find the strategy to achieve it. We found out that we had to mimic, as far as possible, natural forest processes in our operations. For that reason we had to develop and apply:

- an ecological landscape planning model,
- adapted management methods,
- day-to-day nature conservation measures.

To start with the last, day-to-day nature conservation involves all the daily decisions that machine operators make, while deciding which individual or groups of trees to leave behind in a harvesting operation for retention. This includes determining border lines to lakes, streams, bogs, non-productive areas and so on.

Second, to restore natural habitats, which have been disappearing in our managed forests for more than 100 years, we have to reintroduce forest fire. Research has shown that in the natural state approximately 1% of the forest burns annually. Using prescribed burning on dry and mesic sites, all fire dependant species will find new habitats for their survival. On moist and wet sites, regeneration after harvesting takes place underneath the shelter of a comparatively dense seed tree stand.

Ecological landscape planning forms the basis for all operational activities. It aims at identifying and protecting key habitats, places where high conservation values can be found. Around those, dispersion facilities are created for the threatened species. Dispersion corridors connect wet and moist areas, winding like 100-200 m wide snakes of forest through the landscape. Dispersion areas surround dry and mesic sites, where prescribed burning is carried out in specially designed harvesting areas. Landscape planning also involves setting targets to satisfy the need for different habitats, like stands of broadleaved trees.

The nature conservation goal is not that difficult to achieve in itself. However, when taken together with the economic goals of the company, it becomes a challenge which requires well educated employees to handle.

When the board of directors gave its approval in 1993 to implement the two new strategies, it was only the beginning of a long learning and implementation process. Their introduction over the years has required a lot of information, education and practical exercises in the forest. The philosophy for the introduction was, that to achieve long-term results, the ordinary employees and long-term contractors must do the work. This requires time for educational and on-the-job training activities. However, it ensures that the new competence will remain in the company and it makes the employees proud of taking part in the process of change. All employees and contractors were held responsible for performance at their own workplace. It was also made clear to them that it was a learning process and that it was acceptable to make mistakes, as long as one learned from them.

To follow up the change in performance in the forest, an annual green balance sheet was produced for the first time in 1994. In the beginning there was a rapid improvement, and in 1997 the overall performance goal was nearly met. However, in 1998 there was a decline in performance. This was a sign that we have to continue the educational and support activities, but now on a more individual basis.

Public involvement, communication and certification

From a communications point of view, we now had to consider how to bring the message to the public that we have changed our forest management. To illustrate the different phases we have gone through in the forestry operations and the communications work, the following formulae are applicable:

Sustainable Forestry		*Trustworthy Messenger*		*Market trust*
0	X	0	=	0
0	X	1	=	0
1	X	0	=	0

In the beginning we did not practise sustainable forestry and we did not try to convince anyone that we did. When the public debate started we tried to tell the public that the then forest operations were sustainable. At that time foresters were still listened to. However, as forest operations did not change, that was criticised and the market trust was zero. When we eventually changed forest practices, the foresters' reputation was such that it was impossible to convey the message to the public – we were not trusted. So the question was, how should we communicate our new behaviour? Which messenger should we use?

PR people?	– No that did not work!
Foresters?	– Nobody believed us!
Journalists	– Not likely! They do not like to write positive articles about industry.
ENGOs?	– Yes, if they were satisfied with our performance!

What we needed was a third party verification of the changes and state-of-the-art performance in our operations. In 1995 certification through the Forest Stewardship Council (FSC) reached Sweden, two years after we introduced the new strategies. By the end of the year, a major Dutch customer was the first to ask for FSC certified products. In the following years more and more customers asked for FSC certified products, nobody asked for ISO 14001 certificates or EMAS registration of the forest operations. Furthermore, the FSC concept was very much the concept of the green movement and hence it was accepted by our former critics.

This was the incentive we needed to look further into FSC certification. To get an understanding of it, we went through a certification evaluation of the Ludvika district, parallel to the development of the Swedish national FSC standard. In October 1996 the Ludvika district became the first forest management district to be certified in Sweden. By the end of 1998 all the management districts of Stora Enso in Sweden were certified.

This development makes it possible to add the last line in the above set of formulae.

Sustainable Forestry		*Trustworthy Messenger*		*Market trust*
0	X	0	=	0
0	X	1	=	0
1	X	0	=	0
1	X	1	=	1

Through changing our forest operations and finding a trustworthy messenger, we finally achieved market trust. It is important to point out however, that all major changes in our forest operations were introduced in advance of the possibility of FSC certification. The decision to change our strategies was market driven. When certification became an option it was what we needed to verify our new behaviour.

To conclude, public relations are much better nowadays. We have a constructive dialogue with the ENGOs. The ENGOs say yes to sustainable forestry. Negative publicity has almost ceased. Positive publicity is occurring for the first time, without the industry writing it.

We see certification and standardisation schemes such as FSC, ISO and EMAS as complementary options, not competing, and aim at introducing them all.

So the answer to the question in the title – Why engage in forest certification? – is simple: Lack of trust!

Carving a woodland future

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Abstract
Public appreciation and enjoyment of landscapes can be heightened through the medium of the arts, and parks and woods often provide an appropriate setting for public art. Timber sculptures on a wildlife theme are being commissioned for Belfast parks to promote the aims of the urban forestry initiative, and offer a model that can be used elsewhere.

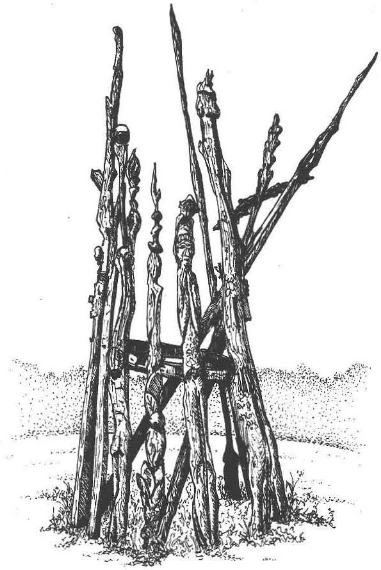
Introduction
The Forest of Belfast was launched in 1992 as an urban forestry partnership to develop the tree resource throughout Greater Belfast. Increasing awareness of the value of urban trees and community participation in tree planting and tree care is central to the initiative. One of the most effective ways in which urban trees are being promoted is through the visual arts.

Wood sculptures in the Forest of Belfast
Many of the events promoted by the Forest of Belfast have involved the arts. Early projects included holding the first Tree Dressing Day in Northern Ireland, commissioning four community murals on the theme of people and trees and organising painting and creative writing competitions about trees (Johnston, 1995, 1998). The visual and performing arts also played an important part in the highly successful two day Tree Fair at Belvoir Park Forest in the south east of the city in June 1993. To mark the event, a sculpture carved from 30-foot (c. 9m) ash poles and entitled 'Tree of Life' was created in a forest clearing by Owen Crawford.

The 'Tree of Life' was followed by a second sculpture, of a kingfisher at Belvoir Park Forest. Carved by Jim Russell and Owen Crawford from a beech tree trunk, it was sited at a viewing point overlooking the forest and the River Lagan, where kingfishers are sometimes seen. The kingfisher is also the symbol of the Lagan Valley Regional Park, which includes the Belvoir woods.

It was recognised that wood sculptures had the potential for increasing awareness of the urban forestry initiative, encouraging residents to visit and revisit parks and woods and to promote the sustainable use of local wood (Simon, 2000). The Forest of Belfast Steering Group agreed to commission further sculptures for woodlands, subject to funding. Long term maintenance was seen as an important issue. Most of the sculptures were to have a lifespan of 5-10 years, after which they could be removed and other sculptures commissioned. It was decided not to create formal sculpture trails, but to site individual works and groups of sculptures in woodlands, initially in parks in the Lagan Valley to the south of the city centre.

In 1996 three further wood sculptures were commissioned. The site chosen for the sculptures was by an informal path that follows the bank of the River Lagan, at Morelands Meadow near Belvoir Park Forest. This extensive riverside area is managed as an informal park with wetlands and meadows shaded by ancient oaks. During the summer months



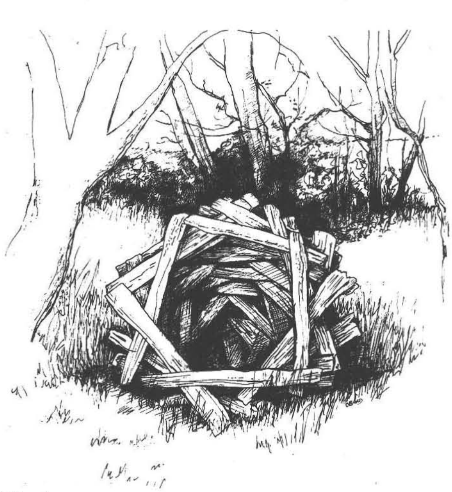
Tree of Life
by Owen Crawford

the area is grazed by cattle. Artists were asked to submit proposals for sculptures to be made of local wood on the theme of wildlife and mans' interactions with wildlife

In July 1997, following a short ceremony held at the Belvoir Forest Centre, 'Nest' by Tim Johnson, 'Horn of Plenty' by Owen Crawford and 'Acorns' by Betty Newman-Maguire were unveiled.

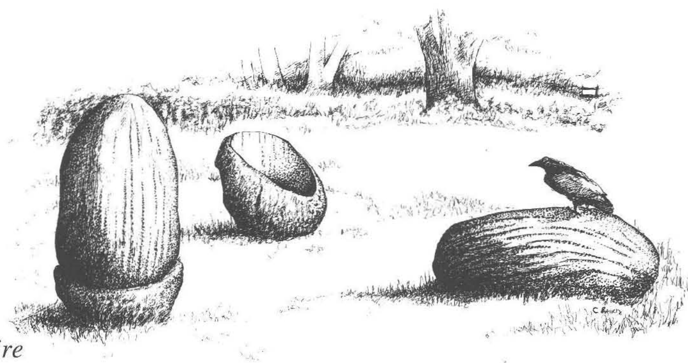
These works were created using a range of woods appropriate for the different themes and were sited in appropriate habitats: 'Nest' was constructed from scrap timber from a sawmill, the finished work being located in scrub woodland, an area frequented by birds such as moorhen, blackbird and crow. 'Horn of Plenty' comprises a figure emerging from the ground holding a bowl, through which a wild rose was planted. It was carved from a beech trunk and was not treated with preservative, the sculptor intending the figure to become colonised with fungi and to slowly decay. 'Acorns' were carved from a fallen oak and sited near an ancient oak tree. The sculptor used the material to focus attention on the cycle of life and to create seating.

The wildlife theme chosen for these works added an informal educational aspect to the project. It was decided that future commissions should also reflect the plant and animal life of the woods and parks. The sculptor Niall Timmins was commissioned to carve several red squirrels, slightly larger than life



Nest
by Tim Johnson

Horn of Plenty
by Owen Crawford

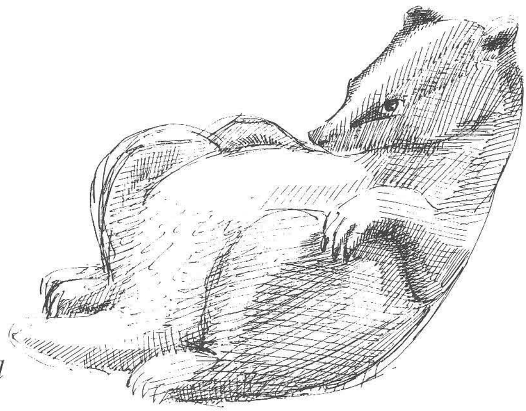


Acorns
by Betty Newman-Maguire

size, on logs in the garden of Malone House in Barnett Demesne, South Belfast. There is a resident population of red squirrels in the park and the sculpture draws attention to this increasingly rare species. This work was unveiled at the end of September 1997 during Red Squirrel Week, when the importance of our native squirrel was highlighted throughout the UK. Each of the guests attending the ceremony was given a small tree grown from local seed, to encourage them to plant native trees to support local wildlife.

In 1997 funding was also obtained for a project entitled 'Woodland Workshops and Woodland Sculptures'. Groups of school children from different communities worked with educational staff from two voluntary organisations involved in the Forest of Belfast, discovering more about woodland wildlife and suggesting ideas for two wildlife sculptures. One group of children investigated the lifestyle and threats to urban badgers. They worked with Owen Crawford who carved an oak trunk into a sculpture of a large badger which children can play with and sit on. This is sited by the Nature Study Centre at Sir Thomas and Lady Dixon Park. The other group searched for and studied mini-beasts, exotic and native plants and other features of the Botanic Gardens. They worked with Niall Timmins, helping him create a wildlife obelisk from thick ash planks on a metal frame, that has been sited in this park.

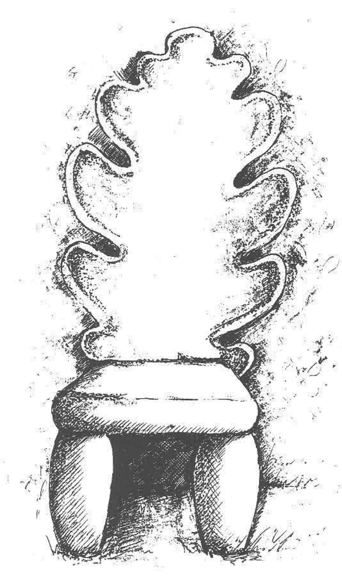
The following year, a group of sculptures was created for Barnett Demesne, in wood-



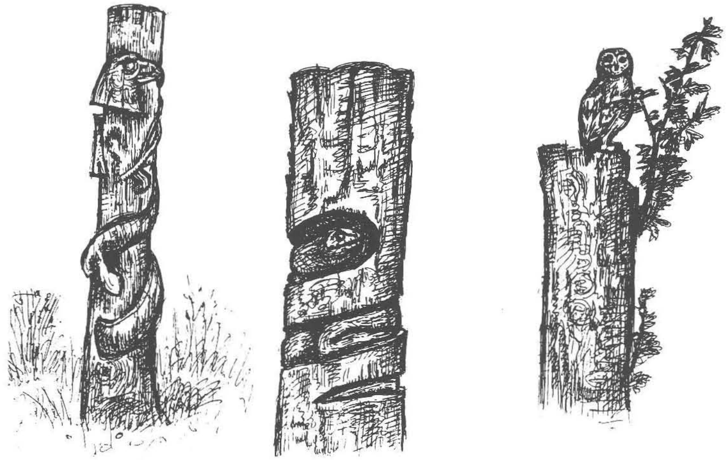
Badger
by Owen Crawford

land but near paths to permit easy access. Sculptor Ned Jackson Smyth constructed an 'Oak Throne', a giant chair of local oak, the back carved like an oak leaf. His colleague Niall Timmins carved a 'Frog on a Log' and, when two old sycamore trees had to be felled, the stumps were left for him to carve two more animal sculptures, 'Owl' and 'Lizard'. These have proved to be the works to which park users are most attracted.

A single large tree trunk was also chosen for the most recent work, by Scott Butt from Newfoundland. His placement was arranged as part of the 'Wood Exchange Project' which is developing creative links between sculptors in Ireland, Newfoundland and Labrador. He worked in Barnett Demesne and transformed the trunk of a recently felled ash tree into a carved Pole with images of Canadian wildlife and culture, including an eagle head, canoe, eel, feather and wigwam. The sculpture was unveiled by the Honorary Canadian Consul on Canada Day, the 1st of July 1999.



Oak Throne
by Ned Jackson Smyth



Ash Pole *by Scott Butt*, **Lizard and Owl** *by Niall Timmins*

Discussion

The sculptures are appreciated by tourists, visitors and park staff. There has been widespread press coverage and the scheme has been highlighted on local radio and television. Many of the sculptors have also attended environmental festivals organised by the Forest of Belfast in partnership with other organisations. These Tree Fairs, held with the Forest Service at Belvoir Park Forest (in 1993 and 1996) and with Belfast City Council Parks and Amenities at Barnett Demesne (in 1998 and 1999), have allowed members of the public to talk to sculptors and to see them at work undertaking commissions for the Forest of Belfast.

Most of the finished works have been easy to place, by simply digging a hole and backfilling around the base with gravel. However, transporting heavy wooden sculptures to chosen sites in parks, sites that are often away from roads and in dense woodland, has caused some problems. Additional expenditure has been incurred in hiring rough terrain vehicles and lorries with telescopic cranes to transport and site each work.

There is growing interest in the visual arts in Belfast and there is no shortage of ideas for new sculptures. The project is increasing exposure for the Forest of Belfast and for sculptors interested in public art. The sculptures are also recognised as having an important role in environmental education. With assistance from sponsors and grant awarding bodies, the momentum is growing, as this paper is being written two new wood sculptures are being created by Ned Jackson Smyth and Owen Crawford. Two sculptures are also to be commissioned for sites near the new cycle path by the River Lagan. As well as increasing the number of sculptures, it is also hoped to gradually develop the scheme, by introducing a broader range of materials and themes and by extending the project to encompass woodlands throughout Greater Belfast.

ACKNOWLEDGEMENTS

I would like to thank all of the sculptors for their interest, enthusiasm and creativity and members of the Forest of Belfast Steering Group for their support and help. The assistance of artists who kindly made drawings and scullptures and allowed them to be reproduced for this paper is very much appreciated. The illustrations are by Niall Timmins (Tree of Life), Carol Baird (Nest and Acorns), Owen Crawfod (badger and The Horn of Plenty), Ned Jackson Smyth (Oak Throne) and Diana Oxlade (Ash Pole, Lizard and Owl). I also thank Sean McCrum for organising the placement for Scott Butt and all of the sponsors (The Forest Service, Belfast City Council Arts and Belfast City Council Parks and Amenities, NORTEL Networks, Belfast European Partnership Board and Sustrans).

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Society of Irish Foresters Annual Study Tour North Scotland 4-11 September 1999

Introduction

The Study Tour was the first visit of the Society to north Scotland. Thirty eight members flew into Glasgow airport on Saturday the 4th of September.

The tour was excellently arranged by Dr Hugh Insley, Region Manager, North Scotland Conservancy, Forest Enterprise, who pulled out all the stops for the Society.

The Highlands and Islands region was the location for the tour. It extends from Argyll in the west to Moray in the east, and includes the outer and Inner Hebrides and the Northern Isles. One half of the land area of Scotland is contained in the region. Forestry is an important land use and economic activity, along with Tourism, Agriculture and Fisheries. Tourism alone generates £600 million/annum and employs around 20,000 people.

The Highlands, of course, include Britain's highest peaks (up to 1344 m). Rainfall varies from 750 mm/annum along the Moray coast to 3200 mm in the mountains of the west. Of the 1.2 million ha of forests in Scotland (50% of the UK total) more than half are located in the Highlands and Islands area. Forest cover has increased from 5% of the land area at the turn of the century to 16% today (the overall forest cover in the UK is 10%). Cover ranges from 7% in Caithness and Sutherland to 30% in Cowal and Kintyre. The Forest Enterprise owns 276,000 ha or 46% of the total forest area .

Log consumption in the Highlands is around 850,000 m^3/annum. It is set to double over the next 20 years. This will create major new opportunities for wood processing. Currently, more than 70% of the output is processed in 25 sawmills and one board plant (OSB, at Dalcross, near Inverness). A recent report by the international consulting group, Jaakko Poyry, has highlighted the need to add value to the projected increase in wood production. One option that has been suggested is a large-scale pulp facility. The report has also highlighted the need to reduce harvesting and transport costs. Much of the road network in the Highlands is incapable of supporting sustained wood haulage. Expenditure on road maintenance has been dramatically reduced and funding for road improvement to cater for wood haulage has ceased. There are cases where mature forests cannot be harvested because of the poor condition of public road access. However, significant efforts are being made to increase the use of rail transport. The use of barge transport continues to be an option along the West Coast. Nevertheless the bulk of harvested wood will continue to be transported by road.

The Society spent a day visiting the 'Flow Country' of Caithness and Sunderland. Afforestation in the area has attracted a degree of controversy. Through the 1970s and up to the end of 1980s there was a large private planting programme on the back of a favourable tax regime, low land prices and an apparent lack of conflict with agriculture. Up to 4000 ha were planted each year. In 1988 the support regime for forestry switched from tax relief to subsidy under the Woodlands Grants Scheme. This included wider consultation and commitments to environmental guidelines and standards. A significant shift in planting patterns resulted; more broadleaves and native Scots pine were planted, open space in plantations was increased and there was a dramatic reduction in the planting of non native conifers.

Forestry provides a broad range of non-market benefits to the Highlands, but their value is difficult to quantify. However, research has indicated that the value of non-market benefits, such as recreation, biodiversity, landscape and carbon sequestration, are comparable to these of wood output.

Finally I want to record our gratitude to Dr Hugh Insley, the Forestry Commission and private sector staff for their co-operation, enthusiasm and courtesy during the Study Tour.

John Mc Loughlin, Convenor

Saturday 4th September

The tour began by setting off in a north-westerly direction along the A82, towards the first port of call, the Greenock to Donoon Ferry. Having boarded the ferry we had a pleasant crossing to Hunter's Cross in Donoon. We were met by Trevor Wilson at our hotel (about two hours later than anticipated).

Following a quick sandwich at our hotel, the Royal Marine, we began our journey to Cowal Forest District. On the way Trevor gave us a brief history of Donoon, now a quiet fishing village, but once a U.S. Navy military base. It was also renowned for boat building, an industry which is no longer in the town.

We followed along the course of the River Effic, which is famous for its salmon and sea trout. Other sites of note on our journey included Bemore Mountain Forestry Estate (over 4,300 ha) and Kilmun Arboretum, which has been used for conifer testing since 1989.

At Cowal Forest District, located between Lough Fyne on the west and Lough Lomond on the east, we were met by Russell Lamont, the Forest District Manager, who gave a brief summary of the district.

The area managed by the Forestry Commission in Cowal District is 44,100 ha, 34,400 ha of which is plantation forestry. The soils are predominately peaty and surface-water gleys with lesser areas of brown earths, iron pans and deep peats. Annual rainfall is high, up to almost 3000 mm. Sitka spruce is the main species planted (65.0%). Other coniferous species, Norway spruce, Scots pine and Douglas fir, make up the rest of the forest area, with a small (7.5%) amount of ash, birch and oak.

Throughout Cowal District there are 150 sites which are specifically managed for recreation. There are six SSSI (Sites of Special Scientific Interest, equivalent to Natural Heritage Areas in Ireland). These include Atlantic oakwoods, wetlands, animal habitats and archaeological monuments. It is also home to Argyll National Park, which is the oldest national park in Scotland.

Our first stop was at a very steep roadside clearfelling site. Sitka spruce and Douglas fir were being extracted by cable crane (Mulholland Cable King). Average tree sizes were 0.38 m^3, Sitka spruce and 0.56 m^3, Douglas fir. Production was 270 m^3 (over bark) per week over an extraction distance of 650 m. The timber was sold standing and cost £19/tonne to extract it to roadside.

The second stop was another steep site which was planted in spring 1999 with Norway and Sitka spruce. Deer fencing was necessary as Norway spruce is particularly susceptible to deer damage. Four species of deer occur in the area, fallow, red, roe and sika. Culling is undertaken to achieve a stocking rate of 17 deer/100 ha though this was being reduced to 12/100 ha.

From Cowall we travelled on to Benmore Estate Grounds, where our guide for the evening was Peter Baxter from the Royal Botanic Gardens, Edinburgh. In Benmore, the first conifers, mostly Scots pine and larch were planted in the 1820s. James Duncan who owned the estate during the 1870s planted large areas of conifers. Benmore was subsequently purchased by the Younger family, who retained ownership until 1925 when it was gifted to the state for research and educational purposes. It now home to more big conifers than anywhere else in Great Britain.

Sunday 5th of September

We travelled north, passing Benmore once more and took the A82 towards Fort William. For much of our journey we travelled beside Loch Lomond and through the beautiful scenery surrounding it. Although the day was overcast the landscape, dominated by forestry and heather moorland, looked splendid. Plantations consisted of larch and spruce punctuated by the occasional oak woodland.

We arrived at Lochaber and boarded cable cars to take us up to our meeting point, Nevis Range Ski Area which is situated in the middle of the forest. We were met by John Risby, Forest District Manager, Alan Gayle, Managing Director, Nevis Range, Alan McKenzie, Forest Manager and Dr Hugh Insley, Region Manager, North Scotland, Forest Enterprise.

John Risby gave us a brief insight into Lochaber district which comprises about 3,000 ha, half of which is comprised of Sitka spruce. They are about 60 staff employed. The main features of the district are its scenery, natural habitats, bogs and native woodlands.

In common with areas we had visited earlier, Lochaber has a similarly high rainfall. Water supply and landscape management are very big issues, as are recreation, tourism and native woodland restoration. The wood harvest is, on average, 100,000 m^3/annum. Nevis Range Ski Resort was set up in 1989. In 1988, the aluminium works in Fort William closed and 1500 local people were left unemployed. Nevis Range was founded in an effort to revitalise the area. Up to 250,000 people visit the resort annually. Sixty people work there full time. This figure increases to120 during the summer. The adjoining forest area has been designated as a tourist area with biking trails provided.

President of the Society, Tony Mannion, to left, with Scottish foresters.

Alan McKenzie outlined the forest design requirements for the Nevis Range area. All forest design involves extensive planning to fit in with the surrounding landscape. Site and physical features such as soil, vegetation and topography need to be taken into account. A plan is first prepared in sketch form. It is then evaluated and is the subject of extensive consultation (by public register). Following this process the plan is reviewed with a revised draft being submitted to the Forest Authority for approval. When approved it is implemented and carefully monitored, followed by a five-year review. The same process is followed for felling and restocking (reforestation).

Accompanied by John Risby, we left Nevis Range and boarded the 'Maid of Glencail' ferry and made our way to a Woodland Restoration Scheme at Suanach. We stopped at a site which was afforested with spruce by the Forestry Commission Enterprise in the mid 50s. A programme was introduced in1994 to promote oak woodlands. The project involved many private sector owners in a partnership between was then established between state agencies, crofters, farmers and funders (mainly the EU). We were introduced to Tim Goucher, project manager and Colin Lavin, deer manager who gave us an insight into the project.

Colin Lavin outlined the approach to deer management in relation to culling development and monitoring. Fifteen years previously, there had been 70 wildlife rangers in Cowal District who culled 10,000 deer/annum. This was done without any understanding of the issues involved, so a research project was undertaken to develop a deer management programme. The programme indicated the necessity to have a population assessment every two years, to include fertility and mortality rates. This would give the desired population, current population, rate of change, culling levels necessary and the level of damage to be expected.

The programme has been implemented in Suanach - a deer control group has been was set up with the partners involved in the overall project. A count had been carried out, culling levels were set and have been achieved. During the cull, regular meetings took place with the public. Deer fences were maintained throughout the period. The project has been a success from both a deer management and a partnership viewpoint.

Tim Goucher outlined the development of oak woodland. Conifers and rhododendrons are being removed and grazing has been eliminated. Conditions are being developed for natural regeneration and some under-planting is being done. Most the work is done by the local community. Other ventures are being examined as part of the project. These include tourism, wood harvesting and oak sawmilling. A number of courses are being set up to establish the necessary management skills which are currently lacking in this area. These are being set up in association with the local Community Council and other training organisations. Funding is obtained mainly from the National Lottery and EU LIFE Programme.

Patricia Flanagan

Monday 6th September

The day began with a visit to Glenfinnan Estate where the manager, Alistair Gibson outlined the management of a West Highland estate. It is 3,500 ha in extent and has been owned by the Warren Family since 1974. The estate sells a small amount of wood but the main source of income is deer stalking - the current charge is Stg£300/person/day. In 1998, wood production was 1,500 m^3 and venison production was 9,540 kg. The price of venison was running at Stg£1.32/kg, whereas three years previously it was as high as Stg£3.19/kg. The drop in price is being blamed on imports from New Zealand. In 1998 400,000 New Zealand deer carcasses were imported by the EU.

We drove to Glen Affric to see native pinewood restoration and met Malcolm Weild, District Manager, Fort Augustus along with Tim Lauder, George Mc Larty and Sandra Paul. Glen Affric is the largest semi-natural woodland in Forest Enterprise ownership. The historical background to the destruction of the natural woodlands in Scotland was outlined as follows. In the seventeenth century, the clan chiefs began small-scale clearance of the woodlands. However Glen Affric was spared somewhat due to its very difficult access. The defeat of the clans at the Battle of Culloden in 1746 saw the establishment of the large estates. The Highland clearances followed, sheep were introduced and the area was intensively grazed. Over time this destroyed large tracts of natural woodlands.

Attempts to restore the Glen Affric woodland began in 1960 when it became the first pine reserve in Scotland. At the time remedial treatment did not extend beyond reducing grazing numbers. In the mid 1970s the core woodland was designated an SSSI and in 1979 it was designated the Caledonian Forest Reserve which covered an area 10,645 ha. The classification does not have a legal status. In 1998 there were 70,000 visitors to the Glen Affric woodlands.

The tour moved to Teandore Woods, Torte where we were met by Rob Shaw of Scottish Woodlands Limited. He outlined the group certification process of the UK Woodland Assurance Scheme (UKWAS). It was initiated in 1998 following collaboration between the UK forest industry and the Forest Stewardship Council (FSC). It specifies requirements that forests and forest managers need to achieve to demonstrate good forest management.

The principal aim of certification is to improve forest management and enhance multiple values of forests. Independent, third party audits of the forest determine if the forest meets certain key minimum standards required for inclusion in the certification scheme. At the moment, certification is a voluntary initiative. Some segments of the retail trade such as DIY outlets are demanding wood from certified sources. The main benefits for the forest owner are improved market access and also the ability to demonstrate to interest groups that the forest is being well managed with due regard being taken of social, environmental and economic issues.

The main requirements of UKWAS were stated as:

a signed commitment to the FSC GB Standard and UKWAS;

a management plan with a vision for the development of the forest, objectives, background data, maps and necessary permissions;

the management plan to be based on soundly based decisions, requiring the collection of appropriate data from monitoring;

commercial operations should be not only well managed but also aim to introduce diversity into the woodland ecosystem;

a need for a focus on biodiversity;

forest owners and managers need to act as responsible citizens carrying out consultation with neighbours prior to activities which would impact significantly on them.

Pat O'Sullivan

Tuesday 7th September

We left Inverness and headed north to the Flow Country of Caithness and Sutherland. (The term Flow Country is a media invention derived from the Norse word *flough*, to describe a wet area.) The theme for the day was the planting that took place in the 1980s and current conservation practices that have evolved alongside forestry development.

In Northern Scotland soils are frequently dominated by peat associations. The largest and best preserved area of blanket peat in the UK is found in the Flow Country of Caithness and Sutherland. (The UK has 13% of the world's resource of blanket bog.) Afforestation has led to controversy in the area. The area attracted forestry investors because of low land prices, a lack of conflict with agriculture and developments in soil preparation which made the planting of peatland possible. As the scale of afforestation grew concern arose about the loss of peatland habitat. This led to an effective public relations campaign. A strategy which recognised the paramount conservation importance of large parts of the Flow Country was developed and planting was subsequently located in areas where there was no conflict with nature conservation.

Many historical events such as the 1745 Jacobite rebellion, the Highland clearances, the break up of the traditional clan system and the complete depopulation of many highland glens to make way for sheep have had a major impact on the culture and land use in this area.

Forest policy and practice has evolved in recent years. In addition to its traditional contribution to the economy, forestry now provides a broad range of environmental and social benefits. Within the Highlands and Islands enterprise area 276,700 ha (46%) is owned by the Forestry Commission and managed by Forest Enterprise. The private sector continues to be dominated by extensive private estates but there is increasing ownership by NGOs such as the Royal Society for the Protection of Birds (RSPB), the John Muir Trust and the National Trust.

During the 1970s and 1980s forest expansion in the Highlands and Islands was restricted to hill land. In line with government policy this expansion has been encouraged to move 'down the hill' onto better quality land. Grant enhancements such as the Better Land Supplement' have supported this. The Grampian Forest Challenge has specifically targeted productive forestry on arable land.

In 1988 the support regime for forestry switched from tax relief to a more transparent subsidy through the Woodland Grant Scheme, which includes wider consultation and commitments to environmental guidelines and standards. This has resulted in a significant shift in planting patterns with higher levels of broadleaf and native Scots pine planting, more open space in plantations and a reduction in the planting of non-native conifers.

To gain first hand information on the consultative process and the rigorous environmental restrictions involved in establishing a Woodland Grant Scheme we visited Hope Plantation in the vicinity of Forsinard railway station. Here we were met by Mike Butler and Stuart Smith of Fountain Forestry. They explained that they began operations in the area in 1979. Sitka spruce was the main species being planted. Yield class 14 was being achieved on lower ground following the application of fertiliser. After four to five years problems arose when conservation groups highlighted that bird life was being interfered with and claimed that forestry development was destroying long established habitats. Some 370 ha were planted in the years 1985 and 1988. In 1992 two owners submitted a grant scheme application. There was much consultation until the scheme was finally approved in 1995. Great concern was expressed about the danger to the rivers Halladale and Bianoch from the planned operations.

Ploughing commenced in 1996, when weekly water sampling also commenced in the Bianoch river. Sampling had not ceased at the time of the visit, though it is planned to reduce it at a future date. The area was ploughed by double mouldboard plough using a shortened plough run of 80 m - the normal being 150 m. The forest was established with a fifty-fifty mixture of lodgepole pine and Sitka spruce at a stocking rate of 2,300 plants/ha. Thirty four ha of broadleaves (alder, birch, sycamore and willow) were also planted. Phosphate was applied as unground rock phosphate at 350 kg/ha, a reduction on the preferred rate 450 kg/ha. It is planned to reapply phosphate at years six, eight and 16 (this to poorer areas only). Potash will also be applied. No nitrogen has been or will be applied.

The drainage carried out is considered the minimum required to establish a tree crop, the drains are allowed to settle before cross draining takes place. The results of the water analysis to date shows phosphorus levels to be stable again after a slight increase following the phosphate application to the crop. The Fresh Water Authority carry out analysis of samples taken from the catchment area, sampling has been reduced to monthly intervals as no adverse effects have been revealed to date, but sampling will continue.

Red and roe deer are found in this area, sika have not being sighted. Two rangers manage the deer population. There is a large population of hares which come in from the adjoining hills.

Having concluded the visit to Hope Plantation the party made the short journey to Forsinard Station RSPB Visitor Centre, where Norman Russell informed us that the area is an important haunt for bird life as it is a vast, wet, flat area. It is one of the few naturally treeless terrains in Britain - it is thought that there have been no trees here for 4,000 years. The bird population is unique to the area with a high proportion of some Britain's species such as widgeon (20%), black scoter (20%) greenshank (70%) and dunlin (35%).
The visitor centre which is situated at Forsinard railway station attracts 6,000 visitors annually. The tour party was taken on a short guided walk on the Dubh Lochan trail. The walk is alongside a pool system which has been made accessible to the public by means of a flagstone path with sturdy seats placed at intervals along it. This encourages visitors of all ages to walk the trail. Terry Keatinge of Scottish National Heritage explained that the surrounding area has qualified as a bird and habitat designation area.

The afternoon began with a journey to Westerdale, viewing on route a number of established plantations. There are 6,000 ha of these in the region managed by Fountain Forestry on behalf of clients. The plantations are divided into a number of properties. A typical property is Forsinain South, which is managed for a Danish client. It was planted in 1986/87 with Sitka spruce, following ploughing. Ground mineral phosphate was applied at establishment at 450 kg/ha. When the plantation was eight years old, a mixture of phosphate and potash was applied by helicopter at 650kg/ha. The fertiliser was applied following foliar nutrient analysis. There is no restriction on the use of helicopters for fertiliser application on sites such as the one that was visited. A yield class of 12-14 was predicted at establishment, it is currently 18.

Passing the Altnabreac plantation it was noted that the crop was not vigorous. This was attributed to nutrient deficiency as second fertilisation was overdue. Other plantations at Bhaird, Fasach and Leir were healthy and well protected by firebreaks. The well maintained road system provides for easy and swift access in the event of fire.

The increasing realisation at national and European level of the conservation value of peatlands was the topic of the final stop of the day. This was at Bad a Cheo, near Rumster, in the Dornoch Forest District of Forest Enterprise where the tour was welcomed by Chris Nixon.

Experiments at Bad a Cheo have investigated the effects of agricultural and forestry development on peatland between 1940 and 1980[1]. The broad objectives behind the experiments included the conservation of peatland habitats within the forest as part of the design

[1] During this period it became possible to successfully afforest deep peat soils through the use of drainage and ploughing technology, together with the use of fertiliser.

and management of open ground. The identification of larger open areas in extensive forests with potential for restoration of former bog habitats also featured as an objective. The property also contains Sitka spruce/lodgepole pine mixture experiments which were planted between 1968 and 1989. These have been used to study the process of peat drying due to afforestation, to assess its effects on water quality and quantity, and on the conservation of adjacent blanket bog habitats. The research has shown that forests on blanket peats dry the surrounding peatland. A buffer zone is necessary to protect areas of active bog from adjacent forest cover. The tour party, having traversed a wet and extensive area of blanket bog was shown this drying effect by Russell Anderson of the Forest Research Agency. As we entered a plantation we identified the subsidence that is taking place at its edge. Unmistakable shrinkage cracks in the peat were pointed out as was we walked further into the plantation. At a further stop outside the plantation area it was shown that the peat reached a depth of 6 m at various points. Research results also pointed to bog growth.

A realisation of the conservation value of peatlands led to a change in emphasis from the early 1980s. In addition, the designation of large tracts of Caithness and North Sutherland as SSSI led to a sharp decline in the planting of conifers on deep peats. The EU Habitats Directive (1992) recognised active blanket bog as a habitat of European significance, requiring priority for conservation. The UK Biodiversity Action Plan for blanket bogs, proposes targets for conserving and improving the quality of the remaining bogs and restoring some priority degraded areas.

As we were leaving this area the President, Tony Mannion, reminded us of how far north we had travelled, when he directed our attention to the Orkney islands, clearly visible on the horizon.

Frank Nugent

Wednesday 8th September

We headed east towards Aberdeen on the A96, passing the Inverness CSW oriented strand board mill on our way to Culban Forest. In a well restored woodsman's house now used for group visits, Alistair Young, Forest District Manager, Forest Enterprise gave a brief introduction to Culban Forest. The forest (mainly Scots pine) is 2,876 ha in extent. The climate of the area is relatively sunny and warm for Scotland. It was acquired by the Forestry Commission between 1922 and 1931 and planted to help stabilise the extensive sand dune systems. The sand dunes and sand flats were moving inland at an average of 4.5 cm daily. Marram grass was tried initially but this method was ineffective in stabilising the dunes. This was followed by another attempt, this time using Scots pine planted through pine brash laid on the surface of the dunes (sometimes fixed down). This proved to be successful in arresting the inland progress of the dunes. Further planting took place between 1922 and 1960. The brash also proved to be effective, not only in aiding forest establishment, but also in introducing seed of native species, and insect and spider life. Culban Forest now has a large number of species normally found in native pine forests.

The forest is a commercial timber producing area with a harvesting programme of about 140,000 m^3/annum, of which about a third is thinnings. It is also an SSSI (since1973), because of the rare flora and fauna and the geomorphology of the dunes. As both a productive forest and a nature reserve open to the public, Culban Forest is managed as a multi-functional area. Roe deer occur but at a low density of 5-6 animals/100 ha and have not yet caused serious damage to the Scots pine.

A forest design plan is now the basis of the Forest Enterprise's management of the forest. During the development of the plan the public were consulted. The three types of environmental protection carried out at Culban are sustainable forest management, naturalness and process protection. Two of the tools used to implement environmental protection are continuous cover forestry and the gradual reduction of coupe size. At the first stop an 18 ha reforestation site had been planted with Corsican and Scots pine in 1998, one year after harvesting. Pine weevil is a problem. Planting stock is treated before dispatch from the nursery. The restocking (reforestation) manager, Andy Chadwick, pointed out the importance of stout planting stock and suggested that a natural parasite may be used in future to control pine weevil. Areas to be replanted are either lightly scarified (Stg£170/ha) or mounded (Stg£270/ha). Natural regeneration of Scots pine was evident, but it is hindered by moss cover. Various strategies were suggested to expose the mineral soil to increase seedling survival, including the introduction of pigs in specially fenced areas. This method is at the trial stage and first indications are encouraging.

One of the more unexpected problems encountered is poor drainage due to the collapse of the old drain systems through harvesting. These drains must be renewed in order to prevent lakes developing between the sand dunes. Drought damage is rare. Fertiliser is not applied. Weeding is not generally needed but broom and birch are selectively cleaned out. Local provenances of Scots pine are used as far as possible in reforestation.

The second stop was at a species trials examining the performance of a number of larch and pine species. From their performance in the trials it was evident that Corsican and Scots pine had been correctly chosen to stock most areas. We moved to a third stop where we looked at a site managed under a continuous cover regime. The decision to change to continuous cover forestry on this particular area was based upon the occurrence of natural regeneration under the existing canopy. Harvesting coupes approximately 0.2 ha in size had been opened by selective felling. The next stop was at a mature Scots pine which had been partially buried by a sand dune. The stem had been re-exposed after decades beneath the sand to show reverse tapering. Although a number of theories were proposed no conclusive explanation was given for this unusual phenomenon. Douglas fir has been planted and was regenerating well on small pockets of better soil, which are usually former agricultural areas not covered by the sands. Rhododendron is also a problem – the policy is to contain rather than to eradicate it.

Dr Jack Durand and Marie Aherne enjoying the tour

On leaving Culban we travelled on towards Aberdeen, passing through Forres village where we admired the topiary and also found out that the last witch in Scotland had been burned there! We arrived at Mosstodloch Sawmill, which is owned by James Jones & Sons Limited. The company employs 462 people directly and between 50 and 100 on contract. The annual turnover for the group is £Stg47 m. It operates at nine sites with the main office at Larbet. Seven of the nine sites are sawmills with a total annual intake of 210,000 m^3. There is also a pallet manufacturing plant, producing 60,000 pallets/week. A new venture for the company will be the manufacture of I-beams and other engineered timber products. This venture will be based in Forres and is due to commence in late1999.

The four sawmills owned by James Jones in Northern Scotland have a combined output of 150,000 m^3 of sawnwood. All harvesting and haulage is contracted out. The mill at Mosstodloch was opened in1957. Today it processes 115,000 m^3 of wood, mainly from forests within a 50-mile radius. The minimum top diameter processed by the mill is 14 cm, the maximum butt diameter is 40 cm. Recovery is 53%. At the time of the visit 60% of production was pallet timber, 30% fencing and 10% construction timber. Newly installed kilns will result in 30% more construction grade material being produced, reducing pallet products to 30%. At Mosstodloch 80% of all wood processed is cut to order.

After a tour of the highly automated sorting, processing and stacking stages, the tour left Mosstodloch for the Grampian Mountains passing the famous 'Christies' nurseries. On arrival at the Grampian Mountains' site we were met by Julie Snodgrass, District Forester, and Mark Reeve who is a Regional Forester in a neighbouring area. Afforestation of farmland was the theme of the visit. Areas had been planted by Forest Enterprise (200 ha) and the private sector (300 ha).

In 1993 vegetatively propagated Sitka spruce was planted at 2,500 trees/ha. Although the general plant quality was good, the plantation had been filled-in three times, because of rabbit damage. It had also been weeded three times. Problems had been experienced with twisted leaders because of the early rapid growth on good soils at high elevations.

The purchase price for the land in 1991 and 1992 was £1,100/ha, but the current price for equivalent land was £2,000/ha. Roe deer are a big problem in the Grampian area and red deer have begun to move in.

At next stop we were introduced to John Donnelly who is the project manager of the Grampian Challenge. The project's objective is to support the farming economy through diversification into other areas such as the planting of marginal land. He explained that the winners of the challenge receive 'top ups' to the available grants and premiums. The additional amounts are funded by the Forestry Commission. Annually 1,500 ha of proposed afforestation are entered into the competition. Five hundred ha will be awarded top up grants in 1999. A minimum area of 10 ha and a minimum of 66% commercial conifers are required. The project intends to support the planting of between 25,000 and 30,000 ha over a 10-year period.

In an indicative forestry strategy for Grampian, a substantial area (285,000 ha) has been designated as 'preferred' for new woodlands. Much of this is in the Buchan area. The normal afforestation grant is between £800 and £1,800/ha (average £1,200). A supplement of £600/ha for conifers and £750/ha for broadleaves is paid for the planting of better quality land. This brings the average grant to £2,500/ha where supplemented with the top-up from the Grampian Challenge. The Farm Woodland Premium Scheme offers between £160 and £300/ha/annum and is available for ten years after planting or for 15 years if more than half the area is planted with broadleaves or native Scots Pine.

Morgan Roche

Thursday 9th September

Travelling south along the A9 we left Inverness, the fastest growing city in Scotland. The countryside was a mixture of pastureland with hedgerows, interspersed with blocks of coniferous forestry, mainly Sitka spruce but comprised of lodgepole and Scots pine, and larch. Travelling further into the Grampians the landscape gradually changed to open hill and mountain summits with pockets of native birch nearer the roadside. At Aviemore, a village heavily reliant on tourism and surrounded by a mixture of woodland and pasture land, we left the A9 and entered Glenmore Forest.

Situated within the Cairngorm Mountains Glenmore Forest is one of the most land-locked forests within the Highlands and Islands District and experiences a more continental climate than most forests in Scotland. We met our hosts and leaders, David Jardine and Jim Gillies, at the impressive Glenmore Forest Park Visitor Centre. Opened in 1948 and managed by Forest Enterprise it is Great Britain's most northerly Forest Park. It caters for all types of visitor, from families to hill walkers and offers a mix of recreational activities ranging from skiing to sailing, walking to wildlife watching. The Forest Park is to become a National Park in the coming years. This will entail management of the area taking into account the amenity aspect of the forest. From the Visitor Centre we proceeded into the forest. It was a hunting ground of the Stuart family from the 12th to the 16th centuries and the forest was left untouched. However, by the mid 1800s clearfelling of the last good stand of Scots pine was underway. The wood was floated down the river Spey to be used for ship building.

In the late 19th century more forest was felled, this time as fuel for iron smelting. The last major clearfell in the forest took place in 1914. The Forestry Commission acquired the area, comprising 1000 ha, in 1923. Trial plots were planted and successful efforts were made to reforest the area. The present day forest contains 50% Scots pine with the balance comprised of a number of other species. Remnants of the natural Caledonian pine forest are present in the forest. This is the most easterly block of native Scots pine in Scotland. The Forest Enterprise is restoring the forest to its natural state. This is a difficult task, involving the removal of all non-native species from the forest and encouraging the natural regeneration of native species. To encourage pine natural regeneration the deer population in the area was reduced to five deer/100 ha. There are some areas of good Scots pine natural regeneration but non-native species, especially Sitka spruce and western hemlock are also regenerating. This is a problem with no easy solution, contractors were being hired to uproot unwanted seedlings.

Jim Gillies explained to us the importance of the forest for wildlife conservation, being home to rare red wood ant and the even rarer capercaillie. The capercaillie is the largest member of the grouse family and is solely dependant on Scots pine as its food source. Twenty five km of deer fencing in the forest had been taken down to aid in conservation, as the capercaillie is a low flying bird which suffers high mortalities following collisions with deer fences.

We moved to Faskally Forest, north of Pithlochry where we met our leader Charlie Taylor, Forest District Manager for the Tay area, to view a good example of continuous cover forestry and the management of a busy recreation facility. Situated in an area with a forestry culture and tradition, Faskally forest was the property of the Earl of Brolben in the 1600s and the Duke of Atholl from the 18th century. It was during the18th century that the Duke planted European larch on the site. The 34 ha forest consisting mainly of pine and larch was purchased by the Forestry Commission in the1950s and Faskally House was converted to a forestry training school. It was at this time that the forester Mark Anderson propounded his theory of continuous cover forestry. An intensive management plan for the forest was undertaken with a lot of the work being done by students. The plan involved felling trees in equal area plots each year over a over a 128-year conversion period. Although the training school was closed in the late 1960s the forest is still managed on a continuous cover forestry basis, but the management plans have been scaled down over the years due to lack of manpower. Managing the forest in this way has entailed:

1. getting timber gangs used to small felling areas;
2. using 'parent extraction racks' at 20 to 25 m intervals;
3. using short pole timber extraction (in the past full pole lengths were skidded out);
4. scarifying clearfelling sites to aid natural regeneration, with some planting taking place where necessary;
5 adapting yield models to fit non-routine forest management;
6. endeavouring to receive a good return on harvested wood due to varied log size;
7. converting the forest to the original species, beech, Douglas fir and Norway spruce, with Scots pine on some of the more open areas.

A bonus of continuous cover forestry is that less weed control is needed due to the retention of an over storey.

The forest is also important from a recreational point of view. Being situated close to Pithlochry, a booming tourist centre, the forest receives between 70 and 80,000 visits a year. This entails managing the forest to cater for different uses. A carpark and walks have been provided in the forest while it continues to be managed on a continuous cover basis.

Ari van der Wel (Jr)

Friday 10th September

The beautiful morning afforded an opportunity to view forestry in the Southern Scottish Highlands area of Sterling and in particular, the Trossachs Region, known as 'Rob Roy Country'.

The Trossachs are designated an area of outstanding natural beauty. Since the early 19th century. They have had a reputation as Scotland's first and most enduring holiday region, providing sharp contrasts between Lowland and Highland landscapes as represented by it's lakes, craggy mountain tops and deep cut, forest filled glens.

Within the Region, Forestry Commission woodlands are managed by the Forest Enterprise, Aberfoyle Forest District, South Scotland Region. The high amenity value of the forests is supported by active management, underpinned by high conservation values. The terrain features a diverse cover of woodland types and tree species. These range from remnants of native broadleaved woodland to commercial coniferous forestry, occurring on a variety of habitats, from peatlands to high, exposed hillsides. There are also areas where new planting and/or natural regeneration is helping to recreate sustainable broadleaved and coniferous woodland habitats.

The theme for the day's itinerary was native woodland restoration, felling and landscape design planning, reforestation using natural regeneration and new planting methods in sensitive landscape areas, and the adoption of continuous cover forestry systems to avoid the impact of clearfells in areas of high recreational use.

Following an overnight stop and an early departure from the pleasant town of Pitlochry, we journeyed southwards, taking the scenic lake route to the Trossachs Pier Visitors Centre, located under the shadow of Ben A'an on the eastern edge of Lake Katrine, where our hosts for the morning were West of Scotland Water.

At the Lough Katrine Native Woodland Restoration Project we were met by Nick Mainprize, Forestry Commission, Perth Conservancy, George Browne, Manager, West of

Scotland Water and Chris Perkins, Environmental Consultant, West of Scotland Water. In his welcome address George Brown outlined the importance of the Lough Katrine and its catchment. It is one of a group of reservoirs which have provided water to the city of Glasgow for over 100 years. The catchment comprises 9,200 ha; it is managed by West of Scotland Water and includes a 220 ha SSSI, habitats of international importance, a National Scenic Area and a landscape with facilities enjoyed by over 180,000 visitors annually.

West of Scotland Water's prime objective is to protect the environment from erosion/run-off by providing sustainable protection forests, comprising native species such as downy birch and sessile oak. A detailed environmental statement supports an increase in native woodland cover from 8% to 11% within the catchment.

The coniferous plantations owned and managed by West of Scotland Water form the predominant landscape surrounding the lake catchment. Due to the maturity of the plantations and to avoid the onset of windthrow, a restructuring process involving the felling and removal of 22,250 m^3 was proposed by West of Scotland Water in May 1999, utilising the latest cable crane extraction techniques to reduce ground disturbance.

George Browne and Chris Perkins outlined that as part of the felling and design process, the main objective of the reforestation plan was to increase the area of native woodland by natural regeneration and/or planting. This was to create biodiverse protection woodlands which will improve the hydrology, landscape, wildlife, flora and fauna of the area.

Natural regeneration was the preferred method of establishment to ensure that the new woodlands mimic those which previously existed. Some 165 ha are to be established using this method with a further 118 ha by planting. The seed will continue to be collected from Lough Katrine's native woodlands in order to ensure a genetically pure base.

To facilitate the successful establishment in the regeneration areas it will be necessary to erect 14,500 m of deer fence and 8,450 m of stock fence over a five year period. Fence lines have been designed to reduce negative visual impact. The use of fertilisers will be minimal, used only in extreme circumstances and then subject to environmental impact assessment and foliar analysis. Use of herbicides for bracken control will be subject to contact application only.

Sheep numbers will be reduced in line with the new woodland developments. Archaeological features will be protected and managed. Woodland management, landscape, hydrology, farming, archaeology and ecology will be continuously monitored. Visitor access will be encouraged and developed via forest walks, cycleways, interpretation and improved visitor information. West of Scotland Water proposes to manage and conserve all the semi-natural woodland within the catchment over a 25-year period. This should ensure sustainable woodlands of high conservation and amenity value which will protect Lough Katrine's legendary water supply.

Following a briefing on the aims and objectives of the project we boarded the steamship, SS Sir Walter Scott, celebrating 100 years in service and last screw driven steamboat on Scotland's inland waters. We travelled 13 km to Stronachlachar along the lake's southern shore to view project works in progress at a number of points along the passage. In addition to the project works, the boat passage provided an opportunity to view historic sites such as Ellens Isle, Royal Cottage, Silver Strand, Factor's Island and the burial place of the Clan Mc Gregor.

Disembarking at Stronachlachar, we travelled alongside the scenic Lough Chon and Lough Ard to the Queen Elizabeth Forest Park, north of Aberfoyle. There we were met by

Peter Forde, District Forester, Environment, and Stuart Chambers, District Forester, Planning and Design. Perched high up on the Duke's Pass on the edge of the Highlands overlooking the Forth Valley, the Queen Elizabeth Forest Park (QEFP) has some of the most spectacular scenery in Scotland. Mountains and lakes, forest and open hill ground provides for a wide range of outdoor activities as well as providing varied habitats for many wildlife species. Recently declared as a National Park, the Park currently provides extensive waymarked walks and cycle trails, two touring caravan and camping sites, a self catering log cabin site and a visitor centre. Approximately 1.25 m visitors utilise the Park annually and the visitor's centre caters for 125,000 visitors/season (open from March until mid October).

Following lunch, our hosts, Peter Forde and Stuart Chambers, briefed the tour party on current management practices in the park. The Highland Fault Boundary, marking the merger of Highland and Lowland woodland and tree species, cuts through the park. As a result, current and future management planning and practices must cater for variation in woodland habitats, plus the amenity and recreational needs of the visitors. They outlined the major characteristics of the park which comprises 20,000 ha of mixed broadleaved/coniferous woodland which are managed primarily on a commercial basis by the Forest Enterprise. In addition, management has responsibility for a further 9,000 ha of woodland outside the Park boundary which includes 22 SSSI, mainly remnants of old oak woodlands planted since the 1820s. In recognition of Forest Enterprise's commitment to sustainable forest management, the strategic forest plan has as its primary objective to increase the area of native woodland. A secondary objective is to replace exotic conifers with native Scots Pine. The final objective is to replace current clearfelling systems with continuous cover systems.

Based on these objectives a strong emphasis is now placed on the preparation of felling and design plans in all of the areas to be treated. In the adoption of continuous cover forestry, felling coupes in the future will vary from 0.2 ha (minimum) to 2.0 ha (maximum). As part of the design process, reforestation plans will make provision for the introduction of native broadleaved and coniferous species.

Following the briefing session, the party was afforded the opportunity to tour the Park where a number of stops were arranged for discussion on a wide variety of topics regarding the implementation and application of sustainable forest management in the National Park.

In the course of the tour, the leaders identified that the changeover to continuous cover forestry in QEFP presents a challenge for management in the future. Based on the existing even aged structure of these largely mature and predominately mixed coniferous stands it is anticipated that the changeover will take many years to achieve. As to how best to achieve the changeover process a number of felling/selection systems are currently under investigation at QEFP. These include:

- shelterwood system, the forest regenerates under its own shelter,
- uniform system (seed tree method),
- group system,
- irregular shelterwood,
- strip systems: shelterwood strip, strip and group, wedge system,
- selection system for light demanding species.

It was acknowledged that continuous cover forestry experiments are still in the initial developmental phase. However, based on similar trials elsewhere it is anticipated that:

- natural regeneration will be difficult to manage,
- deer culling/fencing is imperative,
- soil preparation (scarifying) will be necessary,
- new planting to aid natural regeneration will be required,
- establishing young crops will take longer,
- the management level required will be more intensive;
- harvesting costs higher than for clearfelling systems.

The visit to the QEFP was most informative and pleasant owing to the enthusiastic contributions provided by the leaders in outlining sustainable forest management processes and practices in the park. It provided an apt conclusion to our Study Tour of Scotland, highlighting the fact that sustainable forest management and FSC certification is now a reality. All stakeholders should be involved in the process and the visual impact of felling and species mix must be considered. By implication, Irish timber growers and forest managers must now be prepared to embrace the challenges which sustainable forest management presents, and draw on the experience gained in the Scottish Highlands to date.

We then retired to our hotel at Drymen where we celebrated the annual dinner of the Society. The following morning we were up bright and early and headed for Glasgow for our departure to Belfast and Dublin.

Eamon Larkin

Participants

M. Aherne, T. Collins, J. Crowley, J. Doyle, A. Duffy, J. Durand, K. Ellis, C. Farmer, P. Flanagan, J. Fleming, B. Flynn, T. Gallinagh, J. Greehy, C. Hanley, G. Hipwell, E. Larkin, S. Manahan, T. Mannion,(President), T. Mc Donald, J. Mc Loughlin,(Convenor), P. Mc Closkey, K. Mc Donald, B. Monaghan, P.J. Morrissey, F. Nugent, M. O'Brien, R.Ó Cinnéide, C. O'Donovan, E. O'Keeffe, B. O'Neill, T. O'Regan, P. O'Sullivan, M. O'Sullivan, T. Purcell, M. Roche, J. Treacy, A. van der Wel Jr, T. Wilson.

The Study Tour group listent attentively to a Scottish host

Letters to the Editor

The Editor
Irish Forestry

Dear Sir

Over the past 15 years there has been a very large area of the country afforested – mainly with Sitka spruce on highly fertile sites.

We now face a problem – THINNING- which is essential to:

1. improve the quality of the crop;
2. stabilise the crop against windthrow.

This is not being done on time because 'it is uneconomic to do so'. We are thus left with two options:

1. thin at a later date, with the threat of serious wind damage resulting in the easy option of premature clearfelling and less than 50% of potential sawlog;
2. carry out a 'NO THIN' regime. This should be unacceptable to any forester.

To overcome these problems in the future I would suggest planting at 3 x 3 m spacing superior provenance stock with fine, less frequent branching, good form and vigour; thus delaying the need for thinning until more profitable stems are produced.

This wider spacing is practised in other countries, even at 4 x 4 m in New Zealand. We must not base our future policies on practices developed in the past using unproven stock taken from the wild.

Yours etc.,

Robert Tottenham

(Editor's note: Letters to the Editor on all aspects of forestry, both current and historical, will be welcomed for publication in future issues of Irish Forestry.*)*

Book review

Economics of Irish Forestry: Evaluating the Returns to Economy and Society

J. Peter Clinch. 1999. COFORD, Dublin. ISBN 1 902696034. 276 pages. Paperback. £15.

Reviewed by Padraic M Joyce (emeritus Professor of Forestry, University College Dublin)

Foresters are well aware of the many benefits, apart from timber production, that forests provide, such as recreation, amenity, water quality etc, and have continued to seek a valuation methodology, although some are sceptical that such exists. In recent years, however, methodologies have been developed which purport to provide a solution. In his book, Dr. Clinch makes full use of these to produce what is undoubtedly the most comprehensive assessment of the economic value of the Irish afforestation programme to date.

Using the Government Strategic Plan for the Forestry Sector as a case study, the book sets out to examine whether investments in forestry in Ireland make a positive contribution to the economy and society. The Total Economic Value of the future afforestation programme is estimated using both market and non-market valuation procedures and this is assessed using Cost Benefit Analysis. Employing non-market valuation techniques, a monetary value is allocated to benefits which do not pass through the market place. All benefits and costs are adjusted for time by discounting, and a 5 per cent discount rate is chosen for purposes of analysis as it is the government test discount rate for public sector projects.

The author proceeds to explain the concept of Total Economic Value which comprises actual use value, option value and existence value, and goes on to outline the non-market valuation methods, i.e. the Production Function Approach, the Contingent Valuation Method, the Hedonic Price Method and the Travel Cost Method. Only the first two are used in the study. The contingent valuation method is used to estimate option value, existence value and future use value while production function approaches are used to estimate other externalities.

Following a discourse in chapter 4 on Policy Instruments each of the succeeding chapters provide an explanation of the valuation approach of a particular benefit. Chapter 5 deals with timber. The Forest Strategy has a target of planting 725,000 ha, 80 per cent of which is expected to be conifers and the remainder broadleaves. Making assumptions in regard to species, yield class and timber prices, projections are made for the timber benefits from the strategy. On the assumption that the predominant species will be Sitka spruce and that competition in the UK market is expected to intensify a timber value for the Forest Strategy is estimated at £887 m.

Chapter 6 calculates the input costs of planting forests. Recognising that both farming and forestry are heavily subsidised, shadow prices are used to calculate the opportunity cost of afforesting the land. The social cost of agricultural output is estimated to be £79 per ha which, capitalised at 5 per cent, yields a value of £1580 per ha. This figure multiplied by the number of hectares which are projected in the Forest Strategy until 2030, and discounted at 5 per cent, give a land cost of £552 m. In similar fashion the labour and non-labour and land costs amount to £136m and £169 m respectively to provide a total cost of inputs of £857. The valuation procedure and estimates of the benefits from carbon sequestration accruing from the forest estate under the Forest Strategy are outlined in chapter 7. These benefits amount to a disappointing £46 m.

Chapters 8 and 9 concern Water and Recreation and Tourism. Rather surprisingly the effect of afforestation on the water supply is seen as a cost of £10 m but the author does acknowledge that water supply is one of the most difficult externalities to value. Water impacts at establishment, maturity and harvest are all examined in some detail. Data on recreation and tourism are supplemented by surveys undertaken by the author. The first of these surveyed an effective sample of 2,895 households regarding their visits to forests. The responses obtained suggest that there are 7.7 million visits to forests each year, a figure much higher than expected. The second survey of overseas tourist increased this figure to 8.5 million.

Biodiversity and that most controversial of externalities, landscape, are treated in the next two chapters. The biodiversity and landscape values of an expansion in the forest estate are explored. Techniques for assessing habitat value and reasons for conservation of biodiversity are presented. The impact of afforestation on the landscape is examined and the rationale for the valuation procedure used is outlined. A chapter is devoted to survey data which assesses the attitude of the Irish public to afforestation. A majority feels that it will improve the landscape and provide better habitat for wildlife. Over two thirds of the population believe that afforestation will have a beneficial effect on the countryside.

Contingent Valuation is deemed to be the only appropriate valuation method with which to measure the externalities associated with the expansion of the forest estate in regard to recreation, wildlife and landscape. It is therefore no surprise that a full chapter is devoted to an examination of this technique. Briefly explained, contingent valuation "collects preference information by asking households how much they are willing to pay for some change in the provision of a public good, or the minimum compensation they would require if the change was not carried out" (page 22). The next chapter, Cost Benefit Analysis, ties together the various components of Total Economic Value that have been calculated in the preceding chapters. The results are presented in tables on page 178 which show an internal rate of return or "break even" discount rate around 4 per cent. If the subsidy from the EU for afforestation is assumed to be "free", the internal rate of return exceeds 5 per cent. The value of the net external benefits of the Forest Strategy amount to 18 per cent of the timber value at a 5 per cent discount rate.

The book is a welcome insight for foresters into the cost benefit analysis approach to the economics of forestry in Ireland. They may find the subtleties and intricacies of the economic rationale elusive at times, but they will have little difficulty following the main thrust of the arguments. Silvicultural reasoning is sound and tenets accepted without question by foresters are dissected and analysed. The author argues that the level of subvention of the Forest Strategy is far in excess of that which is justifiable and estimates this excess to be of the order of £1 billion at a 5 per cent discount rate. Foresters will claim that without such subventions forestry could not compete with agriculture as a land use, and many of them will be less than convinced with the validity of contingent valuation as a methodology. Acceptance of "willingness to pay" which does not require one to "put a hand in one's pocket" will be viewed with a degree of scepticism by many.

A note of explanation on the differential in land costs used in the cost benefit approach and financial analysis (pages 178, 179) would have been helpful to the non-economist. In the former the value is shown to be derived from the shadow price of land and is valued at £1580 per ha (page 70). The latter is stated to be the existing market price of land. In reality the present market price of land for forestry is about £2000 per ha. Yet, the land values quoted in tables 15.1 and 15.4 show a differential of the order of 17.1 to 1.3 at zero discount rate. Having regard to the uncertainties associated with the valuation procedures one wonders about the author's concern at the undertaking's failure to breach the 5 per cent test discount barrier. Confidence limits are fairly wide and some of the scenarios in the sensitivity analysis show a more positive picture.

Notwithstanding some reservations about the methodology used for valuation of the externalities, this is a seminal work which rightly deserves a high ranking as a unique study of Irish forestry. It is very well structured and, although the author has the annoying habit of omitting occasional words here and there, it is written with style and clarity. The presentation throughout is totally transparent, and detailed explanation is provided where appropriate. This publication will serve as a baseline study for future forest economists in Ireland.

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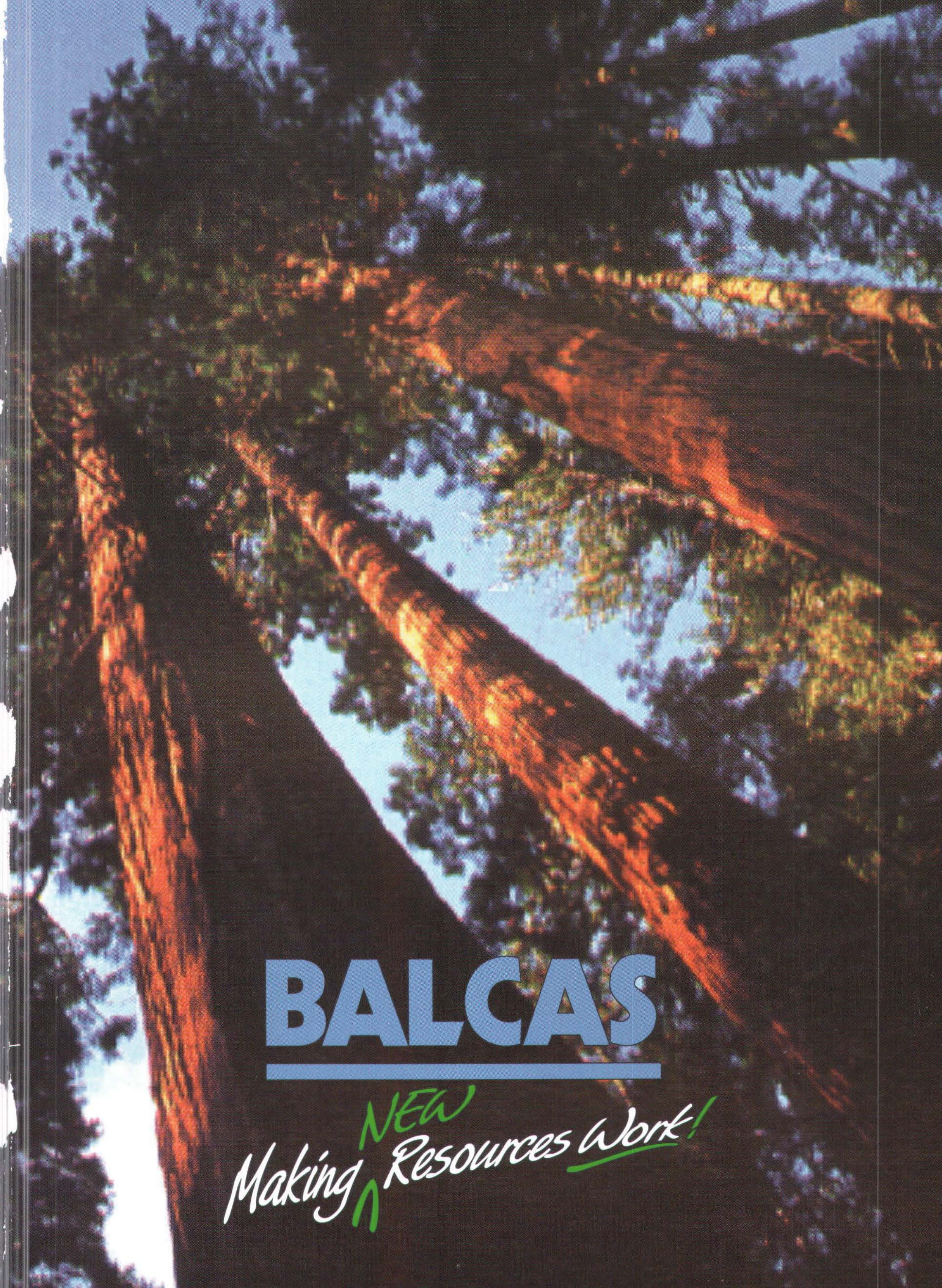
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