Vol. 40, No. 2, 1983

IRISH FORESTRY

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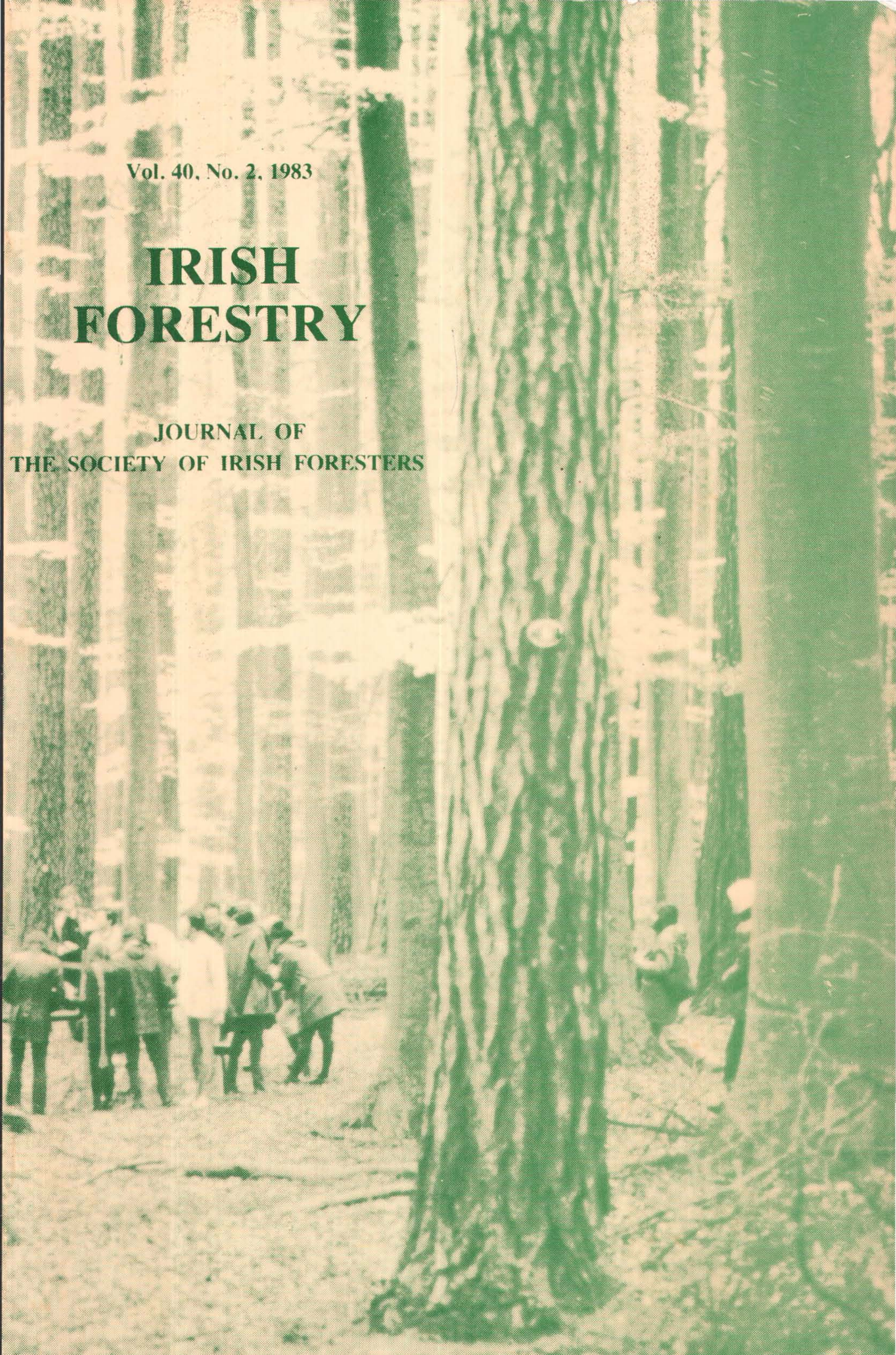

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In this issue:

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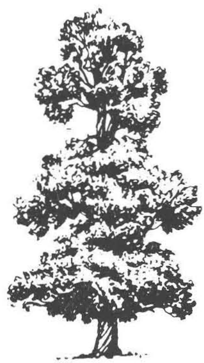

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

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Notes for the Assistance of Contributors

The following notes are designed to aid the speedy processing of scientific contributions to the journal. Authors should comply with them in so far as this is possible.

1. Two copies of each paper should be submitted, in typescript, with double spacing and wide margins.

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

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

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

5. References should be in the following form:
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   DICKSON, D.A. and P. S. SAVILL. 1974. Early growth of *Picea sitchensis* on deep oligotrophic peat in Northern Ireland. Forestry 47:57-88.
   Forestry Abstracts may be used as a guide in the abbreviation of journal titles. Authors should take care to see that references are correctly cited, as the editor cannot guarantee that they will be checked.

6. A short summary of the paper should be included. It should precede the main body of the text.

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

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of the

Society of Irish Foresters

Contents

Note: The opinions expressed in the articles are those of the contributors.

Cover: Larch Veneer at Schlitz (Photo: P. M. Joyce).

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The Society of Irish Foresters

The Society of Irish Foresters was founded in 1942 to advance and spread in Ireland the knowledge of forestry in all its aspects.

The main activities of the society centre around:

(a) Annual study tour

(b) Indoor and field meetings on forestry topics

(c) Production of two issues annually of Society's journal "Irish Forestry"

(d) Annual Forest Walks held on 2nd Sunday of September

There are three types of membership:

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Submissions to the journal will be considered for publication and should be addressed to: Dr. J. J. Gardiner, Editor, Irish Forestry, Department of Forestry, University College, Belfield, Dublin 4. The attention of contributors is drawn to "Notes for the Assistance of Contributors".

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EDITORIAL

Bring on the Sociologists

Almost half of our land is classified as marginal and it is generally agreed that it would make good sense to convert much of this to forest. The Western Package incorporated an afforestation programme with this objective, yet after 3 years in operation it has scarcely created an arboreal ripple on our landscape. What has gone wrong?

Many people blame the Forest and Wildlife Service for their failure to promote the scheme with more vigour. The Land Commission could be accused of positive obstruction. Many would fault the University for its failure to provide integrated courses in land-use to undergraduates. Some would point to the blindness of politicians, and local community leaders and few would excuse landowners on the grounds of ignorance or inertia.

The real reason for the lack of progress with the scheme may be a mixture of all of the above, but one fact is now obvious. Most landowners are indifferent to afforestation and many are clearly antagonistic to forestry, irrespective of the incentives offered. This reaction in itself should not be regarded as unique. Many farmers are indifferent to the incentives offered in their own sphere of activity. Only 25% of farmers were classified as development farmers under the very generous incentive package known as the Farm Modernisation Scheme. Similar figures are available for all of the incentive schemes offered to landowners in Ireland over the past ten years. It is also known that the vast bulk of landowners who do not take up these incentive schemes occupy small-holdings of marginal land. Thus, the Western Package in its present form may have been illconceived and doomed to failure since its birth.

Is it too late to salvage something? Perhaps not. If we knew and understood the reasons which underlie this resistance to incentive schemes perhaps private forestry in Ireland might still progress under the provisions of the Western Package. Perhaps now is the time to bring on the Sociologists.

An analysis of variation of leaf characters in *Quercus robur* L. and *Quercus petraea* (Matt.) Liebl. population samples from Northern Ireland

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SUMMARY

The levels of hybridity in 35 population samples of oak (*Quercus* spp.) from Northern Ireland were assessed using leaf characters analysed by Principal Components Analysis and Cluster Analysis. Eight population types were recognised:

1. Populations of pure *Q. robur* (two populations);
2. Mixed populations with no hybrids and a predominance of *Q. robur* trees (two populations);
3. Predominantly pure *Q. robur* with a small number of hybrids (four populations);
4. Predominantly pure *Q. robur* with a small number of *Q. petraea* and hybrid trees (five populations);
5. Approximately equal proportions of *Q. robur* and *Q. petraea* with a small number of hybrids (nine populations);
6. Mixed populations with a high proportion of hybrids (three populations);
7. Predominantly *Q. petraea* with a small number of hybrid and *Q. robur* trees (four populations);
8. Predominantly *Q. petraea* with a small number of hybrid trees (six populations).

It is argued that the level of hybridity (13.3%) observed is not substantially different from earlier surveys of the two species in England and Wales. The pattern of hybridisation suggests relatively ancient hybridisation although some populations showed evidence of more recent crossing. There was also evidence that some hybrids had been planted along with the parental species.

Mixed populations predominated in the survey possibly owing to the inclusion of obviously planted stands. In some mixed populations, there was evidence of a mosaic pattern with *Q. petraea* on the drier areas.

INTRODUCTION

In the British Isles, there are two oak species that have been considered native: *Quercus robur* L., the pedunculate oak, and *Q.*

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petraea (Matt.) Liebl., the sessile oak (Jones 1959). *Q. robur* is considered to be a species of basic clay soils, tolerant of waterlogging and poorly aerated conditions, whilst *Q. petraea* is a species of more acid sandy soils, intolerant of waterlogging and preferring well-aerated soil conditions. These ecological differences between the species are not, however, very clearly defined and the effect of man, through planting and land drainage, has blurred the distinctions even further. Consequently, in several areas, the species grow together (c.f. Carlisle and Brown 1965). In areas where the species are sympatric, they may interbreed to produce initially F_1 hybrids and then, by subsequent backcrossing to one or other of the parental types, a series of backcrossed hybrids or introgressants (Cousens 1963).

Whilst the results of all large scale population surveys in Scotland (Cousens 1963, 1965), Wales (Rushton 1974, 1979), and England (Cousens 1965, Rushton 1974, 1979, Wigston 1974, 1975) have shown that hybrids do occur between *Q. robur* and *Q. petraea*, the estimated level of hybridisation has varied between 7-12% (Rushton 1974, 1978) and 50% (Cousens 1963) although this latter estimate was later revised (Cousens 1965).

Extensive surveys of oak populations for hybrids in Ireland have been few. Cousens (1965) included populations from Ireland in his survey of oaks in Britain but, since the Irish populations were chosen to represent "good" *Q. petraea* the results do not accurately reflect the taxonomic status of oaks in Ireland. Kelly and Moore (1975) record some results for similar quantitative investigations of a small number of woods. Generally, these have utilised the hybrid index method of analysis (Cousens 1963) rather than the multivariate approaches of Rushton (1978) or Wigston (1975).

The work reported in this paper was designed to investigate the taxonomic status of oak trees and levels of hybridity in population samples from Northern Ireland utilising the methodology previously developed (Rushton 1978).

MATERIALS AND METHODS

1. Detection of hybrids

Hybrids may be detected by a variety of means (Gottlieb 1972) but, in the case of *Q. robur* and *Q. petraea*, only two methods have been employed to date — morphology of leaves and fruits (Carlisle and Brown 1965, Cousens 1963, Rushton 1974, 1978, Wigston 1974, 1975) and pollen viabilities (Minihan and Rushton In Press, Olsson 1975, Rushton 1974, 1978).

Analysis of leaf and fruit samples has proceeded broadly along two lines. Cousens (1963, 1965) utilised a hybrid index, pictorialised scatter diagrams, and the "introgression path" approach pioneered by Anderson (1949), and this was also adopted by Carlisle and Brown (1965). However, this procedure has been criticised (Rushton 1978) and several authors have since developed a multivariate approach to such problems (e.g. Jensen 1977, Rushton 1974, 1978, Wigston 1974, 1975). The analyses used in this present study are of the latter type and generally follow the methodology established for the study of oak hybridisation in England and Wales (Rushton 1974, 1978, 1979). A range of characters was examined. The data for each population were organised in the form of a Tree x Character matrix (character means being calculated for each tree) and these data subjected to both a Cluster Analysis (CA) and a Principal Components Analysis (PCA). In order to interpret the results, reference populations, both *Q. robur* and *Q. petraea*, were included in each data set. Initially, only two reference populations were used but the results were then substantiated with a range of other reference populations. Rushton (1978) provides a full discussion of this technique of multivariate data analysis with reference to hybrid problems.

2. Characters utilised

The characters utilised were more or less the same as reported in earlier work (Rushton 1974, 1978).

Sixteen leaf characters were used:

a. Lamina regularity (LR)
This was scored an an index ranging from 0 to 4. A perfectly regular lamina scored 4 and one index unit was deducted for each of the following irregularities:

i. Presence of subsidiary lobes on the sides of the main lobes;

ii. Lobe depths of opposite sides of the lamina markedly different;

iii. Different number of lobes on opposite sides of the lamina;

iv. Leaf outline on opposite sides markedly different.

A leaf showing all the above traits was therefore scored as zero.

b. Number of lobe pairs (LN)

This count did not include the terminal lobe. Cases where the number of lobes on each side of the lamina varied were usually resolved by reference to lamina venation.

c. Number of intercalary veins (SN)

Decisions as to what constituted an intercalary vein proved difficult and, in consequence, the following definition was used: An intercalary vein was deemed to be present if a vein ran more than half-way to the sinus, and was a vein of equal or nearly equal size to those running to the tips of the lobes. This in practice proved a useful definition, but it should be noted that Wigston (1975) found difficulty in scoring this character and later abandoned it. The character was scored as a simple count of the number of intercalary veins per leaf (see Fig 1.1). In Fig 1.1, an intercalary vein is identified (I) whilst another more minor vein (arrowed) would not be counted.

d. Percentage venation (VN)

A ratio expressed as:

$$\frac{\text{Number of intercalary veins x 100}}{\text{Total number of lamina sinuses}}$$

e. Abaxial pubescence (HR)

In the previous surveys, pubescence was considered as two separate characters — stellate hairs and simple hairs. In this study, the two were combined and scored on a scale of abundance (a glabrous leaf scoring 0, a very hairy leaf scoring 4) using a series of type leaves for comparison. Previous surveys (Rushton 1974, 1978) had shown that there was a highly significant correlation between the abundance of stellate and simple hairs.

f. Length of petiole (PL), see Fig 1.1.

g. Lamina length (LL), see Fig 1.1.

h. Total leaf length (LL+PL)

The total leaf length including both lamina and petiole.

i. Petiole ratio (PR)

A ratio defined as:

$$\frac{\text{Total leaf length}}{\text{Length of petiole}} \qquad \frac{(LL+PL)}{PL}$$

j. Length of lamina from the lamina base to the widest part (WP)

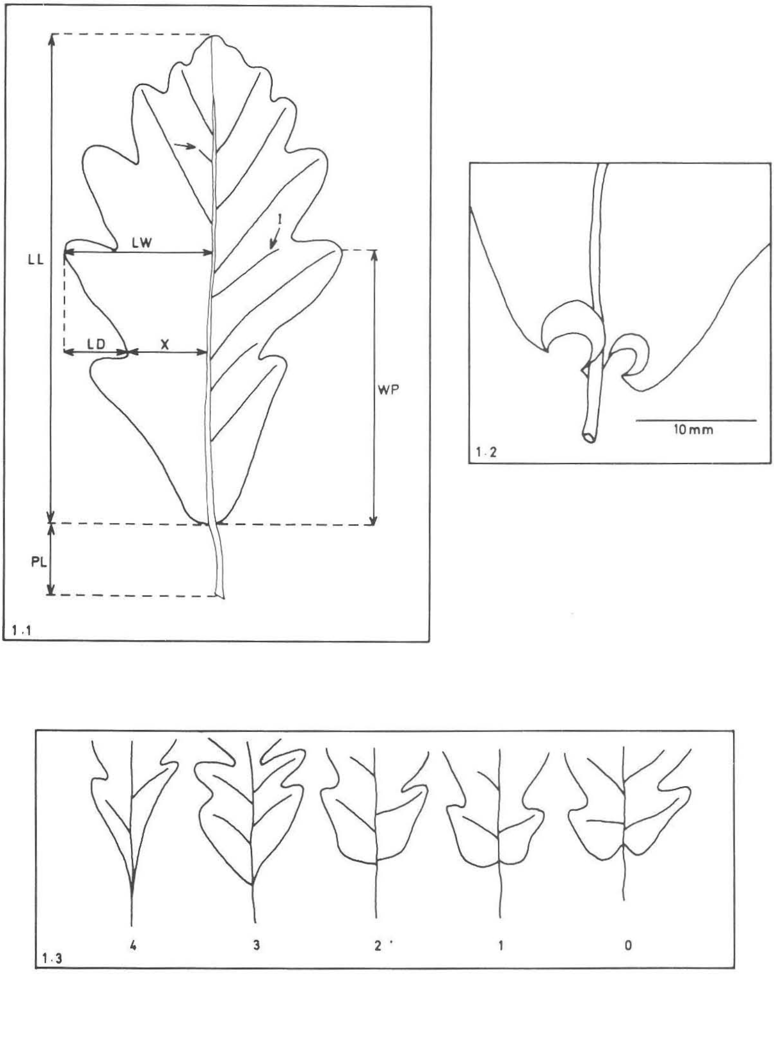


Fig. 1 The estimation and measurement of certain leaf characters in *Quercus* L.

1.1 Quantitative characters (LL=lamina length; PL=length of petiole; LW=lobe width; LD=depth of sinus; X=lamina width; I= an intercalary vein; WP=length of lamina from the lamina base to the widest part).

1.2 The abaxial leaf surface showing a well developed auricle.

1.3 Variation and scoring of the basal shape of the lamina. The numbers refer to the index score.

k. Lamina shape or obversity (OB)

Obversity was determined by use of the following ratio (see Fig 1.1):

$$\frac{\text{Lamina length}}{\text{Length of lamina from the lamina base to the widest part}}$$

l. Lobe width (LW)

This was measured from the midrib to the tip of the lobe at, or immediately below, the widest part of the lamina (see Fig 1.1).

m. Depth of sinus (LD)

Depth of sinus was computed as follows: Lamina width measured from midrib to the base of the sinus at, or immediately below, the widest part of the lamina=X. Then LD=LW–X (see Fig 1.1).

n. Lobe depth ratio (LDR)

Lobe depth ratio has been calculated as the ratio of the width of the lobe to the depth of the sinus immediately below e.g. Maze (1968), Silliman and Leisner (1958), Tucker (1963) i.e. LW/LD. This method of assessment was retained specifically for that lobe at, or immediately below, the widest part of the lamina.

o. Auricle development (AU)

This was scored as an index 0 to 4; a strong auricle scored 0, no auricle 4. A series of type leaves was used for comparison (see Fig 1.2).

p. Basal shape of lamina (BS)

This was scored as an index 0 to 4; a cordate base scored 0, a cuneate base 4. A series of type leaves was used for comparison (see Fig 1.3).

3. Sample collection, measurement and analysis procedure

Members of the Forest Service supplied oak leaf samples. The geographical distribution of the material collected is shown in Fig 2. Generally, these were collected during September/October from oak populations, and consisted of a sample of five leaves/tree from a standard canopy position (Rushton 1978). Selection of trees within populations was random. Collecting instructions issued to the Forest Service indicated that up to 50 trees could be collected per site. At the same time, acorns and peduncles were collected. The

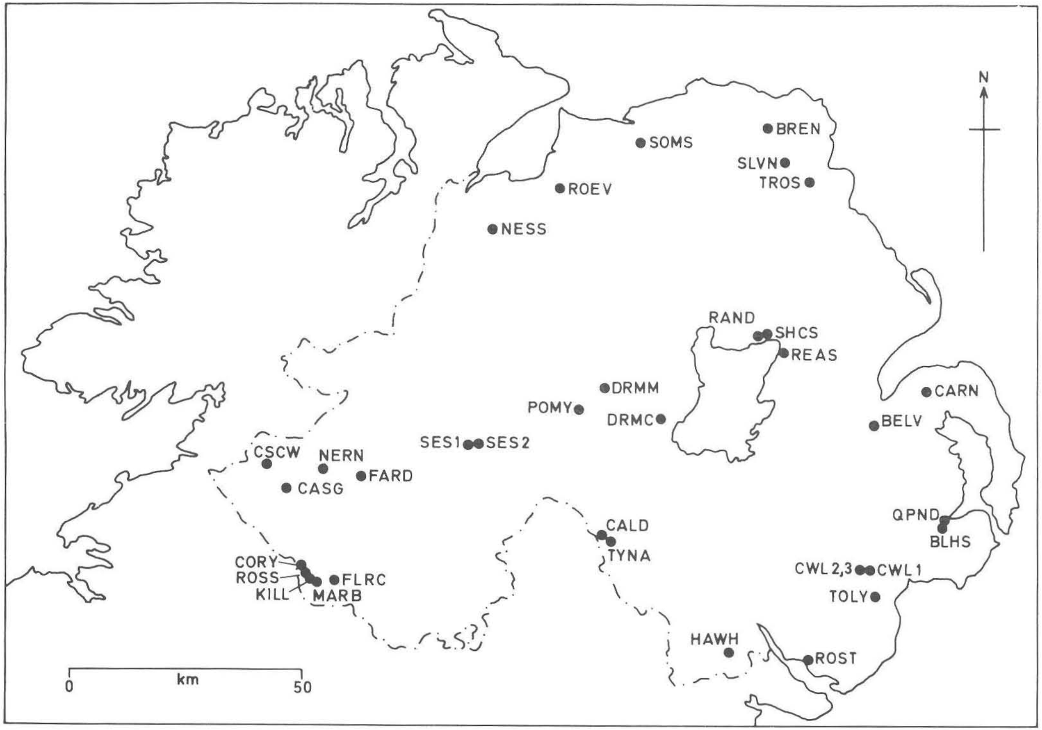


Fig. 2. Distribution of the 35 population samples of oak (32 sites).

sites, together with sample sizes, are listed in Table 1. The author relied on the goodwill of the Forest Service to supply material and no control was exercised over which populations were sampled, nor over sample sizes. Consequently, in some instances, sample sizes were very small but have been included for completeness.

Correlations established between leaf, acorn and peduncle characters have shown that hybrids between *Q. robur* and *Q. petraea* can be efficiently and accurately assessed using leaf characters alone (Rushton 1974, 1978). Since only a small proportion of the samples had well developed fruiting structures, they have not been included in this survey.

Each leaf was assessed for the 16 leaf characters described above and a mean value calculated for each character for each tree. Some leaves, and in some instances all the leaves from a single tree, were not recorded as poor preservation had caused extensive fungal growth which masked such characters as hair development, auricle development and veining patterns. A total of 1087 usable tree samples were supplied from 35 "populations" from 32 sites. For each population in turn, the data matrix consisting of 16 Characters x N Trees was combined with two other data matrices, one of 16 Characters x 25 reference *Q. robur* trees and the second of 16 Characters x 22 reference *Q. petraea* trees. These two reference populations were the same as used in previous work (Rushton 1974, 1978). They were a sample from the Wyre Forest (SO 748 763, *Q. petraea)* and one from Austy Wood (SP 173 633, *Q. robur*). The combined data matrix was then subjected to a PCA using a PASCAL program developed for the VAX 11/780 computer and a CA from the CLUSTAN 2.1 suite of FORTRAN IV programs (Wishart 1982). The cluster analysis used was Ward's Error Sums of Squares Method, a polythetic, agglomerative clustering strategy, using squared Euclidean distance as the similarity coefficient (Ward 1963, Wishart 1969).

The results of each PCA of the combined data matrix were then examined for the presence of trees intermediate between the two reference populations. Earlier work (Rushton 1974, 1978) had indicated that, on grounds of pollen viability, these could be regarded as having hybrid ancestry. The assessment of individual trees was confirmed using the CA results and a series of PCA results using alternative reference populations.

By way of example of the method of PCA interpretation, the PCA results for four populations are given in Fig 3. These illustrate a population which is predominantly *Q. robur* with a single hybrid tree (Fig 3.1), a mixed population with a small number of hybrids (Fig 3.2), a population which is composed predominantly of hybrids

Table 1 Site details including grid references and sample size for the 35 populations.

Name of Forest	Code	Grid Ref.	Sample Size	
Ballyhassen Wood	BLHS	J4947	50	Adjacent Strangford Lough. An old mixed wood with evidence of extraction and regrowth from stools. 0-15m. Acid brown earth.
Belvoir Park, FNR	BELV	J3469	50	Mixed woodland. 15-30m. Acid brown earth.
Breen Wood, NNR	BREN	D1233	40	Old oakwood clothing the sides of a series of glacial overflow channels. 90-150m. Brown earth.
Cairn Wood, FNR	CARN	J4577	38	An old woodland on slopes of Cairngaver. 150-210m. Acid brown earth.
Caledon Estate	CALD	H7443	4	Estate planting. 50m. Grey-brown podsol overlying sandstone.
Cassol Glen, (Lough Navar Forest)	CASG	H0754	20	Alongside small river. 90-120m.
Castle Caldwell, FNR	CSCW	H0206	40	Small woodland on promontory on Lower Lough Erne. 30m.
Castlewellan FP, Sample 1	CWL1	J3337	25	Estate planting of Oak and Sycamore. 120-150m. Acid brown earth.
Castlewellan FP, Sample 2	CWL2	J3237	15	Estate planting of hardwoods. 150m. Acid brown earth.
Castlewellan FP, Sample 3	CWL3	J3237	32	Estate planting of Oak and other hardwoods. 150-180m. Acid brown earth.
Corry Point Wood, (Florence Court Forest), FNR	CORY	H0937	33	A mixed hardwood stand on promontory on Lower Lough Macnean. 30m. Gleyed soil and peat.
Drumcairne Forest	DRMC	H8870	40	Sample included part of the "Old Wood". 60-90m. Acid Brown earth.
Drum Manor, FP	DRMM	H7677	34	Estate planting around small lakes. 60-90m. Acid brown earth.

Florence Court Forest	FLRC	H1734	35	Oak and other hardwood plantation and estate plantings. 30m. Gleyed soil and peat.
Glenariff Forest, (Trostan Forest), NNR	TROS	D2021	10	Alongside Glenariff River, total population about 65 trees. 200m.
Hawthorn Hill, FNR	HAWH	J0319	47	Mixed woodland including Oak on slopes of Slieve Gullion. 150-210m. Acid brown earth.
Inishmakill Island, (North Erne Forest), NNR	NERN	H1558	50	Island in middle of Lower Lough Erne formed as a result of lowering of the lough in the 1890s. Some mature oaks. 30m.
Killesher, FNR	KILL	H1235	11	Mixed woodland developed on limestone on the lower slopes of the Cuileagh Mountains. 90-120m.
Marble Arch, (Marlbank Forest), NNR	MARB	H1234	20	Wooded (predominantly Ash) limestone gorge of the Cladagh River. 60-150m.
Mullock Moss Wood and Derue Wood	FARD	H2356	50	No site details available. 60-90m.
Ness Wood	NESS	C5211	40	Alongside deep-sided gorge of the Burntollet River; Oak removed in the 1840s but now substantially regenerated. 60-120m. Acid brown earth.
Pomeroy Forest, FNR	POMY	H7072	40	Old estate planting. 150-180m. Acid brown earth.
Quoile Pondage, NR	QPND	J5048	40	Adjacent to Strangford Lough; Oak spreading after a barrage was built across the River Quoile 20 years ago. Trees now up to 6m tall and bearing acorns. 0-15m. Nutrient rich.
Randalstown Forest, NNR	RAND	J0988	50	1936 plantation of Oak in mixture with Norway Spruce. 15-60m.
Rea's Wood, NNR	REAS	J1485	9	A colonising woodland on the shore of Lough Neagh. Alder, Ash and Sycamore with Oaks in the drier areas. 15-30m.
Roe Valley Country Park	ROEV	C6720	40	Deep sided gorge of the River Roe. 15-30m. Acid brown earth.
Rossaa, NNR	ROSS	H1036	13	Part of the ribbon of woodland around the Cuileagh Mountains. 90-120m.

Name of Forest	Code	Grid Ref.	Sample Size	
Rostrevor Oak Wood, NNR	ROST	J1718	40	On steep slopes; evidence of clearing in the 1740s followed by regrowth. 60-150m. Acid brown earth.
Seskinore Forest, Sample 1	SES1	H4864	14	Estate planting from the 19th century. 90-120m. Gleyed peat.
Seskinore Forest, Sample 2	SES2	H4764	20	Possibly a more recent planting than SES1. 90-120m. Gleyed peat.
Shanes Castle	SHCS	J1188	40	Original estate planting (150 years ago) with Lime, Elm and Beech. 15-30m. Gleyed brown earth.
Slieveanorra Forest	SLVN	D1526	40	No site details available.
Somerset Forest	SOMS	C8430	2	Recent (1950s) planting. 15-30m. Gleyed brown earth.
Tollymore FP	TOLY	J3431	48	Large scale planting dating back to 1756. 15-250m. Acid brown earth and coarse drift.
Tynan Abbey Estate	TYNA	H7542	7	Estate planting. 50m. Grey-brown podsol.

(FNR=Forest Nature Reserve; FP=Forest Park; NNR=National Nature Reserve; NR=Nature Reserve)

N.B. Many of the sites possess a varied soil and geological make-up and therefore the details above should be taken only as a general indication of site conditions. The height above sea level is given for each population.

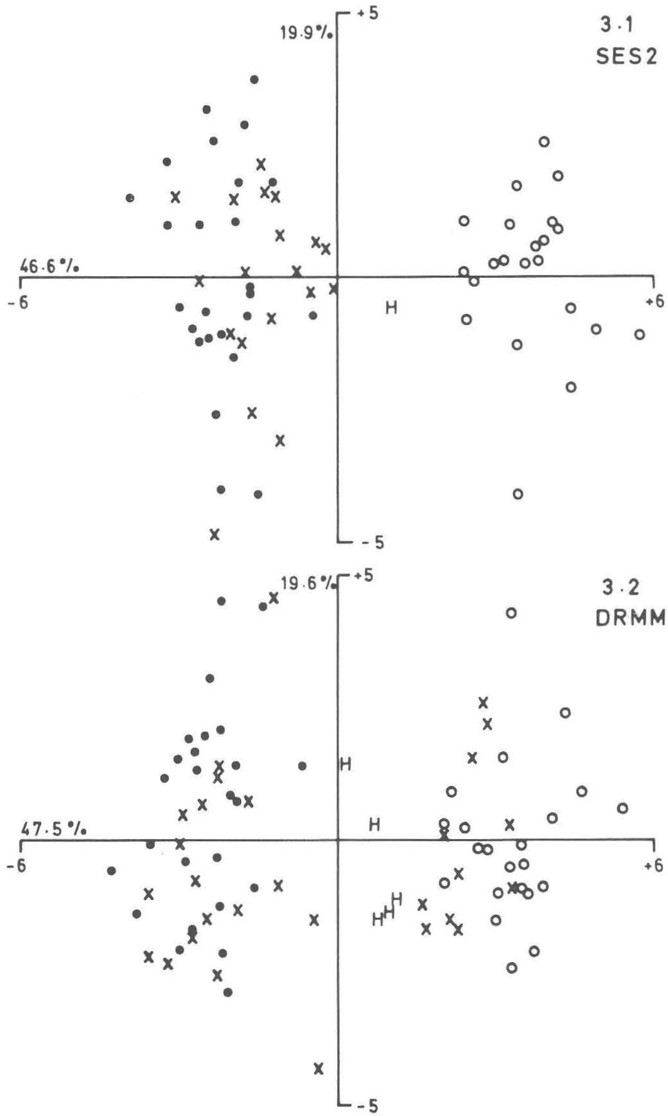
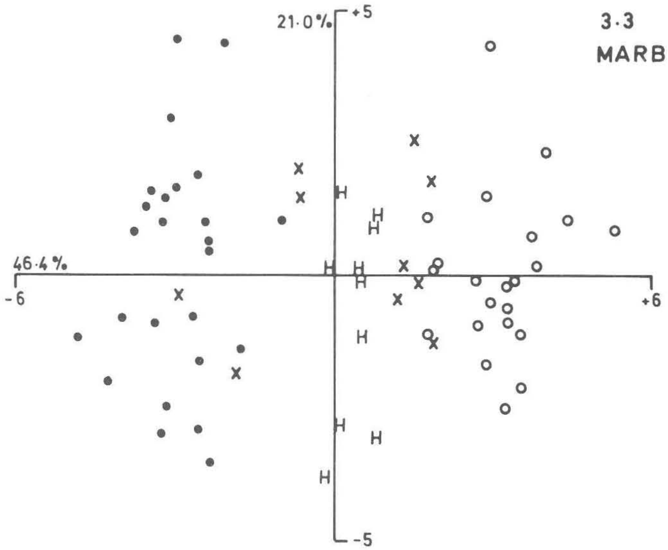


Fig 3. Illustrative PCA results showing a reference pure *Q. robur* population (●), a reference pure *Q. petraea* population (O) and a sample oak population from Northern Ireland. In the sample population, hybrids are identified by H and non-hybrids by X. The percentage of variance accounted for by each component is also shown.

3.2 Seskinore Forest Sample 2 (SES2): predominantly *Q. robur* with only one hybrid tree.

3.2 Drum Manor Forest Park (DRMM): a mixed population with a small number of hybrids.



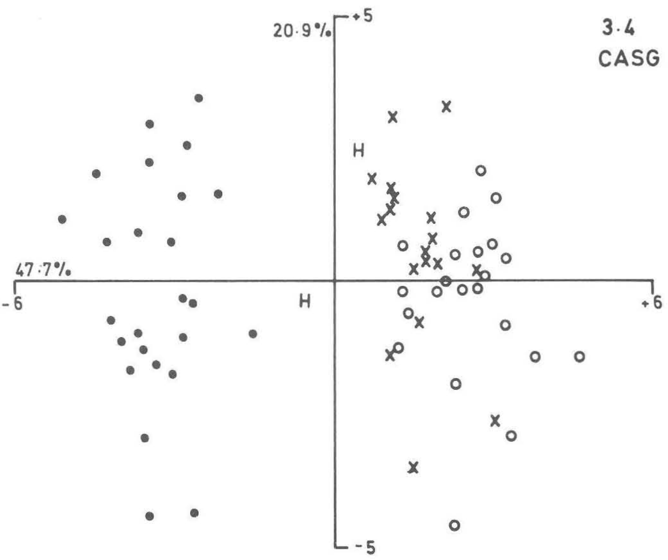


Fig 3 continued

3.3 Marble Arch (MARB): predominantly hybrids.

3.4 Cassol Glen (CASG): predominantly *Q. petraea* with a small number of hybrids.

(Fig 3.3), and a population which is primarily *Q. petraea* with a small number of hybrids (Fig 3.4). Rushton (1978) includes details of the use of CA along with PCA.

RESULTS

The results may be examined in three ways:

A. The general pattern of results within Northern Ireland;

B. A comparison of results with those of earlier surveys particularly those of Rushton (1978, 1979), who used equivalent survey and sampling methods;

C. Individual population results.

A. The general pattern of results

The main results of this study are included in Fig 4. The trees for each population were designated, on the basis of the PCA and CA, as either *Q. robur, Q. petraea* or hybrid. The proportions of each, in each population, were calculated and the results expressed as a histogram for each population. The populations fell, more or less, into five different categories:

1. Populations with only *Q. robur* trees. Two populations were of this type (Fig 4.1, 4.2) although both were represented by very small sample sizes.

2. Mixed populations with both *Q. robur* and *Q. petraea* trees but no hybrids (Fig 4.3, 4.4). In both populations comprising this type, the predominant tree was *Q. robur* accounting for 96% and 89% of the trees in the two populations.

3. Predominantly *Q. robur* trees with hybrids, but with no evidence of *Q. petraea* trees (Fig 4.5-4.8). Four populations comprised this category, and the percentage of hybrids in these populations was generally small — 5%, 5%, 5% and 25%.

4. Mixed populations with *Q. robur, Q. petraea* and hybrids. The majority of population samples (21 out of 35) fell into this category, but four subcategories were observed:

a. Populations with a predominance of *Q. robur* and generally with fewer *Q. petraea* and hybrid trees (Fig 4.9-4.13).

b. Populations with more or less equal proportions of *Q. robur* and *Q. petraea* and with a generally much lower percentage of hybrids (Fig 4.14-4.22). This was the largest category with nine populations.

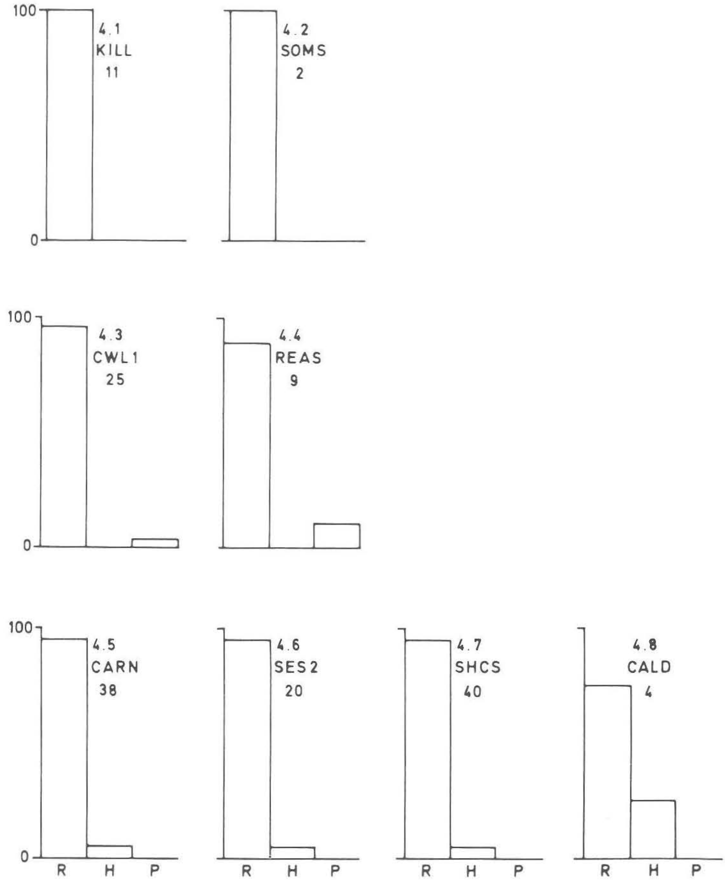


Fig 4 Percentage occurrence of *Q. robur* (R), *Q. petraea* (P), and hybrids (H) in oak population samples. Population code letters are listed in Table 1. The population sample size is also given.

4.1-4.2 Category 1: pure *Q. robur* .

4.3-4.4 Category 2: mixed populations with no hybrids and a predominance of *Q. robur* trees.

4.5-4.8 Category 3: predominantly pure *Q. robur* with a small number of hybrids.

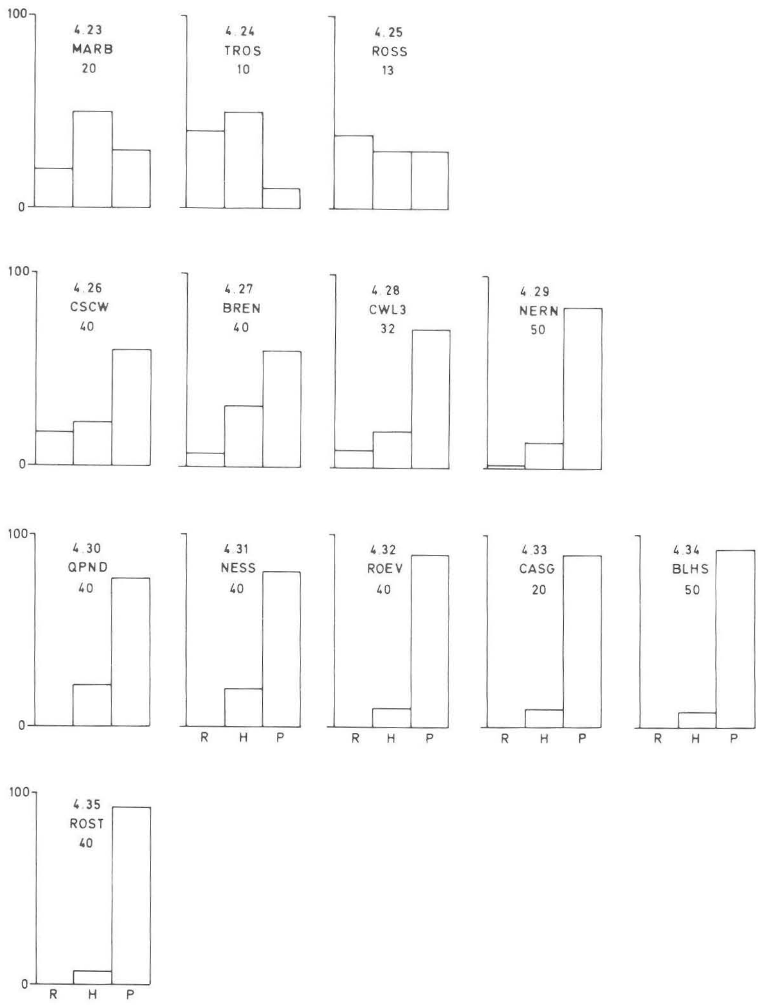


Fig 4 continued

4.9-4.13 Category 4a: predominantly *Q. robur* with a small number of *Q. petraea* and hybrid trees.

4.14-4.22 Category 4b: approximately equal proportions of *Q. robur* and *Q. petraea* with a smaller number of hybrids.

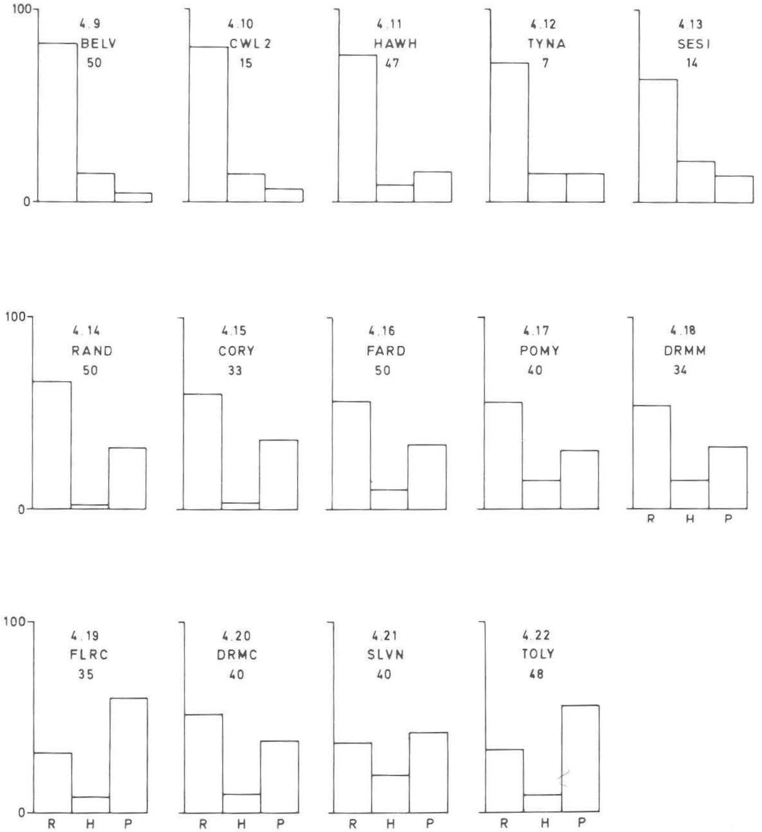


Fig 4 continued

4.23-4.25 Category 4c: mixed populations with a high proportion of hybrids.

4.26-4.29 Category 4d: predominantly *Q. petraea* with a small number of hybrid and *Q. robur* trees.

4.30-4.35 Category 5: predominantly *Q. petraea* with a small number of hybrid trees.

c. Populations in which the proportion of hybrids was generally high, usually exceeding the proportions of the two parental types. Three samples fell into this category (Fig 4.23-4.25), the percentage of hybrids being 50% (MARB), 50% (TROS) and 31% (ROSS). These population samples were generally small.

d. Populations with a preponderance of *Q. petraea* and generally with fewer *Q. robur* and hybrid trees (Fig 4.26-4.29). These populations were the reverse of Category 4a above.

5. Population samples with a high percentage of *Q. petraea* trees and a generally low percentage of hybrid trees, but with no *Q. robur* (Fig 4.30-4.35). This was the second largest category with six populations and is the reverse of Category 3 above. The percentage of hybrids ranged from 7.5% (ROST) to 22.5% (QPND).

Overall, of the 1087 trees recorded, 455 were *Q. robur*, 487 were *Q. petraea* and 145 were thought to have some hybrid ancestry.

B. A comparison with earlier surveys

The results from this survey have been compared to those of the earlier survey in England and Wales (Rushton 1978, 1979) in Table 2. In England and Wales, the populations with *Q. robur* affinities (Categories 1, 2, 3, and 4a above) accounted for about 58% of all sampled populations. In Northern Ireland, these populations were only 37% of the total. However, further differences were evident between these *Q. robur* populations — the hybrid populations (Categories 3 and 4a) accounted for only 14.8% of the England/Wales populations whilst in Northern Ireland they accounted for 25.7%; in England and Wales the pure *Q. robur* populations accounted for 43.7% whilst in Northern Ireland it was only 11.4%. Indeed, the general absence of pure populations, both *Q. robur* and *Q. petraea,* from the results represents a major difference between this and the England/Wales survey.

The *Q. petraea* populations (Categories 4d and 5) were very similar between the two surveys except that no pure *Q. petraea* populations nor populations of pure *Q. petraea* with a small number of *Q. robur* trees were found in Northern Ireland.

A very large difference was evident between the mixed populations which accounted for 25.7% of populations in Northern Ireland but only 5.2% in England/Wales.

The level of populations with hybrids was similar in both areas. In the earlier survey, the level of hybridisation was estimated to be between 7.7% and 12.6% depending on the limits set for hybrid definition. In this survey, the level of hybridisation was 13.3%

Table 2 A comparison of the results of the present survey with those of an earlier survey in England and Wales (Rushton 1978)

Category of Population	England/Wales (Rushton 1978) No. Pops.	%	Northern Ireland (Present Survey) No. Pops.	%
1. Pure *Q. robur*.	50	37.0	2	5.7
2. Pure *Q. robur* with a small number of *Q. petraea* trees.	9	6.7	2	5.7
3. Pure *Q. robur* with a small number of hybrid trees.	5	3.7	4	11.4
4a. Pure *Q. robur* with a small number of *Q. petraea* and hybrid trees.	15	11.1	5	14.3
4b. Mixed populations with more or less equal numbers of *Q. robur* and *Q. petraea* trees, usually with a small number of hybrids.	7	5.2	9	25.7
4c. Populations dominated by hybrids often with a small number of *Q. robur* and *Q. petraea* trees.	8	5.9	3	8.6
4d. Pure *Q. petraea* with a small number of *Q. robur* and hybrid trees.	15	11.1	4	11.4
5. Pure *Q. petraea* with a small number of hybrid trees.	9	6.7	6	17.1
6. Pure *Q. petraea* with a small number of *Q. robur* trees.	7	5.2	0	0.0
7. Pure *Q. petraea*.	10	7.4	0	0.0
TOTAL	135	100.0	35	100.00

(i.e. 145 trees out of 1087). This level of hybridisation is comparable with the England/Wales survey. Unlike the earlier work, there did not appear to be any discernable pattern to the distribution of population types.

Cousens (1965) concluded that in populations of *Q. petraea* in Ireland, there was evidence of past hybridisation but truly intermediate trees accounted for less than 2.0% of the total. It should be pointed out however that this was not a random sample of populations and that populations had been chosen to represent "good" *Q. petraea.*Direct comparisons are not therefore possible. Kelly and Moore (1975) have noted that where *Q. petraea* occurs on limestone near to geological boundaries, hybridisation between the two species is quite frequent.

C. Individual population results

Rea's Wood — REAS

Rea's Wood consisted of a sample of only nine trees, which were identified as eight *Q. robur* and one *Q. petraea* tree. The population is actively colonising part of the Lough Neagh shore-line recently exposed as a result of lowering of the lough. The site is relatively water-logged. The colonising trees appear to be *Q. robur* which is recorded as being more tolerant of water-logging conditions (Jones 1959).

Quoile Pondage — QPND

Quoile Pondage also represents a site where oak is spreading — in this case after the construction of a barrage across a river. Of the 40 trees in the sample, 25 were collected from areas closely adjacent to the BLHS population from which the QPND trees are probably spreading. The profiles of the two populations were very similar — neither population has *Q. robur* trees; the percentage of *Q. petraea* is 77.5% in QPND and 92% in BLHS.

Rossaa, Killesher, and Marble Arch — ROSS, KILL, and MARB

The ROSS and KILL samples are part of a long ribbon of woodland which follows the 90-120m contour around the northern base of the Cuileagh Mountains. MARB, within one km of the KILL sample follows the course of the Cladagh River. The composition of the MARB and ROSS samples is remarkably similar (Fig 4.23 and 4.25); both contain more or less equal proportions of *Q. robur, Q. petraea* and hybrids (Category 4c). However, the KILL sample is very different, being composed of only pure *Q. robur* trees (Fig 4.1, Category 1). Such a mosaic is not unique and similar instances have been recorded, e.g. Wyre Forest (Hickin

1971), and usually the mosaic can be interpreted by reference to underlying soil type, parent rock or drainage pattern. In the case of ROSS, KILL, and MARB the actual reasons remain unknown and warrant further investigation. At MARB, there is a very high number of hybrids. Ash (*Fraxinus excelsior* L.) dominates this wood and this is particularly true of the wetter areas adjacent to the Cladagh River. The oak is confined to the higher slopes in mixture with both ash and beech (*Fagus sylvatica* L.) (Tomlinson 1982). Because of their even size and spacing the oaks are thought to have been planted (Tomlinson 1982). If they are of planted origin, then the large number of hybrids is probably derived not from *in situ* hybridisation but from hybridisation in the original parental population from which the seed was derived. Planting might also account for the very different profiles of the ROSS and KILL populations.

Castle Caldwell — CSCW

This population was collected from the long promontory stretching into Lower Lough Erne between Bleanalung Bay and Castle Bay. The sample was predominantly *Q. petraea*, but with a small number of both hybrids and *Q. robur* trees (Fig 4.26, Category 4d). In this case, careful records were kept of the positions of individual trees. All seven *Q. robur* trees came from the wetter areas, the *Q. petraea* trees from the drier parts and the nine hybrid trees were scattered throughout the wood.

Inishmakill Island — NERN

Tomlinson (1982) records this site as consisting of several kinds of intermixed woods some of which have developed since the lowering of Lower Lough Erne in the 1890s. The vegetation shows a marginal fringe of mixed scrub and alder/ash scrub with both wet and dry oakwoods occurring inland of these. Tomlinson notes that *Q. petraea* occurs to the west of the island in the drier parts. The sample examined in this survey indicated a predominantly *Q. petraea* wood land but with a small number of hybrids and one *Q. robur* tree (Fig 4.29, Category 4d).

Discussion

Although it is not possible to draw firm conclusions concerning the natural distributions of the two oak species and their hybrids in Northern Ireland owing to the extensive removal of natural woodland and its replacement by plantations (McCracken 1971, Tomlinson 1982), it is possible to make some general points.

The supply of samples by the Forest Service, Northern Ireland has undoubtedly influenced the pattern of the results in that many of the populations were from estate plantings or non-natural woodland stands. Many of the populations dominated by *Q. robur* appear to be either estate plantings (e.g. SHCS) or more recent commercial plantings (e.g. SOMS). Conversely, many of the populations of natural or semi-natural status showed *Q. petraea* affinities. Mixed populations predominated in the samples, in contrast to the earlier survey in England and Wales (Rushton 1978), and many of these were also of planted status e.g. POMY and RAND which was planted in 1936 in mixture with Norway Spruce (*Picea abies* (L.) Karst.).

Several factors are important in interpreting these results but two will be examined here — firstly, the history of planting and species preference and secondly the status of *Q. robur* as a native tree in Ireland and the spread of oaks to Ireland from Britain after the last Ice Age. Cousens (1965) provides background information on both these points.

Tree planting in Ireland was not recorded until the 16th century and by the 18th century planting included many exotic species. By the 1820s charcoal smelting had become unprofitable and consequently oak felling was largely suspended. Cousens (1965) argued that the majority of the oak in Ireland today is derived from woodland that was last felled in the early 1800s. Jones (1959) and Gardiner (1974) have noted that, towards 1800, gardeners and foresters were advocating the planting of *Q. robur* in preference to *Q. petraea* as the wood of the former was thought to be superior. Furthermore, the two species differ in their response to acorn storage and shipment. Acorns of *Q. robur* are said to withstand transport and storage much better than those of *Q. petraea* (Jones 1959). The *Q. robur* acorns were also larger, produced in larger numbers and probably produced larger seedlings (Jones 1959) and this led to *Q. robur* being planted in preference to *Q. petraea* in England and other parts of Europe. Cousens (1965) has argued that *Q. petraea* was seldom used for planting. In Ireland, McCracken (1971) notes that various species of oak were available for sowing from the early 1700s. For example, the Royal Dublin Society sponsored plantings and by the 1780s had a species list which included several oak varieties and species including scarlet, turkey, prickly, Turner, Luccombe, American swamp, champagne, black and white oaks. However, McCracken does not mention whether *Q. robur* and *Q. petraea* were separately listed. At about this time, McCracken records nurserymen's lists in Dublin offering various species of oak for sale. Thus, estate planters of the time presumably would have had the choice of *Q. robur* or *Q. petraea* but may have chosen to plant *Q. robur* because of the adverse publicity.

It is almost certain that the purity of the seed available from nurserymen would have been questionable. The reasons for this are related to the taxonomy of the species and also to the remarkable range of variation present within the species. The taxonomy of the two species was also in a state of flux and, although the two species descriptions were well documented, there were still misleading accounts published and mistakes made. Indeed, quite recent accounts of the species have been erroneous e.g. Harris (1927). The range of species variation also would have led to trees being misidentified and even to hybrids being confused with the pure types.

Proof that *Q. robur* was actually planted in preference to *Q. petraea* or, indeed, that planters knew which species they were planting is difficult to establish with certainty. There are instances of *Q. petraea* plantation. For example, Kelly and Moore (1975) have recorded the planting of (presumably) *Q. petraea* in Killarney during the 1800s. One confusing aspect is the practice of "dibbing" or "dibbling" — planting acorns freshly fallen from the trees into their final position (Fitzpatrick 1966, Forbes 1933) which would have led to local consolidation of variation patterns.

Many of the estate plantings sampled here have yielded samples dominated by *Q. robur* e.g. SHCS. However, these usually have a proportion of *Q. petraea* and hybrids as well and, in many instances, the proportion of *Q. petraea* is equal to that of the *Q. robur* trees. Whether these represent contaminants of the original seed source or whether they represent regeneration from existing woodland at the time of planting cannot be ascertained. The hybrids themselves could also represent part of the original plantings or they could reflect hybridisation that has occurred since the plantings were established. The presence of hybrids in more recent plantings e.g. RAND which was planted in 1936, is almost certainly due to contamination of the original seed supply. The RAND plantation also contains 66% *Q. robur* and 32% *Q. petraea* — the conclusion must be that "oak" was planted with little attempt to differentiate the species. Of course, it could be argued that such indiscriminant planting also occurred in the past. The MARB population may represent an example of a substantially hybrid planted population.

No populations have been detected which were composed of only pure *Q. petraea*. All populations with a substantial percentage of *Q. petraea* (i.e. Fig 4.26-4.35) had a small proportion of hybrid trees and, in many instances, a small proportion of *Q. robur* trees as well (Fig 4.26-4.29). Many of the sites on which these woodlands are developed are comparatively wet. In some *Q. petraea* populations in England, *Q. robur* and hybrids have been observed in the wetter areas (Rushton 1979) and it is likely that the *Q. petraea* populations in Northern Ireland with either a small proportion of hybrids or a small proportion of hybrids and *Q. robur* trees may represent similar examples (e.g. Castle Caldwell, CSCW).

The native status of *Q. robur* has recently been argued by Kelly and Kirby (1982). McEvoy (1943) has also concluded that *Q. robur* is native to Ireland and was naturally the main species of the central plain. Other woodland remnants on the siliceous rocks of the periphery of this central area were of *Q. petraea* affinity (Cousens 1965). The majority of the supposed natural or semi-natural woodlands in this survey also showed *Q. petraea* affinities. One of these, the Rostrevor Nature Reserve (ROST) has been described (Tomlinson 1982) as being the successor of the oakwoods that were once extensive over much of Ireland. Tomlinson has argued that, in the case of ROST, the woodland escaped clearance owing to its inaccessible position. Similar examples occur — the Roe Valley (ROEV), Ness Wood (NESS) etc.

The intermediate trees identified in this survey have been interpreted as having a hybrid origin. In the earlier survey of England and Wales (Rushton 1978, 1979) supporting evidence for the hybrid status of these intermediate trees was supplied from pollen viability studies. For the present survey, one population (BREN) has been checked for pollen viability and, although a relatively complex situation was found (Minihan and Rushton, in press), generally the analysis of pollen viability supported the view that the trees with intermediate morphology were of hybrid status. Further, there is strong evidence from the PCA results that many of the samples with hybrids show a distribution of intermediates compatible with that expected from introgressed populations.

Cousens (1965) has argued that there are four recognisable stages in introgression:

1. Establishment of F_1 hybrids and the start of backcrossing;
2. Continued hybridisation and well-advanced introgression;
3. Cessation of hybridisation and continued backcrossing resulting in a gradual assimilation of the "alien" genes;
4. The process of assimilation is complete and only comparison with non-introgressed populations would indicate any evidence of past introgression.

From his observations in Ireland of 12 populations (13 samples, 329 trees) Cousens (1965) concluded that generally the Irish material was in a late phase of Stage 3. Observations of the results for the large majority of the populations with hybrids in the present survey indicate that the hybrids are probably of backcross status and the populations also in Stage 3 above. There are, however, some exceptions. For example, of the nine intermediate trees in Quoile Pondage Nature Reserve (QPND), six were morphologically completely intermediate between *Q. robur* and *Q. petraea* and were probably F_1 hybrids.

In this survey no completely intermediate populations were detected unlike the survey of England and Wales (Rushton 1978, 1979) although Mercer (1967) has described one such population from Co. Wicklow. Kelly and Moore (1975) have noted mixed populations with varying amounts of hybrids where soil enrichment caused by nutrient flushing allows *Q. robur* to become established on siliceous rock. It is felt that in Northern Ireland, mixed populations are more likely to have arisen through plantation rather than spread.

It would appear, therefore, that within the samples there is evidence of both ancient and relatively modern hybridisation between *Q. robur* and *Q. petraea* in Northern Ireland. Furthermore, the extensive presence of *Q. robur* and backcrossed hybrids in natural and semi-natural woodlands is evidence of the native status of *Q. robur* in Ireland. There is also evidence that several woodlands show a mosaic arrangement with *Q. robur* in the wetter and *Q. petraea* in the drier parts.

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Land Classification for Plantation Forestry

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SUMMARY

The purposes of land classification as a basis for deciding land use strategies, and the main approaches to it are discussed, including Land Capability and Land Unit classifications. The problems associated with evaluating the various options for the allocation of land are then described, especially in the context of conflicts between agriculture, forestry, conservation, etc. The various classifications used within forestry are discussed, including those based on site productivity, vegetation, soil, climate and multifactor classifications. In conclusion, some thoughts are given on how conflicts over land use many be reduced and the additional types of assessments which may be required in the future.

INTRODUCTION

Among the many purposes of classifying land are (1) those of providing a basis for rational decisions on its use and (2) having decided the use, of determining more precisely what sort of treatments are needed to manage it effectively on a sustained basis.

Evaluation involves carrying out, bringing together and interpreting basic surveys of such variables as soil, vegetation, climate and other factors in terms that are readily understandable to the user and releveant to the physical, economic and social context of the area concerned (Dent, 1978). Classifications depend upon a good data base. When the use of the land is being considered the information must also be relevant to the requirements of possible alternatives (e.g. forestry, agriculture, conservation and water gathering) as a means of solving land-use conflicts and arriving at an optimum combination of uses. Such evaluations are usually preceded by a recognition of the need for change.

Levels of classification

There are many levels of planning and hence of land evaluation and classification. For example, some global planning is done by international bodies such as FAO. Broad national planning is carried out for developing policies which enable regions to be identified for more detailed study. Much of this type of classification is done using existing maps, aerial photographs and/or satellite imagery. Lower levels lead to the identification of land for potential projects, and a detailed study of the site itself is needed to indicate the fitness of a given type of land for a defined use, either in its present condition or after improvement. This precedes the implementation of the plan, when even more detailed classifications may be needed for management. Classifications are therefore hierarchical, dividing areas into smaller and smaller relatively homogeneous units (Botero, 1981).

For each level, information is required in different degrees of detail. Contributions are needed from the natural sciences, technology of land use and economics, and often from sociology as well. Land classifications for most purposes are often eventually expressed in economic, or socio-economic terms (e.g. an estimate of employment provided) rather than physical ones for comparing land capability. However, they are based on physical criteria because physical boundaries are less susceptible to change (Dent, 1978). Thus, at a national, or regional level many classifications for forestry are based on climate but at the management level many other factors are needed by the users, often including climate, soil, vegetation and topography.

In spite of attempts at standardisation (e.g. FAO, 1976) there is no common recipe for carrying out land resource surveys and classifications since no system could cope with all environmental and socio-economic conditions. Scace (1981) reviews 46 systems of land use classification which "fall far short of the number known to be in use".

Types of classification

Classifications fall broadly into two groups: single factor classification of, for example, soil or climate, and multifactor methods.

Classifications based on single factors (which may be indicative of complexes), have the advantage of being simple to understand and cheap to carry out. They can also be combined quite readily as overlays on maps. If well designed they often work prefectly well: there is no point in complexity for its own sake.

However, the earth operates as a series of interrelated systems within which all components are linked. Integrated multifactor methods may, many feel, more adequately describe biological systems, and help explain how they operate. More objective classifications are often possible by such means and they are seen by many as being the direction for site classifications in the future (e.g. Bevege, 1981; Barnes *et al*, 1982). This does not mean that information-gathering systems about single attributes should be abandoned. They are as necessary for some integrated systems as single factor ones. The skill comes in delineating manageable units.

Land Capability Classifications

A distinction is often made between land *capability* and land *suitability* classifications. Capability refers to broad systems such as arable farming or grazing and is often defined rather vaguely in terms of the limitations which prevent some activities being considered, whereas suitability classifications are for specific crops or systems, such as eucalyptus production or herring fishing. They tend to concentrate upon the more positive features associated with that use (McRae and Burnham, 1981). Neither capability nor suitability classifications reveal any socio-economic information such as farm size or type of land tenure (Scace, 1981).

Capability classifications for agriculture, forestry and wildlife divide the land into a number of ranked categories according to the degree of its physical limitations for that purpose. A large number, including the British Land Use Capability Classification for agriculture (Bibby and Mackney, 1969) are based on the United States Department of Agriculture classifications of the 1930s. Commonly, seven or eight classes of land are recognised, Class I being the best, and a number of sub-classes represent major kinds of limitations on the land. In Britain these may include wetness; various soil limitations such as shallowness or low fertility; steep gradients which make mechanisation difficult; liability to erosion, and climatic limitations.

Canada has probably gone further than most countries in developing capability classifications for specific purposes. About one million square miles accessible from settled regions, have been assessed according to their capability for five resource sectors: forestry (McCormack, 1979); agriculture (CLI, 1965); recreation (CLI, 1969); wildlife, specifically ungulates and water fowl (Perret, 1970) and freshwater bodies have been evaluated for sports and fish (CLI, 1970). The Canada Land Inventory also has a socio-economic Land Classification and an Agroclimatic Classification for delineating climatic zones significant for crop production. The forestry classification is similar in structure to many of the agricultural classifications though details differ. Site index, or yield class, is used for the main classes because it is relatively easy to obtain productivity information of forest crops compared with agricultural systems.

Parametric Classifications

The division of land into a small number of categories in Land Capability Classifications is unavoidably artificial. An alternative approach is to use various soil and site properties (parameters) that are believed to influence yield, combined in a mathematical formula, the so-called parametric approach. Formulae may be additive, multiplicative or more complex and have been discussed by McRae and Burnham (1981). An ideal combination of soil and site properties gains the maximum score with progressively lower scores for poorer land.

Numerous additive systems were devised in Germany during the 1920's and some were (and still are) incorporated into legislation as a basis for land taxation. A multiplicative system is used in California for the same purpose. Helliwell (1967) has devised a multiplicative system for assessing the amenity value of trees based on seven variables. For each variable a unit on a scale of 1 to 4 is applied. The seven figures so derived are multiplied together to give a notional amenity value and this can, in turn, be multiplied by a constant to give a monetary value. The system has been widely used for assessing the contribution made by individual trees to amenity (Helliwell, 1978).

Parametric systems appear objective but their apparent objectivity and precision are illusory. Even the most elaborate systems assume relationships between crop behaviour and soil, site and other parameters that are still very imperfectly understood. That some systems seem to give reasonable results is "a triumph of the ingenuity of the workers who have developed them" (McRae and Burnham, 1981). However, in that some do give apparently reasonable results, theoretical imperfections can occasionally be overlooked. The additive British windthrow hazard classification for forestry (Booth, 1980) is one.

Land Unit Classifications

Capability and Parametric classifications both tend to have restricted objectives in keeping with an organisation's interests or statutory obligations. They have the disadvantage of being independent and relatively non-interactive, and so not particularly useful at some of the higher levels of planning where a framework is required for identifying all actual and potential land uses.

Land Units (or Land Classes) are being increasingly used for such classifications. They are areas of land with similar attributes of landform, soil, climate, hydrology and vegetation in which different uses may be appropriate. Land units can be mapped at a great variety of scales (with appropriate field checking) from satellite images, air photographs and maps and are widely used for providing the framework for investigations in developing countries (LRDC, 1980).

A system based on Land Classes is being used for examining alternative land use strategies in Britain, and was divided by the Institute of Terrestrial Ecology (Smith, 1982). Initially a survey area is divided into one kilometre grid squares and attributes in them are measured from Ordnance Survey, geological and other maps. Each square is allocated to a land class, and the classes are then used as strata for sampling ecological, land use, and land capability characteristics. The mean values of the sampled characteristics are used as a basis for economic or other calculations to produce alternative strategies. The agricultural capability is assessed in terms of the outputs of meat, milk etc., and the forestry capability in terms of yield of timber from each land class. Alternative strategies for agriculture and forestry development are formulated in terms of minimum acceptable levels for meat, timber, etc; the areas in which the present land use is preferred; constraints on the use of certain types of land and the output which is most desired. The land use pattern which gives the maximum amount of the most desired output is calculated using linear programming. These patterns are the alternative strategies.

The Institute of Terrestrial Ecology's Land Class system is proving to be very reliable for identifying rural areas where a change in land use may be appropriate.

Evaluating Options on Land Use

Eventually decisions have to be made about how specific areas of land should be used. In a few cases these present no problems. For example, steep slopes above villages in areas liable to avalanches should have a forest cover, however suitable they may be for other purposes.

In more complex situations land can, in theory, be allocated by the application of an appropriate system of land unit or capability assessment and this is done in many developing areas with low populations. However, where land use has evolved over long periods allocation is more complicated, influenced not only by environmental but also technological, economic, social and political factors. For example disagreement frequently occurs over the transfer of land from agriculture to forestry in Britain (Williams and Harding, 1982). Present policies are vague and, in so far as they exist, often conflict. In the context of conservation, the Ministry of Agriculture spends millions of pounds tempting farmers to drain and plough the countryside, fertilise, remove hedges and use pesticides while the Department of the Environment offers incentives to resist these temptations. Present decisions for allocating land on the market in upland Britain ultimately depend upon consultation and judgement of experienced officials concerned with agriculture, forestry, planning, etc.

It is unfortunate that during a period when the idea of achieving better integration of forestry and agriculture is receiving so much attention that, except on large privately-owned estates, trees are not considered by farmers as an alternative crop in Britain or Ireland. This has arisen because of divisive educational systems, difficulties in obtaining annual returns from trees and, in Britain, the fact that tenant farmers are often constrained from planting.

One possible method of allocation between forestry and agriculture has been developed by Maxwell *et al* (1979). They have described a modelling approach for square blocks of 10 ha (though any other size could be used) in the context of the hills and uplands of Scotland. The basic variables for economic analysis are altitude, soil type, vegetation, existing access and fencing. In order to reduce the number of solutions they applied constraints in allocating agricultural land: (1) it must consist of economically viable units which (2) must be contiguous and (3) agriculture must use land considered unplantable by forestry. The model attempts to minimise fencing and roading by aggregation of blocks selected for agriculture. It examines land allocations based on a range of possible stocking rates. The choice of discount rate is, as always, a problem and considerably influences results. In Britain, the test discount rate can often be as low as three per cent (which in real terms is considered high in relation to private industry). This tends to favour forestry, whereas rates of 5-7 per cent or more favour agriculture (CAS, 1980). Interestingly, and quite contrary to normal experience of foresters, while the more intensive agricultural systems tend to take the best land, the less intensive ones (which use more land), leave the better ground for forestry.

Having decided upon the best allocation by such means, nothing can be achieved unless the money is available for implementation. Investment in forestry is relatively expensive and there has been a noticeable shortage of both government and private money for it in the last few years.

While it is relatively easy to carry out cost/benefit analysis to optimise the use of land for *commercial* activities it is still difficult, if not impossible to link particular benefits with market values for many other uses. These especially include the benefits associated with landscape, nature conservation, jobs provision and other effects for which preferences tend to be established by political or group decisions rather than individual choice (Grayson, 1974). It is, at least, possible to estimate the economic "benefits" which are forgone by not managing areas commercially, or managing them in something less than the optimum way. This has recently been done for various silvicultural systems, in relation to conservation, by Pryor and Lorrain Smith (1982). In some cases serious conflicts arise and necessitate public enquiries and result in extensive "civil disobedience" by protesters.

Classifications for Forestry

Having produced a basis for deciding that land should be used for forestry (and possibly other purposes simultaneously), it is then necessary to carry out various *suitability* classifications. These help in deciding treatments such as species selection, the need for drainage and nutrition and, when converted into economic terms, enable the most desirable options to be selected.

Site productivity classifications (Yield class)

The single most useful classification of land for forestry is its productive potential in terms of the volume of usable timber on a unit area. It is particularly useful where there is existing forest and is expressed either in terms of productivity over a given time or as average annual productivity. Site productivity estimates normally rely on easily measured stand variables (height and age or some other index or growth). In much of the world "site index" is used, (the height a crop achieves at a predetermined age), or as mean annuall increment either at a fixed age or at the age when MAI culminates. The latter is the basis of the "yield class" system used in British forestry (Edwards and Christie, 1981). Such systems are most appropriate to pure, even-aged stands.

There are problems with these, as with other methods of classification. Different species, or even provenances, give different yields on the same site and it appears to be quite common for second rotations to be higher yielding than first. When attributes of unplanted ground have to be evaluated for making decisions, initially about establishment operations and species selection (and productivity) and later about factors such as fertilising, windthrow risk and harvesting, other features must be used as well. Especially within climatically narrow districts, they are made on the basis of features with an integrated character, such as soil and ground vegetatioin.

Ground vegetation

Classifications based on the composition of ground vegetation are common in Europe and in other areas where there is enough natural or semi-natural vegetation (Jahn, 1982). Various indicator plants or plant communities are used to give a guide to productive potential. In Britain and Ireland a system has been widely used as an aid to the selection of species since the time of Anderson's (1950) classical work on the subject.

There is, of course, no causal relationship between, for example, the suitability of a species to a site or rate of tree growth and the composition of the vegetation, but both are to a large extent determined by the same basic variables such as temperature, light, water supply, soil aeration, fertility, etc., none of which can easily be measured in practice. The main problem is that vegetation is often highly complex and difficult to sample objectively.

One of the best known classifications is that of Cajander (1909) in Finland. He classified natural and thinned crops of Scots pine and Norway spruce as well as treeless sites, based on the dominant plant species. He was able to predict site productivity with reasonable certainty and the need for drainage is based on his classification today. Similar systems are used elsewhere in areas of very uniform climate, parent material and land surface. In such circumstances ground vegetation can be a very sensitive indicator of the remaining site variability (Killan, 1981), especially if it has not been too much modified by man's activities.

However in Britain the main classification is based on soil and a consequence is that most foresters are relatively ignorant about the native flora and practical ecology. Such knowledge is especially important in the context of conservation and management of semi-natural woodlands. The lack of it has led to a justified impression among many (e.g. Peterken, 1981) that continental European foresters are more sensitive and sympathetic to the ecosystems they manage than the British.

Soil

Soil classifications are commonly used to indicate the potential of forest sites (Hägglund, 1981) since soils usually express nutrient status, water holding capacity and reflect many aspects of climate and waterlogging or drainage.

Soil is the major attribute for classifying sites for silvicultural purposes in the United Kingdom, with vegetation sometimes being used as a secondary indicator of fertility (e.g. Dickson and Savill, 1974), or drainage status. Soil has appeared more relevant than vegetation for four main reasons:

(1) Many factors affecting productivity and treatment are

direct soil properties or environmental characteristics which influence soil formation (McRae and Burnham, 1981).

(2) A large number of sites have been so extensively modified by agricultural practices and burning, that vegetation is not always a reliable indicator of conditions. This may be particularly true in areas dominated by heather and bracken.

(3) In establishing tree crops, many sites are so modified microclimatically and in terms of drainage, cultivation and nutrition that the pre-existing semi-natural vegetation is profoundly changed, often invaded by luxuriant weeds.

(4) Within a few years of planting the exotic species commonly used, there is virtually no ground vegetation left. Most is shaded out and killed.

Unless nutrient conditions are particularly difficult, as on many peats, soil physical properties are more important than chemical ones for forestry classifications. The British classification, devised by Pyatt (1970) and revised in 1982, forms the basis for the delineation of types of ground for each of which a distinct form of silviculture may be appropriate. From it specifications can be given which aid the selection of species and indicate the need for cultivation, drainage and nutrition. When the exposure of the site has been estimated, it allows the assessment of windthrow hazard (Booth, 1980). Based on the classification, a number of silvicultural guides have been produced for the nine regions of upland Britain (Busby, 1974) within each of which there is a narrow range of lithologic types, a characteristic range of terrain types, soils, climate and growth rates (Toleman and Pyatt, 1974). The classification does not take account of some potentially limiting factors such as the gradient of slopes, ground roughness and occurrence of boulders which are of relevance to harvesting, other uses of machinery and for setting wage rates. For this a separate Terrain Classification (Rowan, 1977) based on similar Scandinavian classifications (Berg, 1981) has been prepared.

Soil classifications such as Pyatt's (1970) place emphasis on the soil properties which influence yield and which, though they may be modified by cultural operations, impose relatively permanent limitations on the use of the soils. These include the status of the natural drainage, available depth for rooting, the presence of compact or cemented layers, the texture and general level of acidity or alkalinity and the occurrence of peat.

Climate

In broad classifications (global, national or general) climate can be one of the best indicators of forest productivity. A knowledge of climatic differences can also be valuable on more local scales, in situations where exotic species are to be introduced. Many climatic classifications have been produced and of those which have focussed specifically on Britain and Ireland most have been reviewed by Gregory (1976). Among the more relevant for forestry and other forms of vegetation growth are those of Tansley (1939), Fairbairn (1968) and that of Gregory (1976) himself who produced a pattern of 15 regional climates based on length of growing season, rainfall magnitude and rainfall seasonality.

Local variations in climate associated with topography are also very important in, for example, recognising frost hollows, sites prone to windthrow and today, sites liable to atmospheric pollution. Climate and, to a lesser extent, soil combine to give progressively more adverse conditions for growth with increasing altitude to the extent that the difference in climate of, for example, Ben Nevis or Snowdon and their adjacent lowlands are at least comparable in range with the more familiar contrasts between the climates of western Ireland and East Anglia, or Cornwall and Caithness (Taylor, 1976). Such differences are recognised in setting economic upper planting limits and we are familiar with classifications of relative "exposure" based on flag tatter (Lines and Howell, 1963) to estimate these limits.

Multifactor classifications

Multiple factor methods of ecological site classification have been used in Germany, other parts of Europe and Canada for over 30 years. They have been very fully discussed in a recent book, edited by G. Jahn (1982). They are based on interrelationships between climate, physiography, soils and vegetation. At the lowest, "site unit" level, appropriate for mapping at 1:10,000, sites have similar silvicultural potential, are prone to similar risks and have similar levels of productivity. They are, in effect, extentions at a lower and more ecological level of the Land Unit Classifications already discussed. These classifications are the basis for silvicultural and most other forms of planning associated with forestry. Proponents of them state that they are faster to use than single factor methods and overlays.

They are usually based on the work of soil scientists or plant sociologists and "are often overcharged with specific academic objectives and do not meet the utilitarian requirements of foresters" (Kreutzer, 1969). They appear to be much more appropriate for use in semi-natural forests than where bare land, or highly modified land, is being planted with exotics (Jahn, 1982).

Discussion and Conclusions

Classifications for determining the value of land for various uses are now reasonably well developed. They differ considerably in the extent to which they consider detail as this depends upon the availability of survey information. In developed countries, with good Ordnance Survey maps and records of geology, soils and climate, besides detailed socio-economic information, sophisticated methods are increasingly being used. At the other extreme, satellite images may be all that is available at the start.

Problems begin to arise in deciding how specific areas should be used and these difficulties are particularly serious in places where land use is fairly intensive and has evolved over long periods. Conflict often arises.

Among the possibilities for resolving some of this conflict are the development of more objective methods for allocation land between agrigulture, forestry, conservation and other uses, of the type being developed by Maxwell, *et al*, (1979). An end to our divisive systems of agricultural and forestry education would also do much to aid understanding and promote integration. Both foresters and farmers are concerned with growing crops. I have never understood why growing trees should be considered so completely different from growing grass, potatoes or cattle that it requires totally separate courses in most universities and colleges. Most of the principles are the same, only the details differ. Also, on rather less certain ground, it might often help if foresters were to become more concerned and involved in planning and decision making at higher levels of land evaluation. They are normally far more interested in the technical and managerial aspects of the work in their own enterprise. This is a failing also noted in American forestry by Stine and Byrne (1982).

At the forest level, classifications vary considerably according, in part, to the intensity and objects of management. Classifications appropriate to one situation are not always in another. For example, S. Hagner (1980), a Swedish silviculturalist stated: "I am suspicious of classifications based on the composition of ground-layer vegetation, for such classifications contain sizeable sources of error. Classifications on the basis of .... factors such as soil mineral characterists or water table demand extensive sampling. I very much doubt that such indicators could be of real practical use".

Classifications which may be needed in the future include the possible identification of sites which need nutrient management. We are moving from the days of correcting gross deficiencies to a period when more subtle information for maintenance of site fertility is required (Ballard, 1980). Ireland, at least, seems also to be moving from imposing standard ground preparation treatments on all sorts of land. If tunnel ploughing and mole drainage, for example, are going to be more widely used it will be necessary to ensure they are used on appropriate sites. We are all too well aware of the dangers of thinning in this part of the world. If the trend towards no-thinning and wider spacing continues, and if we also hope to grow reasonably valuable sawlogs, I am becoming convinced that we shall have to prune trees in the safer areas. We must try to identify these sites better by improving upon existing windthrow hazard classifications. Finally, I have been very impressed in some of the older forests of northern England and southern Scotland at the extent of natural regeneration of Sitka spruce and other species. I believe it could become a normal means of replacing crops on some sites but we need to identify the situations in which it occurs. Most of these comments clearly involve areas of research as much as classification.

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The Effect of Tree Espacement upon Wood Density in Sitka Spruce

(Pices Sitchensis (Bong.) Carr.)

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The influence of planting espacement on the growth and wood properties of Sitka spruce has become a subject of much interest in Ireland. Initial espacement has increased gradually and nowadays plant density is normally about 2000-2500 plants per hectare. Wider planting espacement is attractive because it postpones early thinning and results in bigger poles at first thinning. Wide initial espacement plus fertiliser application has resulted in faster grown Sitka spruce trees. Many foresters are concerned that the wood produced by these trees may be so low in wood density as to make it too weak for many load bearing uses.

This paper describes the effect of initial spacing on wood density and the relationship between ring width and wood density, in a young Sitka spruce plantation.

Materials and Methods

Wood samples were obtained from the Forest and Wildlife Service spacing trial 11/63 at Doneraile Forest, Co. Cork, which was established in 1963 on a gleyed soil. The design of the experiment was a randomised block with four replications and five spacing treatments. The spacings were 1.2m x 1.2m, 1.8m x 1.8m, 2.4m x 2.4m, 3.0m x 3.0m and 3.6m x 3.6m. Each plot was provided with a surround and the treatments were continuous into the surround. The expected yield class of the site is 26. In 1972 the trees planted at 1.2m spacing closed canopy and the trees planted at 2.4m x 2.4m closed canopy in 1975. The trees planted at 3.0m apart have only recently formed a full canopy.

For the purpose of this experiment the Forest and Wildlife Service permitted the felling of a limited number of trees from the surround areas. Sample trees were chosen on the basis of the mean diameter at breast height in the selected spacings. In November 1981, eight sample trees were felled from the surrounds of the 1.2m, 2.4m and 3.0m espacements. Due to the small numbers of trees in the 3.6m plots, it was considered undesirable to fell trees from this espacement. The selected trees ranged in height from 10.2m to 14.8m. After felling, discs approximately 2.0cm wide were removed from each tree at heights corresponding to 3.5%, 15%, 30%, 45%, 60% and 80% of total height. Ring widths were read directly from these by passing each disc, on a graduated moving stage, under the cross hair of a Digital Positiometer. Readings were taken along two diameters at right angles to each other. This gave four readings for each annual ring. The discs were then sawn on a small bandsaw, (kerf width 0.75mm), to give two semi-circular segments and a rectangular section which boxed the pith. From this latter section groups of annual rings were split off for wood density determination. Wood density was determined by the water displacement method of Olesen (1971). Approximately twenty-five measurements were taken per tree.

RESULTS

Mean wood density values per espacement are given in Table 1. Although there appears to be considerable variation within treatments, statistical analysis showed that the mean wood density variance was constant for each treatment. Analysis of variance showed no effect of spacing upon mean wood density.

Table 1: Mean Wood Density (gm/cc) by Spacing

Block No.	Espacement (m)		
	1.2	2.4	3.0
I	0.3321	0.3381	0.3340
II	0.3565	0.3171	0.3326
III	0.3873	0.3191	0.3606
IV	0.3949	0.3580	0.3614
$\overline{X}$	0.3677	0.3331	0.3471

Analysis of Variance

Source	S.S	D.F.	M.S.	F. Ratio
Blocks	0.002807	3	0.000935	
Spacing	0.002425	2	0.001212	4.62
Residual	0.001574	6	0.000262	
Total	0.006806	11		

Tabulated F.05 (1), 2,6=5.14

In view of the manner in which the trees at the various espacements closed canopy, it appeared reasonable to seek differences in mean wood density of the wood in the nine outer rings and below 45% of total height were examined (Table 2). Analysis of variance showed that there were significant differences in the mean density of the wood formed at the various espacements during the period mentioned.

Table 2: Mean Wood Density (gm/cc) in the Nine Outer Rings Below 45% of Total Height.

Block No.	Espacement (m)		
	1.2	2.4	3.0
I	0.3260	0.3066	0.2928
II	0.3348	0.3312	0.2991
III	0.3807	0.3220	0.3291
IV	0.3714	0.2950	0.3285
$\bar{X}$	0.3532	0.3137	0.3124

Analysis of Variance

Source	S.S	D.F.	M.S.	F. Ratio
Blocks	0.002035	3	0.000678	
Spacing	0.004310	2	0.002155	6.45
Residual	0.002004	6	0.000334	
Total	0.008349	11		

Tabulated F.05 (1), 2,6=5.14

A multiple range test showed that the wood formed in the trees spaced at 1.2m was denser than that formed in trees spaced at 2.4m or 3.0m. No significant difference in mean wood density could be found between the trees planted at 2.4m and 3.0m (Table 3).

Table 3: Multiple Range Test for Mean Wood Density in Nine Outer Rings Below 45% of Total Height.

Spacings	Diff.	S.E.	Calculated Q	P.	Tabulated Q
1.2 and 3.0	0.0408	0.00914	4.46	3	4.33
1.2 and 2.4	0.0395	0.00914	4.32	2	3.46
2.4 and 3.0	0.0013	0.00914	0.14	2	3.46

q=0.05

Simple linear regression analysis was used to examine the relationship between ring width and wood density (Table 4). The correlation co-efficient between the two sets of data was — 0.35. This indicated that a weak negative association existed between wood density and ring width.

Table 4: Original Data for Mean Ring Width and Mean Wood Density.

Espacement (m)	Mean Ring Width (mm) per tree	Mean Wood Density (gm/cc) per tree
1.2 x 1.2	3.6051	0.3293
	3.7388	0.3350
	3.4450	0.3870
	3.1471	0.3261
	3.4878	0.3757
	3.7655	0.4142
	3.4736	0.4119
	4.1965	0.3627
2.4 x 2.4	6.1038	0.3532
	5.0741	0.3231
	6.1873	0.3527
	6.3755	0.3633
	6.3758	0.3155
	6.9401	0.3193
	6.8586	0.3279
	6.9116	0.3102
3.0 x 3.0	6.9651	0.3451
	7.4486	0.3760
	7.0633	0.3967
	6.7820	0.3261
	8.1185	0.3236
	7.1758	0.3415
	8.4660	0.3582
	7.2996	0.3096

Discussion

Evidence from the literature suggests that increased planting espacement results in a reduction in wood density (Gardiner and O'Sullivan, 1978: Cown, 1974). Such an effect could not be demonstrated in this study. The sample mean difference in wood density between trees planted at 1.2m and 3.0m spacing was .0206 gm/cc. This indicates a 'fall-off' in wood density of 9.9% at the wider espacement. This is a relatively small reduction in wood density and the number of samples necessary to detect differences of this magnitude have been found to be quite large (Cown, 1974). A similar reduction in density in the wood formed in the lower portions of the stems during the time interval between canopy closure at the narrowest and widest espacements was found to be statistically significant. Thus small reductions in wood density due to spacing probably persist for a short period only. When canopy closure occurs at the wider espacements it seems likely that differences in wood density will even out. It would, therefore, seem that low wood density will not be a critical factor in the degrade of timber grown at initial espacements up to 3m. Other factors which contribute to overall wood quality, such as knot size and the volume of juvenile wood are also adversely influenced by wide espacement. These factors may have a greater influence upon wood utilisation than small reductions in wood density.

Acknowledgements

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The Potential Contribution of Irish State Forests to the Supply of Energy

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Forest and Wildlife Service, Site Productivity and Biomass Section, Crop Structure and Biometrics Section.

SUMMARY

This paper estimates what the energy-supply of a hypothetical conventional State forest of 360,000 ha would be if it were totally composed of Sitka spruce, Yield Class 14 on a rotation of 50 years. The data base is small and results are, therefore, tentative. Nevertheless, it appears that a large forest estate might be able to supply an equivalent amount of energy as used by its potentially dependent forest industries. Whilst the annual supply of energy to the total national budget appears to be modest, the long term contribution would be accumulative because of the renewable nature of the source. It is felt that two aspects should now be examined: (1) the role dry matter might have in the country's forests, as an alternative measure to volume alone and (2) the approach research should adopt in relation to biomass investigations.

INTRODUCTION

When fossil fuel energy is cheap and abundant, the search for alternative sources of power tends to be less active than in periods when it is expensive or scarce. Supply deficits have been experienced on a large scale during the Second World War which produced many innovations to overcome them. Between 1974 and 1982 the world suffered dramatic price increases in crude oil that were followed by the establishment of programmes to create alternative power sources. Ireland has experienced all of these trends and may be on the verge of a period of relatively cheap and abundant fossil fuel, if indications about finds materialise into commercially productive oil wells. Does this mean that research related to renewable power sources will become less important in the near future? Hopefully not. Fossil fuel deposits have a limited life span which renewable sources of energy would help to extend. In the long term future, the world is likely to be forced to shift its dependency from non renewable sources to alternatives as the former are depleted. The sooner this transition is prepared for, the easier will be the changeover.

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Relatively little information is available to describe the contribution that productive forest land could make to the national energy supply under current management techniques. This paper attempts to evaluate the biomass potential of conventional State forests using available data and certain assumptions which are outlined. Sitka spruce (*Picea sitchensis* (Bong.) Carr.), which covers about 50% of State forest land, was used for this evaluation, because more dry weight information exists for this species over a greater range of tree sizes than for any other.

Embraced under the term 'conventional forests' are those that are managed in the traditional way, through silvicultural techniques designed mainly for the production of industrial wood rather than energy.

BASIC DATA

Basic data consisted of individual tree volumes and biomass components which were used to create a series of equations. These were employed, with selected plot data, to obtain biomass and volume on an area basis. Biomass/volume ratios were then worked out and used to convert a selected British Forestry Commission volume yield table to a biomass yield table, on the basis of which yields from a hypothetical forest estate were calculated. Details are given below.

I COMPILED INDIVIDUAL TREE EQUATIONS

Equations that predict dry weight for components of individual trees, based on easy to measure variables like DBH (diameter breast height) and H (total tree height), are widely used. These equations may be local, regional or national. If the regression coefficients of two equations are shown not to be statistically different, then the data may be combined and a new formula drawn up to cover the geographic range of both.

In the case of Ireland, a comparison of this type is thought to be premature for conventional forests, because too few data exist. It was assumed, in this paper, however, that available information could be combined to obtain equations that reflect, to some degree, the biomass of standing Sitka spruce trees within the country. This assumption, and the fact that the samples were not chosen at random from the population, invalidates any statistical measure of error. However, in the absence of adequate data the approach taken here should be seen as a preliminary step in determining the biomass potential of Irish State forests.

Eighteen weighed sample trees were available from previous studies (Carey and O'Brien, 1979, and Carey, 1980). A further 14 trees were selected for biomass determination in order to include a wider variety of site types. Table 1 gives details of stand and site charisteristics of sample tree locations.

Several equations were then created:

(1) Biomass Equations

Five equations were compiled, using the 32 sample trees. The type of equation or model employed is known as 'Schumacher and Hall' in volume table construction and has the following format:

$$\text{Log Ye} = a + b\,(\text{Log DBH}) + c\,(\text{Log H})$$

where: Ye is the estimate of individual tree component biomass
DBH is the diameter at breast height in cm
H is the total height of the tree in m
a, b and c are regression coefficients
Log is Logarithm to base 10.

Equations were compiled for: total overground biomass (TOOG) and component biomass of the complete stem overbark (TOSO); branches-with-needles (TOBN); merchantable stem to a top diameter of 7cm (STMO); and total slash (TOSL). The latter is defined as TOOG less STMO. The regression coefficients are shown below:

Component	Regression Coefficient		
	a	b	c
TOOG	–1.185263	1.897357	0.691947
TOSO	–1.453427	1.708470	1.002647
TOBN	–1.464177	2.375586	–0.070251
STMO	–1.595717	1.851189	0.946490
TOSL	–1.149487	2.046517	0.071603

(2) *An Equation for Estimating Percentage Bark by Weight*, was compiled for stems of Sitka spruce to a top diameter of 7cm over bark.

It is:

$$\text{Ye} = 23.97362 - 0.52344\,(\text{DBH}) + 0.00652\,(\text{DBH})^2$$

where: Percent bark $= 100 \times (\text{Sin}^2\text{Ye})$
DBH = Diameter at breast height (cm)

Table 1: Stand and Site Characteristics of Sample Tree Locations.

Characteristic	Glenmalure	Glen Imaal	Cloosh Valley	Camolin	Curraghmore
Age (years)	33	50	25	46	48
Yield Class (m^3/ha)	14	20	22	12-13	17-18
Density (trees/ha)	3,760	468	2,540	1,075	825
Geology	Mica schist and granite	Granite and shale	Granite	Ordovician shale	Silurian shale
Soil	Peaty gley-blanket peat	Peaty podzol	Brown podzolic	Brown podzolic	Brown podzolic
Elevation (m)	350	250	100	300	180
Mean Annual Rainfall (mm)	2,115	1,225	2,000	860	1,370
Mean Daily Air Temp (^oC)	7.6	8.5	7.7	7.8	9.3
Number of samples	8	10	10	2	2

The equation was derived from 18 trees and they are the same as those used in compiling biomass estimates for Sitka spruce in: Carey and O'Brien, 1979, and Carey, 1980.

(3) Volume Equations

These were compiled using the basic data (32 trees) for the biomass component equations.

They are:

$$Ye(1)=4.265123+1.954895\ (\text{Log DBH})+0.921085\ (\text{Log H})$$

$$Ye(2)=-4.407932+2.099353\ (\text{Log DBH})+0.863421\ (\text{Log H})$$

where: Ye(1) is log of total stem volume overbark
Ye(2) is log of volume overbark to 7cm top diameter

DBH is Diameter breast height (cm)
H is Total tree height (m)
Log is Logarithm to base 10.

II PLOT DATA

The mean yield class for State forests is about 14 m^3/ha/yr, while for Sitka spruce alone, it is close to 16. In this study it was decided to use the overall mean yield class of the country (14) in order to predict roughly the dry weight production of the total forest estate, assuming it was composed wholly of Sitka spruce.

Nine pure Sitka spruce compartments were selected; these were separated in age, by 5 year intervals, beginning at 14 years. The compartments, which were fully stocked, had a yield class of 14 according to inventory data, a minimum area of two hectares and a normal thinning status. They were located in the Wicklow/Wexford area. A point was selected at random on a map of each chosen stand. A circular plot of 0.05ha was established within the plantation in relation to the selected point on the map. All trees were counted and all DBHs equal to 7cm and over were measured. A minimum of 8 trees were sampled for total height, including the two largest DBH trees.

For each plot surveyed the following were used as input data into a computer programme:

(1) the total number of trees greater than or equal to 7cm

(2) the mean basal area of the plot

(3) the DBHs, with the total heights of sampled trees

(4) the biomass-component equations

(5) the volume equations and

(6) a table of bark percentages by stem categories, derived from the bark equation.

The programme calculated the dry matter of the following on a per hectare basis for each plot: total overground, total stem, total branches and needles, stem to 7cm, and the total slash, using the biomass component equations. The weight of merchantable bark per hectare was estimated using the bark table; stem volumes to tip and 7cm were worked out with the volume equations.

For each plot the total stem dry matter per hectare was divided by the estimated volume to 7cm and the resulting factors were used to convert the Yield Class 14 yield table (in Forestry Commission booklet No. 34, Page 131) into a total overground biomass table (Hamilton and Christie, 1971). This was done by multiplying the volume-to-7cm by the factors for the same or next closest year. The result is shown in Table 2.

It was only possible to estimate biomass of thinnings in one case and this was shown to have the same proportion of total dry matter/volume to 7cm as the standing volume. Based on this it is assumed that all thinnings and standing volumes have the same proportions for any selected year.

Yield per hectare, for selected components, was estimated by multiplying the total overground biomass (Table 2) by the appropriate percentage weight as found in the plots. These weights were then converted to tonnes of oil equivalent (TOE) to calculate total forest energy yield (Table 3). A conversion factor of 0.37 TOE/tonne of dry matter was assumed (Lunny, F. 1981. Personal communication. National Board for Science and Technology).

Potential Biomass Yields from Fully Productive State Forests

If the Forest and Wildlife Service (FWS) continue to plant at the rate of 6,000 to 8,000 hectares per year, the total area of productive State forest will exceed 360,000 hectares by the early 1990s. Based on Table 3 and assuming an average planting programme of 7,200 ha, we have estimated the energy flows from a fully productive estate of this size (i.e. one which has reached maximum sustainable yield; Figure 1). The study assumes a coniferous forest of Sitka spruce on a rotation of 50 years, yielding an average of about 14 cubic metres of commercial wood or 7.1 tonnes of total overground dry matter per hectare per year. It would, in theory, be permissible to remove 0.94 (MTOE) in perpertuity, from the forest estate of which total residues would constitute about 46% (0.43 MTOE).

Table 2: Total Overground Dry Matter (TOOG) Production for Yield Class 14 Sitka spruce.

Age	Main Crop after Thinning					Yield from thinnings			Cumulative Production		MAI	Age
	Top Ht.	Mean Diam	Basal Area	TOOG	No. Trees	Mean Diam	TOOG	No. Trees	Basal Area	TOOG	TOOG	
yrs.	m	cm	m^2	tonnes		cm	tonnes		m^2	tonnes	tonnes	yrs.
15	6.2	8.3	18.0	27.7	3331	—	—	—	18.0	27.7	1.8	15
20	8.8	10.6	23.7	51.4	2681	12.5	19.2	650	31.7	70.6	3.5	20
25	11.5	13.0	23.9	70.4	1809	12.8	31.7	872	43.2	121.3	4.9	25
30	14.3	16.1	26.3	100.0	1299	14.0	30.8	510	53.4	181.7	6.1	30
35	16.9	19.4	29.0	126.6	982	16.0	28.6	317	62.5	236.9	6.8	35
40	19.3	22.6	31.2	147.8	780	18.6	26.4	202	70.2	284.5	7.1	40
45	21.5	25.6	32.8	173.3	639	21.3	26.1	141	76.8	336.1	7.5	45
50	23.4	28.3	34.2	170.9	545	23.8	20.7	94	82.4	354.4	7.1	50
55	24.9	30.7	35.6	191.3	483	26.0	17.6	62	87.2	392.4	7.1	55

Table 3. Yield of Selected Components in Tonnes of Oil Equivalent (TOE)/ha for Sitka spruce, Yield Class 14, on a Rotation of 50 Years.

TOOG: Total overground dry matter (DM)
STMO: DM of merchantable stem to top diameter 7cm overbark
STMU: DM of merchantable stem to top diameter 7cm underbark
TOSL: TOOG less STMO.

TOE/ha removed

Age	TOOG	STMO	STMU	TOSL	Merch. Bark
20	7.1	4.2	3.8	2.9	.4
25	11.7	7.1	6.5	4.6	.6
30	11.4	7.3	6.7	4.1	.6
35	10.6	7.0	6.5	3.6	.5
40	9.8	6.9	6.4	2.9	.5
45	9.7	7.0	6.5	2.7	.5
50	70.9	53.2	50.3	17.7	2.8

Assumption: There are 0.37 TOE/tonne of dry matter.

Table 2 indicates that mean annual biomass increment would culminate at 45 years, whereas the British Forestry Commission yield tables for yield class 14 show that volume increment reaches a maximum after 50 years (Hamilton and Christie, 1971). The discrepancy is somewhat suspect. It may be due to a tendency of the original equations to underestimate the total biomass of the older selected plots. It was decided to use the more conservative estimate of 7.1 t/ha/year of overground material with a rotation of 50 years, which is closer to the volume rotation of maximum mean annual increment. This production appears reasonable when compared to other estimates made for conifers on peatlands (McCarthy and Keogh, in press).

The total potential residues (0.43 MTOE) made up of slash and bark from all thinnings and the clearfell, and residues from industrial production, would amount to 2% of the projected primary energy demand of the Republic for the year 2000 (i.e. 18 MTOE; Kavanagh and Brady, 1980). By this time the FWS estate should be approaching normality. Clearly, only the satisfaction of a small part of the national annual primary energy demand is possible from the conventional forest. But as national energy consumption is likely to fluctuate in the foreseeable future, it is somewhat misleading to compare a fixed annual output with an ever changing demand. It may be more fruitful to consider that part of the country's energy budget the conventional forest could satisfy constantly.

In Figure 1, the amount of energy consumed by the forest industry is calculated at 0.37 MTOE. This is based on the assumption that the total raw material calculated to be available (0.77 MTOE) requires the same proportion of energy in conversion as the industries of the ECE region of the mid 70s (Prins 1979) and that the structure of the industries are alike. If all available residues from industrial conversion were used (0.11 MTOE), it would be necessary to obtain a further 0.26 MTOE in order to satisfy the demands of the industries. This could, in theory, be obtained from the forest residues (thinnings, clearfell and bark: total 0.32 MTOE), leaving a surplus of 0.06 MTOE. In other words 81% of the forest residues would need to be extracted: the feasibility of doing this would depend on site fertility levels and terrain, as well as financial considerations.

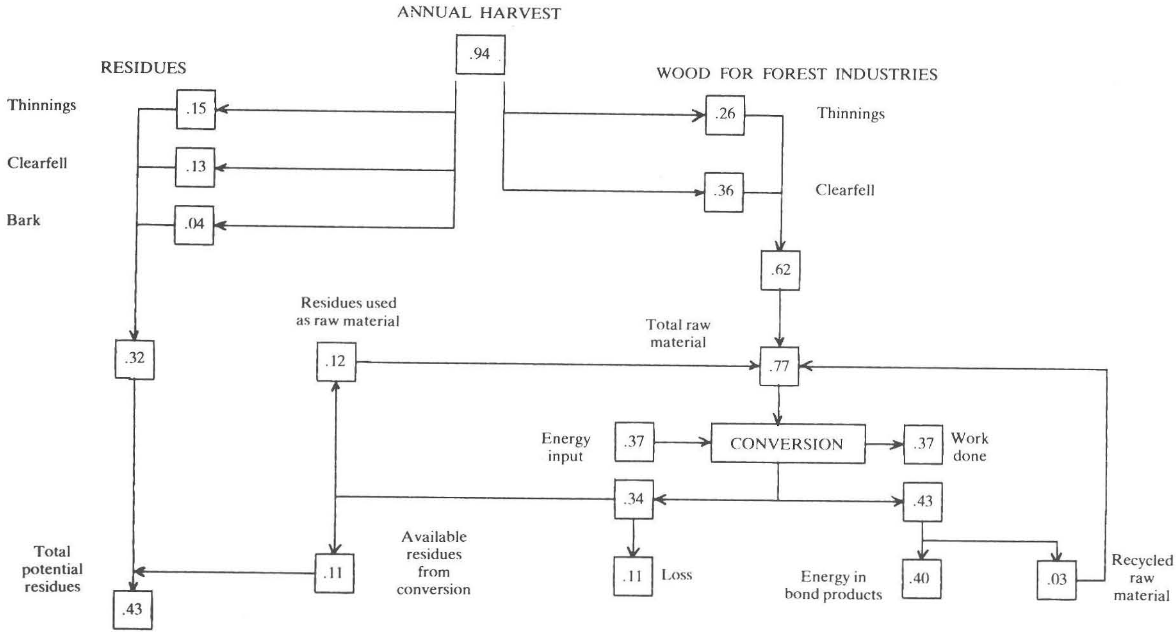
In summary: it seems that it might be possible to supply in perpetuity, from the forest base, irrespective of its size, an amount of energy equal to that consumed by the potentially dependent forest industries, assuming that they have a like structure and similar efficiencies as those of the ECE region during the mid 70s. While the potential yields from conventional State forests seem modest compared to the total annual primary energy demand for the Republic at the beginning of the next century, they are not insignificant when considered over long periods. In an interval of 30 years, an industry consuming 0.37 MTOE/year would use up the equivalent of a small oilfield of 70 million barrels. An oilfield of this size, producing 50,000 barrels per day, would provide 50% of Ireland's oil requirements for about 4 years.

Discussion

It has been pointed out that the amount of forest biomass data, originating from conventional forests in this country is small. These have been used to compile equations and make estimates of standing biomass that should reflect, to some degree, the potential energy production of Irish State forests. However, it is clear from the exercise that extra data are needed if more reliable predictions are to be made.

We feel it is time to re-evaluate the role dry matter might have in the management of the conventional forest and the approach research should adopt to produce the necessary basic information.

Figure 1: Potential Overground Harvest per Year from a Conventional Forest Estate of 360,000 hectares of Sitka spruce, Yield Class 14, on a Rotation of 50 years.



Figures are in millions of tonnes of oil equivalent (MTOE).

Dry weight provides not only a measure of potential energy within trees or stands but may be employed to evaluate the nutrient balances of forest ecosystems or enhance understanding of crop responses to silvicultural treatments in a better way than volume alone. A total crop assessment is possible with dry matter, whereas volume is confined to the stem because of the impracticability of measuring the volumes of branches, leaves and other parts of the tree. On the other hand it is relatively expensive to obtain basic dry matter values for individual trees.

It would be worthwhile to attempt to construct national or regional equations for the major species with the objective of compiling biomass yield tables. These tables would enable inventories and forecasts to be constructed on a weight basis which would provide necessary data for planning the utilisation of forest residues. They would also allow crop nutrient balances to be drawn up to identify stands which would be in danger of excessive nutrient depletion if residues were harvested.

From dry matter yield tables, it would be possible to obtain a more accurate estimate of the potential sustainable production of primary energy from the forest estate, than is now available. This production we think, should be seen in terms of satisfying a definable part of the nation's energy demands and suggest that the amount of energy used by the potentially dependent forest industry could be a guide. The next step would be to explore the feasibility of extracting and converting the residues. In this context, it might be worth concentrating research on assessing whether or not it would be possible to supply energy directly to the forest industries. In order to accomplish this it would be necessary to formulate co-operative projects, involving both the forestry and engineering professions.

The approach suggested would lead to a greater efficiency in the exploitation of the State forest resource and may produce an almost self-sufficient forest industrial sector in terms of energy and raw material supply. The industry should, in turn, be able to provide the country with much of its industrial wood needs for the forseeable future.

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Society Activities

SOCIETY OF IRISH FORESTERS TOUR

24th-26th May, 1983

SOUTH WICKLOW — NORTH WEXFORD

President: N. O'Carroll.

Conveners: J. O'Driscoll and M. O'Brien.

In his opening remarks, N. O'Carroll (President), commented that this was the 41st Annual Study Tour by the Society and he was pleased that this outing of the Society was still going strong. On the first day stops were planned for Coolgreaney, Gorey and Camolin forests.

At Coolgreaney Forest the party was met by M. Sheridan (Divisional Inspector), C. O'Driscoll (Forester-in-Charge), and P. Noonan (Forester). Members viewed and discussed the future of a stand of sessile oak which had been planted in 1840. It was described as being of low yield class (4) but this may be misleading due to selective felling at an earlier stage. Most people agreed that the crop should be retained for some time and that it would put on valuable increment. Arising from this discussion there appears to be a need for a definite policy relating to the proportion of hardwoods to be planted in the future and the treatment of such crops in general. In the same forest the party visited the first stand of Sitka spruce (p 1959, YC 16) to be line-thinned in Ireland. One line in three was removed in 1970 and selection thinnings were removed in 1977 and 1982. It is proposed to thin once more and then clear-fell. The crop has not been pruned and was described as being rough. It was suggested and refuted that there may be a premium of 10% for high pruned crops. A general discussion developed in relation to damage to crops during harvesting operations. Participants identified root damage by large machines and rot due to harvesting by horses as being prime causes of timber loss.

G. Murphy (F.I.C.) and A. Grehan (Forester) welcomed the tour party to Gorey forest where M. Carey (Research Branch) has established a fertiliser trial in a 24 year old ash stand. The soil was described as wet and heavy. Some concern has been expressed as to the quantity of ash in the country. We were informed that there are 6827 hectares of this species, much of which is in private ownership. The ash trees have responded well to fertiliser treatment and there has been a big increase in foliar phosphorus content. However, it was remarked that the crowns were cramped and that the stand should be thinned. The most important facts to emerge from the visit to this stand was probably our collective ignorance of the silvicultural treatment of ash. Since such a substantial proportion of the ash stands in the country are privately owned there appears to be a good case for co-operation between the Forest and Wildlife Service and private growers to investigate the growing of this important commercial species.

After a pleasant lunch at Camolin Nursery, V. O'Connor (District Inspector) and I. Booth (Assistant District Inspector) conducted the party to a variety of sites in the forest. A. Pfeifer (Research Branch) discoursed on the tree breeding programme and on seed production in a lodgepole pine orchard. It transpired that the Forest and Wildlife Service is now self-sufficient in lodgepole pine seed and that approximately 30% of this seed now comes from seed orchards. The potential genetic gain from such seed is estimated to be 25%. This gain will be greatly increased following progeny testing.

J. O'Dowd demonstrated the procedure involved in controlled pollination. There followed a discussion on the possibility of Monterey pine becoming an important commercial species in Ireland. The opinion was expressed that establishment problems experienced with this species can be overcome by using containerised planting stock. Yellowing may be somewhat more difficult to overcome but a selection process is being undertaken in an attempt to produce stock which does not exhibit this defect. It seems that plants grown from seed collected in Ireland give a high proportion of trees which do not exhibit yellowing. If these problems can be overcome, it appears that Monterey pine may become an important commercial species suitable for planting in sheltered areas and on a range of site types in Ireland.

Society members were next taken to a site where Douglas fir (Yield Class 14, Age 61) and pedunculate oak (Yield Class 4, Age 111) were growing side by side. Local management made the point that the Douglas fir, managed for pole production, would yield two rotations of 900 poles and a gross revenue of £50,000/ha. Over the same period the oak, which was of poor quality, would give a total volume of 500m^3 and a gross revenue of £10,000/ha. Most participants were of the view that the oak should be clearfelled. Majority opinion was that the site should be replanted with oak but with an emphasis on quality of seed, planting and silviculture.

Because of a reduced planting programme and increased espacement at establishment most Forest and Wildlife Service Nurseries have surplus acreage for nursery stock production. Such ground in Camolin is given over to noble fir Christmas tree production at one meter spacing. Mr. J. Brosnan (Utilisation) stated that noble fir is rapidly replacing Norway spruce as the Christmas tree. However, as with decorative foliage production, the silvicultural regime under which these trees are produced is critical. Espacement, rate of growth and colour are important factors in determining the quality of both trees and foliage although there are indications that colour in noble fir may be genetically controlled. Trees of the blue variety are being selected by Forest and Wildlife Service staff in order to initiate a breeding programme. An alternative species for these markets may be Caucasian fir. The prospects for greater use of this latter species are currently being examined.

At Bunclody forest on the second morning, local management staff including S. Quinn (Divisional Inspector), V. O'Connor (District Inspector), M. Swords (Forester-in-Charge) and M. Conway (Forester) showed the party some unthinned crops of lodgepole pine. These crops are quite unstable and are to be clear-felled. The discussion centered around a replacement species and this was clearly answered at the next stop where we saw some excellent Sitka spruce on the same soil type. Die-back and unthriftiness in some lodgepole pine plantations is causing concern at the present time. Some crops have become seriously defoliated and are stagnating. D. Ward (Research Branch) stated that a possible causitive organism was *Ramichloridium*, a fungus isolated from similarly infected trees in Scotland. D. O'Brien explained to the group that the optimum clear-felling date for these depends on the performance of both the existing and successor crops.

In the afternoon the group was welcomed to Deacon's Sawmill (Ballon) by Mr. J. McNamara and Mr. Deacon. A long discussion developed concerning the merits of Irish timber, the export market for sawn produce, residue disposal and the drying of lumber. All present were impressed with the efficiency of the mill and the commitment of the management to Irish forestry.

Mr. Moran (Forester-in-Charge) welcomed the party to Shillelagh forest where E. Hendrick presented details of an experiment designed to elucidate various problems associated with reafforestation. The experiment is only three years in existence, but the indications at present are that cultivation of acid brown earths is of no great advantage. Clearing of brash removes substantial quantities of nutrients from the site. The most striking feature of the experiment is the reduction of height growth in areas where lop and top has been cleared. Another notable feature is the profuse growth of *Ulex galii* in the cleared plots.

The morning of the third day was spent at Tinahely nursery where T. O'Brien (District Inspector), J. Neilan (Forester-in-Charge), P. O'Halloran (Forester) and K. Donnelan (Forester) showed the party some of the excellent development work which is being undertaken in nursery practice. Great interest was expressed in the precision sowing of pelleted seed. This system has not yet been perfected, but may be viable if high quality seed is used. G. de Britt (Nursery) informed the group that there is now a significant demand for larger plants for reafforestation purposes. D. McCarthy (Research Branch) outlined details of a soil survey carried out in Forest and Wildlife Service nurseries. This survey indicated that the pH of nursery soils may be decreasing and that while the levels of most nutrients may be slightly low in most nurseries, the deficiency of phosphorus in most nursery soils gives some cause for concern. In view of the low pH values of most nursery soils there may be a case for switching from soluble phosphatic fertilisers to G.R.P. A. Pfeifer (Research Branch) demonstrated the effect of side pruning, undercutting and wrenching upon plant root morphology and gave a very impressive demonstration of container systems and planting tools. E. Hendrick (Research Branch) commented that survival and performance of containerised plants in the field was quite high after three growing seasons. However, bigger containers appear to give the best results and survival of plants grown in plastic bullets is quite low. Finally, D. Ward (Research Branch) and D. Dunne (An Foras Talunais) described the disease cycle of *Phytophythora cinnamomi* and the necessity for a phytosanitary policy.

At Rathangan forest the tour party was joined by S. Quinn (Divisional Inspector), P. Doody (Forester) and S. Maguire (Divisional Engineer). The construction of a reversal road was viewed and discussed. This type of road construction is usually adopted where the removal of peat would create a drainage problem or where large spoil heaps along road sides render extraction difficult. To facilitate this type of construction a tree clearance of 15.5 metres is necessary to give a formation width of 5.5 metres and a depth of fill of 700mm. The average cost is about £12/metre. The average cost of ordinary road construction would be greatly in excess of this. However, reversal road cannot ordinarily be constructed where depth of peat exceeds 2 metres.

The final stop on the tour was at Avoca forest where C. Doyle (Forester-in-Charge) and T. Lynch (Research Branch) demonstrated the effect of thinning intensity upon general crop growth. This experiment has demonstrated that heavy thinning, (removing approx. 80% of Yield Class), increased diameter growth, shortens the rotation length by about 10 years, produced more timber in the large sawlog category and gives a volume loss of 40-60m^3/ha. Economic analysis shows heavy thinning to be more profitable.

Tour Participants

N. Browner, L. Collon, E. Collon (Mrs.), T. Cormican, M. Cosgrave, M. Cosgrave (Mrs.), A. Finnerty, J. Gardiner, G. Hipwell, D. McAree, D. Mangan, L. Moloney, M. Newman, N. O'Carroll, J. O'Driscoll, J. Phillips, R. Tottenham, J. Tottenham, T. Boland, I. Booth, J. Brady, J. Brosnan, M. Davoren, M. Donnellan, M. Doyle, P. Drea, J. Fennessy, J. Finlay, G. Gallagher, E. Griffin, P. Helbert, E. Hendrick, P. Howell, R. Jack, R. Keogh, J. Kilbride, T. Lynch, D. McCarthy, M. MacSiurtain, O. V. Mooney, D. O'Brien, M. O'Brien, J. O'Connor, C. O'Donovan, J. O'Dowd, J. O'Driscoll, T. O'Regan, J. O'Sullivan, T. Purcell, S. Quinn, A. van der Wel, M. Carey, P. Doolan, G. Murphy, T. O'Brien, J. Fanning, P. O'Donoghue.

Book Reviews

FOREST PRODUCTS AND WOOD SCIENCE

John H. Haygreen and Jim L. Bowyer. Publishers: The Iowa State University Press/Ames. Price: $24.95.

This book was written primarily for students who intend to pursue careers in wood science or forest products and to provide an appropriate introduction to wood products for students of materials science.

Part 1 introduces the nature of wood and the trees that produce them. Growth processes are presented only conceptually, but have sufficient clarity for student appreciation. The structural features of wood are well covered, but no attempt is made at wood identification.

In Part 2 the physical characteristics of wood are dealt with. Wood density is considered to be most important. The measurement of wood density and its relationship to other physical properties is emphasised. A unique feature of the book appearing in this is the discussion of the influence of forest management and silvicultural practices upon wood properties.

Part 3 provides an outline of the manufacturing processes involved in producing major wood products. the emphasis is mainly upon the quality of the wood raw material and the yield and quality of the products.

The last section of the book provides a resume of some of the changes in use of the world's wood resources. The use of wood for energy, technological development, and fuel is discussed and evaluated. The appendices give useful data on wood in relation to moisture, decay resistance and mechanical properties.

The book is written in a lucid style which makes it eminently suitable as a reference text for students. It is extremely well illustrated throughout and this makes much of the text self-explanatory. However, in some sections this is over-simplified and may be of limited value to students who already have some knowledge of wood structure, e.g. the section on the struture of softwoods makes only a fleeting reference to crossfield pitting although these structures are frequently critical for wood identification. Similarly, pulping processes are dealt with in a fairly superficial manner and Part 3 in general may be of limited value to forestry students. For students in Ireland the data supplied in the chapter on Wood for Energy have little relevance, but the values and ideas presented are not without substance.

As a standard reference text for students in the fields mentioned and those with no previous knowledge of wood science this book presents a wealth of technical information about wood and its products.

For those students who are anxious to avoid detailed descriptions and technical jargon, the book provides an excellent introduction to forest products and wood science. Those who wish to extend their knowledge of the subject material will find a comprehensive list of references to aid them at the end of each chapter.

THE USE OF HERBICIDES IN THE FOREST—1983

J. S. P. Sale, P. M. Tabbush and P. B. Lane, Forestry Commission Booklet 51. U.K. Price £1.50.

In 1979 the Forestry Commission produced its booklet, "The Use of Chemicals in the Forestry Commission". This contained a section on forest herbicides. This present booklet is designed as a successor to that forest herbicide section. Because of the rapid evolution of herbicides, equipment and methods of application, books on this subject usually become out-dated within a year or two of publication. However, the text of this booklet is held in computer files and it is intended to revise and re-issue it as frequently as necessary.

The layout of the booklet is given in the List of Contents. Sections 3 to 8 cover the main weed types, including grasses, bracken, heather, gorse, broom and broadleaved weeds. In addition, each section contains a broad description of the main problems encountered, followed by a list of recommended herbicides. Herbicide entries are set out in a standard format which gives properties, toxicity, crop tolerance, application rates, timing and limitations. Sections 9 to 11 deal with safety precautions, safe working methods and protective clothing. The introducion issues a warning that all herbicides are poisonous to some degree or other. As a result there is considerable emphasis throughout the booklet on safety precautions, both in the application of the chemicals and in the disposal of surplus.

Although this publication is produced primarily for Forestry Commision staff much of the material should be relevant under Irish conditions and the booklet will be an important reference source for all foresters who have responsibility for the use of chemicals as an aid to forest management.

J.G.

OTHER PUBLICATIONS RECEIVED

Forestry Commission Leaflet 82. *Assessment of Wildlife Damage in Forests.* Melville, Lee and Rennolls. 1983. Price £1.15.

Forestry Commission Booklet 52. *The Use of Chemicals (Other than Herbicides) in Forest and Nursery.* Edited by O. N. Blatchford. 1983. Price £1.50.

Forestry Commission Leaflet 12. *Taxation of Woodlands.* 1983. Price £1.00.

Forestry Commission Booklet 50. *A Key to Eucalypts in Britain and Ireland.* Brooker. *With Notes on Growing Eucalypts in Britain.* Evans. 1983. Price £2.00.

Calender. Trees for All Seasons. 1984. Price £1.75.

OBITUARY

Tom Hayes (1931-1982)

Tom was a native of Ardura, Ballydehob, Co. Cork. He began his formal education at Kilcoe Primary School. He studied at the Albert College at the beginning of the fifties. After completing his training in Avondale he served in Foxford, Cappoquin and Killarney forests. He became Forester-in-Charge at Castlegregory forest. After coming to Kerry he met and married Eileen. His seven children were born in Kerry, his adopted county, whose mountains he loved. He moved to Killorglin forest in the early sixties and set up house in Cromane, near the sea. He was well known throughout Kerry as a most diligent, competent and popular forest manager. He imbued those with whom he came into contact with a great love of nature and of the rural environment. He was a member of the Society and participated in its study tours. He promoted and acted as leader of forest walks in Killorglin forest.

His activities outside of his profession showed a tremendous concern for the welfare of people both socially and economically. He was deeply involved in Muintir na Tire and was County Chairman for some years. He believed firmly in the ideals laid down by Canon Hayes. Tom was a founder member of the local Credit Union and worked unstintingly for it for many years. He was a strong advocate of the principle of self help within a community, to improve living conditions. His strong views on the "work ethic" were evidenced by the amount of hard work he put into his profession and into his gardening activities. He was a very practical man. Once he became involved in a Community Project, and this was always in the role of leader, he persevered through all difficulties to see it through to fruition.

A story I heard, which happened in the local Primary School, exemplified how the local community in Cromane perceived Tom Hayes. A child was asked "who built the local coast-guard station" (which is nearly one hundred years old). The answer was "Tom Hayes".

He was active in his church as a fund raiser and served on the Parish Council. Indeed it was in giving the lead in attempting to put out a fire in the church, that he was suddenly called away from us. This trait of taking quick, positive action was typical of the man. He would never shirk duty, or hold back, but would give his all. Whatever the situation he would "take the bull by the horns".

Above all else Tom was a great family man, fully committed to make sacrifices to get the best for his children. He had been present at the graduation of his two eldest children some months before he died. He was very proud that his second son was doing Forestry in U.C.D. and now a third son has begun his first year and hopes to pursue Forestry.

It is very difficult to write an adequate appreciation of Tom without using some of the over used cliches. He was a loving but firm father, and a loyal, dedicated husband, complementing his wife Eileen in many ways.

On a personal note I valued his friendship and the friendship of his family. To have known him was a privilaged and enriching experience.

The loss to Eileen and his children cannot be measured. May God help them to bear their sorrow.

T.N.

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