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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. 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 SI system (Système International d'Unités) should be used throughout.

5. References should be in the following form:

O'Carroll, N. 1972. Chemical weed control and its effect on the response to potassium fertilisation. Irish For. 29:20-31.

Dickson, D. A. and P. S. Saville. 1974. Early growth of *Picea sitchensis* on deep oligotrophic peat in Northern Ireland. Forestry 47:57-88.

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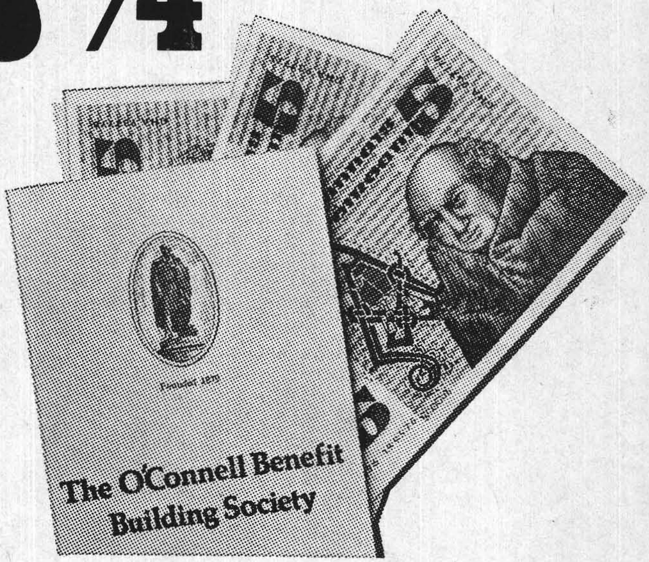

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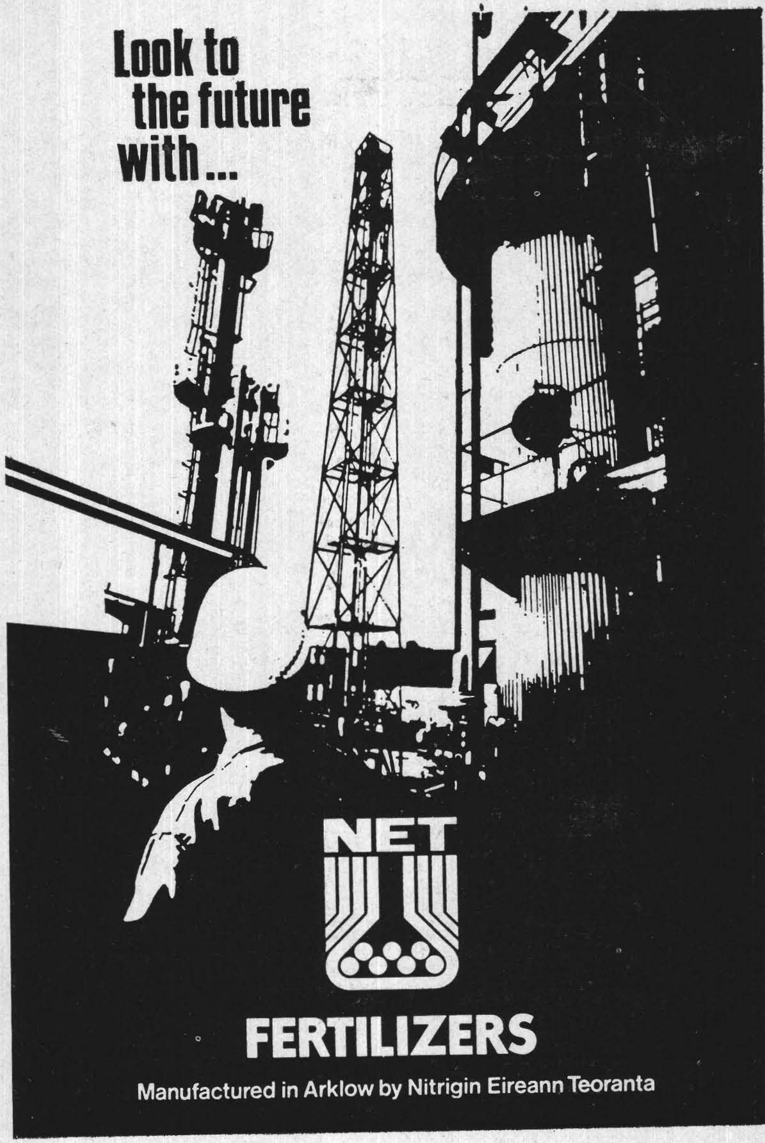
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Society of Irish Foresters

IRISH FORESTRY

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EDITORIAL

A Man Upstanding in his Field

Whereas a lecture provides an opportunity for the lecturer to propound his views and direct them at a passive and sometimes captive audience, a discussion is by definition an open forum in which an exchange of views takes place. Discussions are a feature of meetings of this society, both indoor and outdoor. These discussion periods are designed to provide an opportunity for such an exchange to take place, so that those who form the body of the meeting assume, if they choose, the role of participants at the meeting, rather than that of passive listeners.

The discussion period during a well attended meeting of the society has tremendous potential for a valuable exchange of views. Each member of the group has his own distinct background and years of experience in forestry, which no one man in half a dozen lifetimes could hope to match. Each has his own perspective on reality. Sadly, the potential for discussion is rarely realised. The same faces keep popping up. If a research worker presents a paper, another research worker asks the questions. Very often he might as well be questioning himself (not a bad thing to do), such is the similarity of background and research experience. The questions and answers they draw from the speaker may enlighten the audience somewhat, but the really valuable discussion lies in the comments and the questions of those with a quite different perspective on the topic—in the case of a research presentation, the man in the field who observes phenomena not at a laboratory bench, nor in computer printout, but in the forest, every working day.

The specialist has the advantage. He has access to more information in his area of specialisation than the manager can ever have. But this does not make him a defender of the faith, a guardian of truth. He is in touch with his subject, but his view of reality may become rather distorted, if, in his efforts to keep his ear close to the ground, his head becomes buried in the sand.

Before You Go Any Further

please read this

DO YOU HAVE SOMETHING TO SAY ABOUT FORESTRY, ANY ASPECT OF FORESTRY? If you do, why not say it in the pages of *Irish Forestry?* If you have something interesting to report, a fearsome new insect on your pole-stage Sitka spruce, an unusual incidence of frost damage, an observation on the attitude of visitors towards the recreational facilities in your forest . . . why not let us know about it in *Irish Forestry*?

It is the editorial policy of the journal to publish matters of interest to foresters in Ireland. So, if you the reader have something which you find interesting, then perhaps other readers would be interested too. Don't be worrying about whether or not it's worth publishing ("What if my phenomenon is common knowledge to everyone else?"). Trust your friendly editor. He'll keep the awful secret to himself. There are, after all, two things an editor can do with material he receives. One is to publish . . . .

The procedure for submitting news items, observations, letters to the editor and articles of general forestry interest is simple. Send a single, typed or clearly written copy of what you have to say to the editor. Support it, if you wish, with a letter explaining the background to the material, or why you feel it should be of interest to readers (if this is not self-evident). Leave the rest to the editor. The criterion for acceptance will be interest to readers, bearing in mind the responsibility of the editor to produce a journal with the correct balance between all its elements.

Scientific papers have always been welcomed by the journal. They are, indeed, the essence of the journal and all submissions pertaining to forestry will be considered, whether original research contributions, or reviews dealing with forestry research or development in their widest aspects. Contributions may be submitted from any country, provided they are written in English and that the paper has not been published, nor is presently being offered for publication, elsewhere. Criteria for acceptance will be the standard of the research work and its presentation, and interest to readers. Notes for the assistance of contributors of scientific papers can be found inside the front cover of this and future issues of the journal.

Sitka Spruce in Ireland

PROCEEDINGS OF SYMPOSIUM

On Friday, 11th March, 1977, a symposium organised by the society was held at University College Dublin, Belfield. Six invited papers were presented with discussion. This issue of the journal is devoted to the proceedings of the symposium.

PRESIDENT'S ADDRESS

FELLOW members of the Society of Irish Foresters. Today, we re-discover the symposium. I say "re-discover" because the symposium used to be a prominent feature of Society Activities some fifteen years ago.

The theme of our symposium is Sitka spruce in Ireland. No other tree species has had the same impact on forestry in this island. In species it has risen from a negligable percentage a rotation ago, to become the major single species in afforestation today. Indeed, its importance in general selection is such that if Sitka is selected without any knowledge of the site. the choice is correct, on average, two times out of three.

To set the scene we have two papers; one on the origin and genetic variation of the species and the other on its distribution and productivity in this island. This will be followed by an appraisal of Sitka spruce in relation to insect pests and pathogens. Since much of the land currently used for afforestation is of relatively low fertility we also examine the role of nutrition in regard to the species. This brings us to the real purpose of timber growing; the utilisation of the produce.

Members will have noted that some aspects of Silviculture and Forest Management have not been mentioned. We find it impossible to include everything we would like in a one day symposium. In an attempt to retreive the situation we have allowed time under "General discussion" for those who wish to extend the range of subjects beyond those covered by the papers. Hopefully this arrangement will give members an opportunity to ask questions.

P. M. Joyce

Sitka Spruce, Its Distribution and Genetic Variation

J. O'DRISCOLL[1]

Origin

THE probable origin of all conifers is reputed to be from the periphery of the north Pacific Basin. (Li, 1953). Differentiation into the various families took place during the Mesozoic Era, 225 to 75 million years ago. Eastern Asia has been suggested as the likely origin of all spruces because of the large assortment of species at present found there. In addition *P. koyamai,* a primitive spruce, is found there today (Wright, 1955). These species would have evolved toward the end of the Cretaceous Period 70 million years ago. Today approximately forty species are contained within the genus Picea. All of these are native to the cooler parts of the northern hemisphere. Their southern limit extends to the mountains of northern Mexico, southern Europe, Asia Minor, Himalayas and Taiwan (Figure 1). Over half of the species in the genus are to be found in China with only eight being native to the American continent (Wright, 1955). These include *P. mariana, P. glauca, P. engelmanii, P. rubens, P. pungens, P. sitchensis, P. breweriana* and *P. chihuahuana.* Of these eight, six have ranges in Western North America. Two of these species *P. breweriana* and *P. chihuahuana* however have little or no commercial value. The natural range of these species is mainly confined to the interior of the North American continent, the only exception being Sitka spruce whose range is entirely maritime (Figure 2). In this regard it differs entirely from all the other species in the genus.

Distribution

Paleobotanical evidence has shown that the present distribution of the species is rather similar to what it was prior to the Wisconsin glaciation which occurred during the Pleistocene period 2 million years ago. With the onset of the cold period the ice sheet spread as far south as the 48th parallel reaching a depth of 915 m. on the Queen Charlotte Islands. This effectively wiped out the northern arm of the species distribution (Daubenmire, 1968) (Fig 3). Any surviving populations north of the glacial border were probably on nunataks as has been shown by decumbent individuals of Sitka spruce found on four widely separated nunataks. (Heusser, 1952) The effect of the glaciation on the southern arm of the species distribution was to push it further south. Fossil evidence shows it

1· Research Branch, Forest and Wildlife Service, Bray, Co. Wicklow.

Figure 1
Southern limit of spruce distribution (Li, 1952).

to have occurred south of San Francisco. Remnant populations can be found today in Mendocino county of northern California which is 50 kms further south than the terminus of the present day main population. With the melting of the ice sheet simultaneously along the coast, the rapid recolonisation of former sites was made in all probability from the remnant populations surviving on the nunataks rather than from migration northwards (Daubenmire, 1968).

The present day range extends from latitude 61° in Alaska to latitude 39° in California—a distance of 1,800 miles (Figure 3). Throughout this distribution it is confined mainly to a narrow coastal belt commonly known as the fog belt. Most of the commercial stands are estimated to be within 2½ miles of the coast reaching their maximum density on the Queen Charlotte Islands. Further south this band is still narrower. Its inland penetration is usually along river basins. In this situation it has been found up to 30 miles from the sea in Oregon and Washington. Its greatest penetrations is in Alaska and British Columbia where it occurs up to 130 miles inland. At these extremes of its inland penetration it is associated with white spruce (*P. glauca*). Its elevation range is also limited throughout its distribution with the exception of Alaska where it is found up to 800 m. More usually it ranges from sea level up to 300 m. (Fowells, 1965).

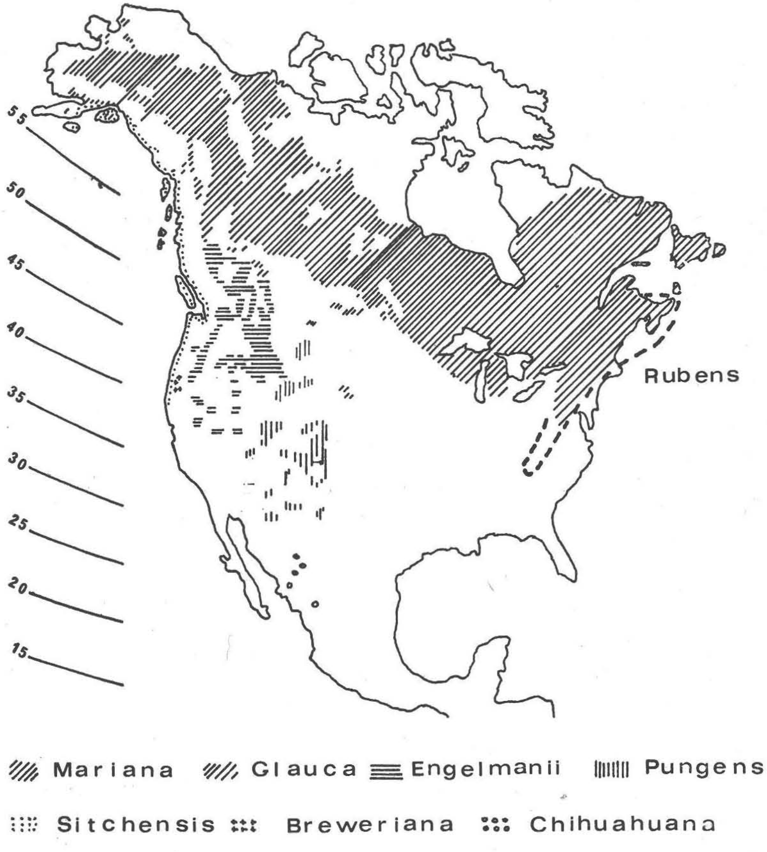

Figure 2
Distıibution of North Ameıican Spruces (Wright, 1955).

Climate

The general climate throughout the range is a maritime one dominated by westerly winds from the Pacific Ocean and is characterised by equable temperatures, long frost free periods, high precipitation, cloudiness and absence of extreme cold. Precipitation is usually in the region of 1250 mm per annum occurring mainly in the period September to April. It can however reach 2000-3,000 mm in the wetter areas of the Olympic Peninsula. Throughout the summer, rainfall is negligable. Frequent fog and low clouds help to make up any deficit during this period (Franklin, 1973). The length of the growing season ranges from 300 days in southern Oregon to 140 days in Alaska (Fletcher, 1976).

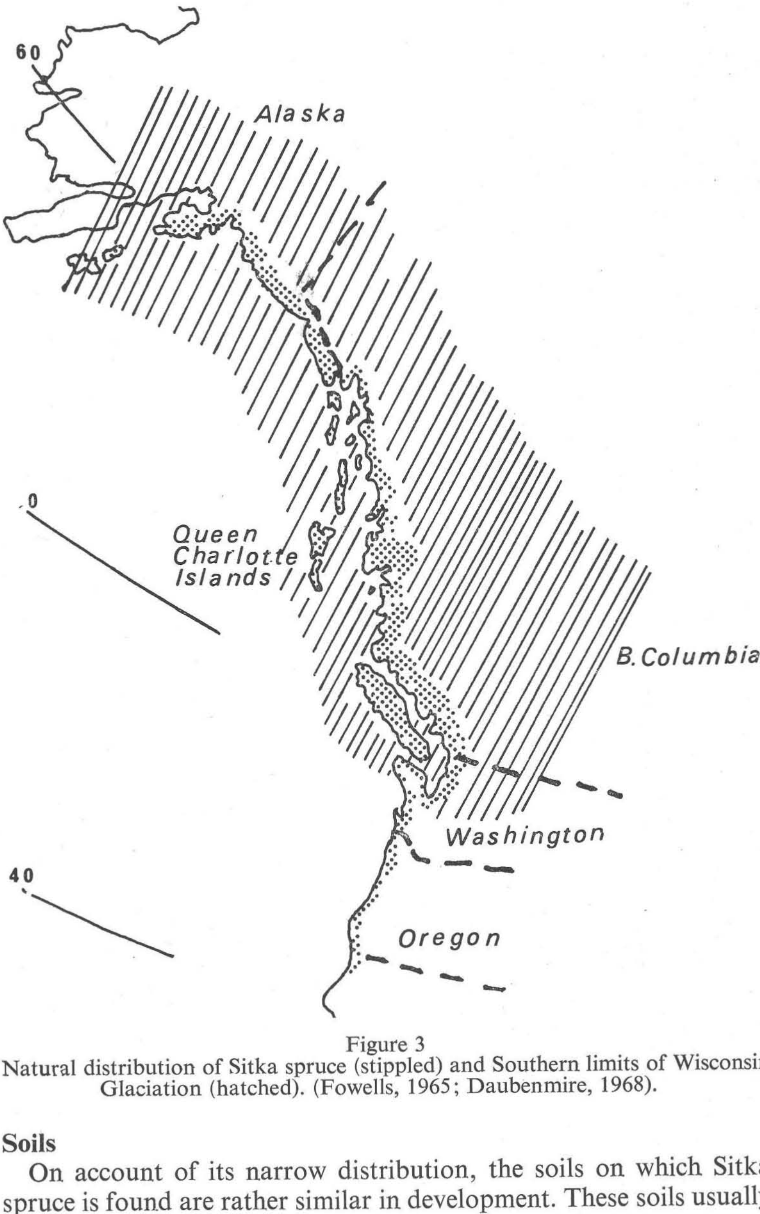

Figure 3
Natural distribution of Sitka spruce (stippled) and Southern limits of Wisconsin Glaciation (hatched). (Fowells, 1965; Daubenmire, 1968).

Soils

On account of its narrow distribution, the soils on which Sitka spruce is found are rather similar in development. These soils usually have a high organic matter content reaching 20% in the upper horizons.

Best growth is to be found on alluvial soils with a relatively high nutrient status. Where drainage is impeded growth is restricted. Day (1957) found on Queen Charlotte Islands that the best growth was on well drained soils allowing maximum root development. Competing species were suppressed on these site types. On less fertile sites the opposite was the case. In the northern part of its distribution the species is found on coarse textured thin soils while to the south it is restricted to alluvial soils or sandy bottoms along streams (Fowells, 1965).

Associated Species

Pure stands of Sitka spruce are found only where disturbance has taken place. Under more stable conditions it is commonly associated with western hemlock (*Tsuga heterophylla*). The proportion of each species varies according to the region. In Alaska, Sitka spruce represents 20% of the spruce-hemlock forest, while in Oregon it represents up to 80%. It is also found in association with western red cedar (*Thuja plicata*), Douglas fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), redwood (*Sequoiadendron sempervirens*) and Lodgepole pine (*Pinus contorta*). The only spruce with which it is associated is white spruce (*P. glauca*) with which it is known to hybridise along the Skeena river valley, British Columbia and in Alaska (Fowells, 1965; Roche, 1969).

Growth

In its native habitat Sitka spruce is a vigorous fast growing tree which reaches its maximum development on the west side of the Olympic peninsula, Washington and north Oregon coast. In this region maximum volume production is found in stands of mixed spruce hemlock with a mean annual increment of 11.9m^3 per hectare at 80 years. The tallest tree, located in Washington, when measured was 5 m. in diameter and 87 m. in height. In Alaska, the largest old growth tree measured was 2.4 m. in diameter. Growth in younger stands is in the region of 24 m. in height and 24 cm. in diameter (Fowells, 1965; Ruth, 1964).

Discovery

Discovery of the species is accredited to the Scottish naturalist Archibald Menzies who sailed as surgeon on the Discovery captained by George Vancouver. It was during the voyage of 1792 that he first identified the species in Admirality Inlet on Puget Sound, Washington (Fletcher, 1976). The first introduction to these islands was in 1831 by David Douglas who named it *Abies menziesii* in 1833 in honour of the discoverer (Veitch, 1881). It, however, had also been discovered by Mertens on Sitka island now Baranof Island Alaska, and described by Bongard as *Pinus sitchensis* in 1832. Following reclassification of the genus to Picea by Carriere in 1855 this has become the accepted name of the species. (Burley, 1965) Some of the plants raised from the David Douglas collection were reputed to have been sent to Curraghmore estate, Co. Waterford (Mitchell, 1972).

Since its first introduction to Europe, Sitka spruce has been planted extensively outside its natural range. A high percentage of

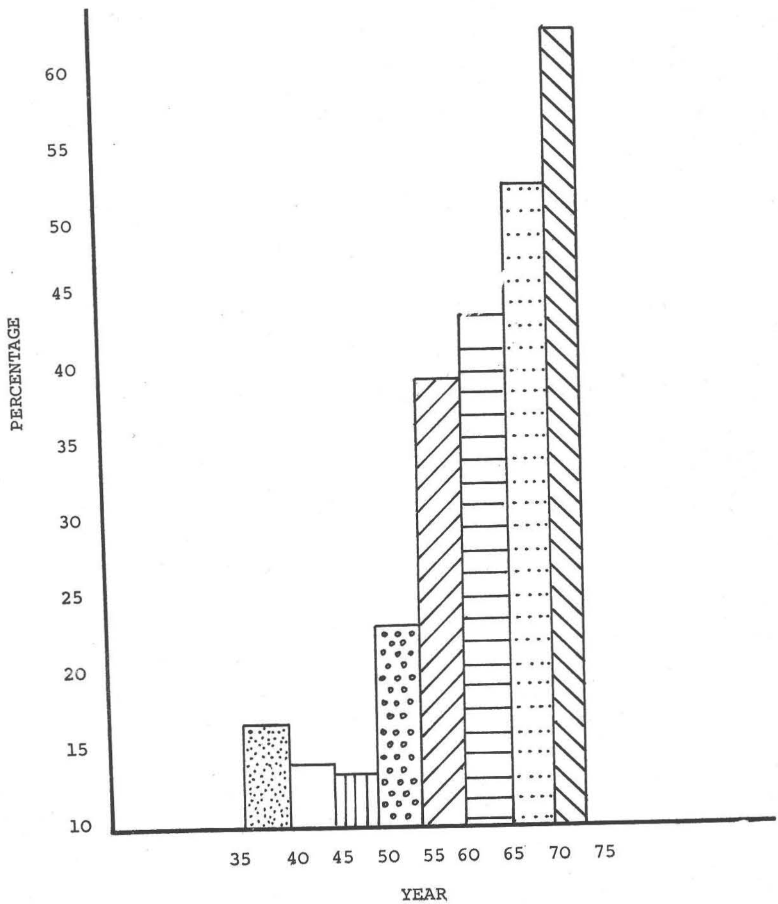

Figure 4

Percentage land area planted with Sitka spruce.

the annual planting programme in Ireland and Britain is composed of Sitka spruce (Figure 4). In continental Europe, Sitka spruce is a species of moderate importance in Denmark, Norway, Germany, Netherlands, Belgium and France. In the southern hemisphere, it is only of minor importance, in New Zealand and Australia.

Genetic Variation

During the glacial period the northern arm of the species distribution would have been subject to severe selection pressure which would have favoured biotypes tolerant to low temperatures. The effect of this would have been to greatly deplete the gene pool. The southern arm of the species distribution would not have been subjected to similar selection pressures and would have evolved under quite different ecological conditions.

Though the species has a considerable natural distribution, study of the species s variation has been carried on outside its natural range—mainly in Europe.

Seed Characteristics

Differences in seed weight have been recorded between provenances with those from Alaska being the heaviest. These differences do not confer any enhanced vigour to the developing seedling nor are they in any way correlated with latitude. Differences in seed length, but not seed width, also occur between provenances but these do not follow any set pattern (Aldhous, 1962; Burley, 1966; O'Driscoll, 1976a).

Variation within seed parameters is greatest among the Washington, Oregon and Lower Skeena Valley provenances (Illingworth, 1976). The former is probably due to the inherent genetic variability undisturbed since earliest times and the latter due to introgression with white spruce (*P. glauca*).

Patterns of variation in germination rate do exist between provenances but these differences are not correlated with any of the seed parameters or latitude. Germination capacity also varies between provenances, those from northern and outer coast provenances being poorest. This characteristic, allied with slow germination rate, could be used as a measure of fitness, as those with poor germination rate and capacity would not be likely to colonise a new site. Cotyledon number has been found to vary from 3 to 8 with a general mean of 5. Within provenance, the number can vary over entire range. This characteristic is therefore of little value in the identification of different provenances (O'Driscoll, 1976a).

Growth

Experiments have shown that the pattern of variation in height growth follows a geographic gradient, though evidence of some ecotypic variation has been found in provenances from Alaska (Burley, 1966). Generally, the pattern of growth in Ireland is such that with decreasing latitude there is an increase in height growth. (O'Driscoll, 1972, 1976a). An apparent break in this clinal pattern occurs at the Straits of Juan de Fuca separating Vancouver Island and Washington. South of these Straits the clinal pattern is reinstated. Two possible explanations can be given for this break. The Straits form a barrier to effective gene flow between adjacent subpopulations thus giving rise to differentiation at this point (Koski, 1970). The Straits also represent the southern limit of the spread of the Wisconsin ice sheet. Populations to the south have had many more generations in which to evolve and adapt to their environments than have populations to the north. Though variation does occur between provenances in root collar diameter growth at the nursery stage, it does not follow a geographic gradient. Evidence would suggest that it is more under the influence of the environment than under genetic control (O'Driscoll, 1976a).

Morphological Variation

Growing Points: At first sight Sitka spruce do not appear to have the same degree of variation in branch numbers as do pines. Studies within and between provenances are limited. The 1972 IUFRO provenance experiment indicated that the number of growing points was strongly correlated with height growth (O'Driscoll, 1976a). This would seem to imply that the more southerly provenances had more branches. However, these branches would be spread over a greater surface area and branching would in fact appear less dense than their more northerly relatives.

Cone variation

Variation in cone size and length/width ratio of cone scale has been found to be clinal, increasing from north to south (Daubenmire, 1968). A different pattern of variation occurs in the Skeena Valley which suggests that the population here is a hybrid one with white spruce (Roche, 1969).

Phenological Variation

Flushing: Significant differences in time of flushing have been recorded between provenances. The pattern of variation is correlated with latitude of origin but does not follow a geographic gradient. There is some disagreement between the two studies carried out as to which end of the range flushes first. Aldhous (1962) found that Alaskan provenances were the first to flush while the 1972 IUFRO experiment found that the more southern provenances were first (O'Driscoll, 1976b). Generally speaking there is considerable within provenance variation. Northern provenances are also found to flush over a longer period of time. Flushing in Sitka spruce is considered to be predominantly a temperature response (Lines and Mitchell, 1966; O'Driscoll, 1976a).

Cessation of growth: The pattern of variation of cessation of growth is very strongly clinal and this characteristic is very obviously under the control of length of photoperiod. The northern provenances are the first to enter domancy with the more southerly ones the last. This has the effect of making southerly provenances more prone to early Autumn frosts when they are moved to northern climes (Magnesen, 1976). This was very obvious in the IUFRO SS experiment, when all the Oregon provenances suffered frost damage in November 1974. Length of growing season is positively correlated with height, growth, the longer the growing season the better the growth (Kraus and Lines, 1976; O'Driscoll, 1976a).

Wood Characteristics: Considerable differences have been recorded within provenances in wood density, tracheid length, spiral grain and seasoning properties. Jeffers (1959) recorded significant differences in density between four provenances. Few studies, as yet, have been carried out on the between tree within provenance variation. Environmental effects represented 33% of the variation in density in trees from 20 stands in Alaska (Farr, 1972). Site quality differences have been shown to effect density. Sunley (1961) reported that Quality Class 3 stands had a higher density than either Q.C. 1 of Q.C. 2 stands. Incidence of spiral grain was also found to be higher in faster grown trees (Brazier, 1967).

Hybridisation: At only two locations throughout its natural range does Sitka spruce grow in close proximity with another spruce, white spruce (*P. glauca*). In the Skeena river valley it forms a natural hybrid with white spruce. The entire valley is a zone of introgression between the two species (Daubenmire, 1968; Roche, 1969). A hybrid swarm is also considered to exist on the Kenai Peninsula, Alaska where the hybrid *Picea x Lutzii* was first recognized (Little, 1953). Through its ability to hybridise naturally with white spruce, its possible evolutionary path can be traced via the *P. jezoensis* × *P. glauca* cross to China which is considered to be the cradle of all spruces. Successful man-made crosses have been made between Sitka spruce and Norway spruce, Serbian spruce (*P. omorika*), Yeddo spruce (*P. jezoensis*) and Engelman spruce (*P. engelmanii*) (Roche and Fowler, 1975). It can be stated that generally genetic variation in Sitka spruce is of a clinal type though further ecotypic variants to that referred to by Burley (1966) may yet be found.

Practical Implications of Sitka spruce variability

Studies to date in Ireland have shown that none of the metrical parameters of Sitka spruce seed have any worthwhile practical implication. This is in contrast to such species as Douglas fir and Lodgepole pine where large seed size of inland provenances can give an initial boost to seedling growth in the first years. Variability of cotyledon number is not sufficiently definite for specific provenance identification.

When the growth parameters are considered, exploitation of the variability in height growth between provenances offers the most positive response. The recently completed nursery stage of the IUFRO experiment has shown that the further south the seed is collected from within the species distribution the better is the growth. The pattern of variation follows very closely that of an earlier experiment at Killarney, planted in 1960 (Figure 5). Both experiments indicate that the most productive provenances for Irish conditions are from the south Vancouver Island–North Washington region. Traditionally we have imported our Sitka spruce seed from the Queen Charlotte Islands. Experimental evidence shows that

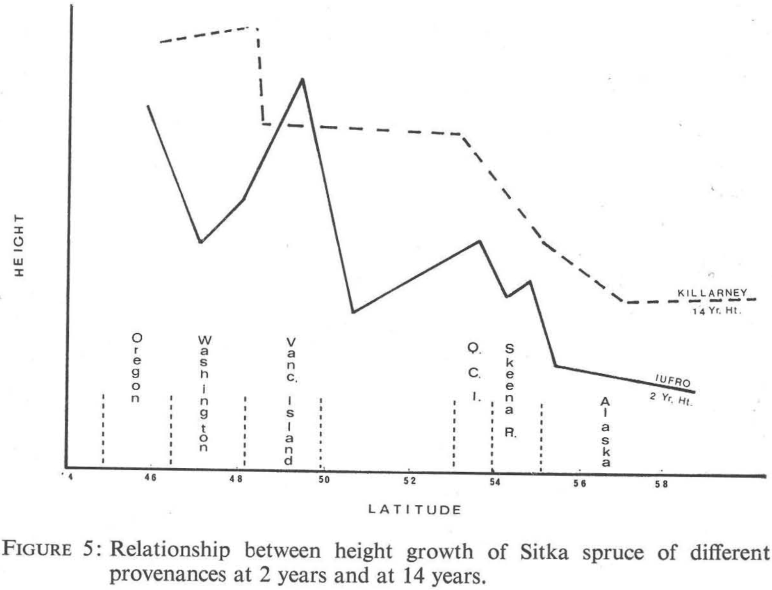

FIGURE 5: Relationship between height growth of Sitka spruce of different provenances at 2 years and at 14 years.

there is a difference of two yield classes between these two regions, 20 for the Queen Charlotte Islands region and 24 for the south Vancouver Island–North Washington region. Over the rotation of the stand this would mean a difference in yield of 198 m^3 which is equivalent to an estimated £1,980. Of the 97,000 hectares planted up to 1972 with Sitka spruce approximately 30% have been planted with seed from *known* Vancouver Island–North Washington provenances. This implies that the production in the remaining 64,000 hectares is below the optimum level and that it could have been increased appreciably by choice of correct provenance or by use of home collected lots from stands of proven quality. Home collected lots were however not available in any quanity up to 1972.

Further increase in growth could be achieved by using still more southerly provenances. These provenances however have the major drawback in that they are more susceptible to early autumn frost. Provenances which do not cease growth by mid September are particularly prone to such damage. Experimental evidence has shown that provenances from South Washington and further south are more liable to early frost damage because of their extended growing season. Optimum length of growing season would appear to occur in these provenances from Vancouver Island–North Washington region.

Sitka spruce is also susceptible to late Spring frost. Here provenance choice offers few options. It has been found that most provenances flush in or about the same time. Though northern provenances flush slightly later the difference is so insignificant to be not worth pursuing. Any improvement in this characteristic would be gained by exploiting between tree within provenance differences where these are proven to be worthwhile.

Branching habit in Sitka spruce follows no distinct pattern by provenance as is found with Lodgepole pine. In fact all provenances appear to exhibit the complete range of branching types. If improvement is to be gained in this characteristic it will be best achieved by the selection of individual trees with definite whorls within the chosen provenances. These can then be placed in a seed orchard to produce progeny with the desirable branch format.

Though the main objective in the exploitation of the genetic variability of Sitka spruce would appear to be that of increased growth, the end product must not be forgotten. There is a danger of a reduction in density with increased vigour. This would have an adverse affect on the strength properties, pulp yields and pulp and paper qualities of the end product (Harris, 1970). Further study may reveal considerable variation in density between trees in fast growing provenances. This will allow the selection of these higher density trees for further propagation and the establishment of a specific orchard for the production of high density reproductive material.

Tracheid length on the other hand was not influenced by vigour and so would not be affective by choice of vigorously growing provenances. Improvement would be best achieved by exploiting between tree within provenance variation. It is therefore, very important at all times to consider the end product when planning to exploit the genetic variability of Sitka spruce.

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The Distribution and Productivity of Sitka Spruce in Ireland

T. J. PURCELL[1]

Distribution

SINCE 1955, Sitka spruce has been the most widely planted species in Ireland. Forty-five % of the total area of high forest now comprise Sitka spruce. Northern Ireland has 70% and the Republic of Ireland 41% of its total forest area under Sitka. These figures include all plantings up to 1974.

The state administers 95% of all Sitka spruce plantations while the other 5% is in private ownership (Table 1).

Almost one-third of the total area of the species, is in the West of Ireland while there is 22 and 24% in the northern and southern regions respectively. Distribution by county and ownership is given in Table 2.

The age class distribution shows that more than 50% of the total area of the species is ten years old or under while more than 80% is under twenty years (Table 3).

Productivity

Sitka spruce has for many years been the most important timber producing species in Ireland. Tables 4 and 5 outline production forecasts for the species from 1980 to 2004 for Northern Ireland and the Republic of Ireland. Volumes are given to 7 cms top diameter,

TABLE 1

Distribution of the total area (ha) of Sitka spruce in Ireland by ownership

	State	Private	Totals
Northern Ireland %	29,560 (20)	2,379 (2)	31,939 (22)
Republic of Ireland %	110,753 (75)	4,368 (3)	115,121 (78)
Totals %	140,313 (95)	6,747 (5)	147,060 (100)

[1] Forest and Wildlife Service, Bray, Co. Wicklow.

TABLE 2

Distribution of the total area (ha) of Sitka spruce by county and ownership

County	State	Private	Total	%
Antrim	5,514	444	5,958	4.0
Armagh	736	59	795	0.5
Carlow	1,493	87	1,580	1.1
Cavan	1,917	92	2,009	1.4
Clare	6,365	322	6,687	4.5
Cork	14,691	511	15,202	10.3
Derry	4,983	401	5,384	3.7
Donegal	11,254	124	11,378	7.7
Down	368	29	397	0.3
Dublin	712	49	761	0.5
Fermanagh	9,663	778	10,441	7.1
Galway	10,118	292	10,410	7.1
Kerry	5,523	74	5,597	3.8
Kildare	472	109	581	0.4
Kilkenny	3,357	77	3,434	2.3
Laois	3,234	193	3,427	2.3
Leitrim	5,115	137	5,252	3.6
Limerick	2,752	95	2,847	1.9
Longford	584	21	605	0.4
Louth	438	24	462	0.3
Mayo	6,394	208	6,602	4.5
Meath	319	57	376	0.3
Monaghan	1,181	87	1,268	0.9
Offaly	1,586	42	1,628	1.1
Roscommon	2,482	105	2,587	1.8
Sligo	3,033	173	3,206	2.2
Tipperary	4,464	139	4,603	3.1
Tyrone	8,296	668	8,964	6.1
Waterford	7,689	325	8,014	5.4
Westmeath	1,268	162	1,430	1.0
Wexford	2,950	228	3,178	2.2
Wicklow	11,362	635	11,997	8.2

under 18 cms top diameter and 18 cms top diameter and over. Volume to 7 cms top diameter includes the subsequent two categories i.e. all volume; 18 cms top diameter is taken as an arbitrary figure to divide pulpwood from sawlog.

Two different policy strategies are evident from the Northern Ireland and Republic of Ireland production forecast estimates. The Northern figures show the influence of a "no thinning" policy. The forecasts for the Republic show that normal thinning is the general practice.

TABLE 3

Area (ha) of Sitka spruce by Age Class, ownership and the percentage of total in Ireland

Age Class Years	Northern Ireland			Republic of Ireland			Totals
	State	Private	Total	State	Private	Total	
1–10	15,125	1,217	16,342	56,664	1,263	57,927	74,269
Percentage	10.3	0.8	11.1	38.5	0.9	39.4	50.5
11–20	9,784	787	10,571	38,230	1,381	39,611	50,182
Percentage	6.6	0.6	7.2	26.0	0.9	26.9	34.1
21–30	3,189	257	3,446	8,674	693	9,367	12,813
Percentage	2.2	0.1	2.3	5.9	0.5	6.4	8.7
31–40	1,042	84	1,126	3,997	411	4,408	5,534
Percentage	0.7	0.1	0.8	2.7	0.3	3.0	3.8
41–50	412	33	445	2,820	208	3,028	3,473
Percentage	0.3	—	0.3	1.9	0.2	2.1	2.4
51+	8	1	9	368	412	780	789
Percentage	—	—	—	0.2	0.3	0.5	0.5
TOTALS	29,560	2,379	31,939	110,753	4,368	115,121	147,060
PERCENTAGE	20.1	1.6	21.7	75.2	3.1	78.3	100.0

Production figures can be affected by changes in felling policy. These changes could include reduction or extension of rotations or alternatively felling when trees reach a certain height.

Mean Yield classes

(1) Northern Ireland

The mean Yield Class for Sitka spruce, derived from sample plots used for forecasting from the 1974/75 Inventory, was 14.8m3/ha/annum.

(2) Republic of Ireland

The mean Yield class for Sitka spruce from the 1968 Inventory of State Woodlands was 14.4m^3/ha/annum. This was based on crops planted before 1958. The survey of state woodlands currently in progress covers crops planted from 1958 to 1968. The latest indications are that the mean yield class is higher than 14.4.

The mean Yield class for private woodlands is 17m^3/ha/annum.

TABLE 4

Sitka spruce production forecast for Northern Ireland (1000sm³) 1980-2004
(Private woodlands not included)

Year	Thinning Yield (cms diam. top) 7	Thinning Yield Under 18	Thinning Yield 18+	Felling Yield (cms diam. top) 7	Felling Yield Under 18	Felling Yield 18+
1980	21.9	16.6	5.3	11.0	2.9	8.1
1985	34.4	26.1	8.3	19.6	8.9	10.7
1990	39.6	27.9	11.7	141.4	60.5	80.9
1995	34.7	19.7	15.0	119.0	48.7	70.3
2000	29.8	12.3	17.5	186.0	59.7	126.3
2004	22.6	7.6	15.0	600.1	213.5	386.6

Total Yield (cms diam. top)

Year	7	Under 18	18+
1980	32.9	19.5	13.4
1985	54.0	35.0	19.0
1990	181.0	88.4	92.6
1995	153.7	68.4	85.3
2000	215.8	72.0	143.8
2004	622.7	221.1	401.6

TABLE 5

Sitka spruce production forecast for the Republic of Ireland (1000s m³) 1980-2004
(Figures include forecast estimates for State and private woodlands)

Year	Thinning Yield (cms diam. top) 7	Thinning Yield Under 18	Thinning Yield 18+	Felling Yield (cms diam. top) 7	Felling Yield Under 18	Felling Yield 18+
1980	241.8	188.7	53.1	47.8	4.4	43.4
1985	410.6	343.0	67.6	172.6	14.6	158.0
1990	591.2	494.4	96.8	193.1	19.2	173.9
1995	766.1	617.4	148.7	182.7	20.0	162.7
2000	951.4	725.2	226.2	205.8	21.8	184.0
2004	1080.8	786.8	294.0	240.0	30.8	209.2

Total Yield (cms diam. top)

Year	7	Under 18	18+
1980	289.6	193.1	96.5
1985	583.2	357.6	225.6
1990	784.3	513.6	270.7
1995	948.8	637.4	311.4
2000	1157.2	747.0	410.2
2004	1320.8	817.6	503.2

Acknowledgement

Figures and information for Northern Ireland were provided by Mr. John A. McEwan, Department of Agriculture, Forest Service.

Discussion following the papers of J. O'Driscoll and T. J. Purcell

CHAIRMAN: **K. F. Parkin**

Mr. Mooney stated that over the past number of years some 30% of Sitka spruce seed imported for the Forest and Wildlife Service has been of Southern provenances (Olympic Penninsula) and 70% was from the Queen Charlotte Islands. He inquired whether southern provenances had better form than others. **Mr. O'Driscoll** replied that all provenances displayed a range of stem forms. **Mr. McGlynn** noted that the mean yield class of Sitka spruce was higher in private than in State plantations and argued from this in favour of a greater emphasis being placed on support for private forestry. The **Chairman** made the point that differences in yield class could be explained, in part, by differences in land quality between the public and private sectors. In reply to **Dr. Joyce's** observation on the different thinning strategies adopted in the two forest services, the **Chairman** explained that the Northern Ireland no-thinning policy on deep peat and gley soils was based on consideration of the extraction difficulty encountered on these soils, the cost of thinning operations relative to the returns and crop stability implications. **Mr. McEvoy** commented on the production forecasts presented, saying that predictions could be altered by a change in policy such as reducing rotation length. This course might well prove attractive in the context of stability problems.

Pests and Diseases of Sitka Spruce

G. DE BRIT[1] and D. MCAREE[1]

Introduction

SITKA spruce (*Picea sitchensis* Bong. Carr) is undoubtedly the most important tree species in Irish forestry. It represents approximately 45% of the forest estate in Ireland. The species is an exotic introduced from North-West America.

These two factors determine that a keen interest be taken in insect and disease problems associated with Sitka spruce. Firstly, because of its dominant position in Irish forestry, if serious pest or disease problems are to arise with the species considerable loss in wood production could be anticipated. Secondly, it is internationally recognised that introduced exotic tree species are inherently more vulnerable to pest and disease organisms than are indigenous tree species.

Bearing these two points in mind we will examine the present situation with regard to pests and diseases of Sitka spruce in Ireland and also look at potentially damaging organisms which do not occur in Ireland and the measures which are adopted to minimise the possibility of inadvertent introduction.

Insects

At present there are only two insects of economic significance attacking Sitka spruce; the large Pine Weevil (*Hylobius abietis* L) and the Green Spruce Aphid (*Elatobium abietinum* Walker).

The large Pine Weevil is a familiar insect to most foresters. Its population builds up in the stumps of coniferous trees following clearfelling operations. The damage is done by the adults feeding on the bark of young conifers which are planted on the clearfelled site.

TABLE 1

Effect of Didicol and Gammolin on the control of *Hylobrius abietis* attack on Sitka spruce

	Sitka Spruce Percentage Survival		
Year	Control	2.5% Didicol	5% Gammolin
1966	82	86	92
1967	15	68	84
1968	1	51	63
1969	1	47	61

[1]Research Branch, Forest and Wildlife Service, Bray, Co. Wicklow.

Unless protective measures are taken against this insect, the replanted crop will suffer very heavy damage; quite frequently this will result in complete mortality of the trees in the area replanted (Table 1).

Currently protection is achieved by dipping the plants prior to planting in 2.5% DDT or 1.6% Lindane (gamma–BHC). The importance of this insect is likely to increase in the future when the clearfelled area is substantially greater than at present. Increased clearfelling will probably also lead to difficulties with root feeding. *Hylastes* spp. notably *H. cunicularis.*

Another factor to be borne in mind in relation to the large Pine Weevil is the general opposition which is developing to the use of persistent chlorinated hydrocarbons. This may necessitate changing to other types of insecticides. It is necessary therefore to continue screening new insecticides in the search for suitable alternatives to DDT and Lindane. We are of the opinion however that the limited use of DDT and Lindane for the control of the large Pine Weevil does not constitute a serious environmental hazard.

The other important insect attacking Sitka spruce is the Green Spruce Aphid. This is a sap feeding insect which feeds on the needles of Sitka spruce. It defoliates all but the current foliage in late winter and spring. Foresters have traditionally held the view, that while the insect causes dramatic defoliation of the tree, recovery is rapid and tree mortality does not occur. Consequently the insect was not considered to be of any great economic significance.

Interest in the insect has increased greatly in the last 8-9 years, during which period there has been 6 bad aphid years. This greatly increased frequency of bad aphid years is thought to be primarily due to the very mild winters experienced in the last 9 years resulting in very improved winter survival of the aphid. However, in spite of the increased frequency of attack tree mortality has not occurred. We have commenced an investigation into the effect on the growth of Sitka spruce caused by defoliation by the Green Spruce Aphid. Preliminary results indicate that one year's complete defoliation can result in a reduction in leader growth of 50% (Fig. 1).

These results suggest that economically significant growth losses may be experienced by Sitka spruce crops if they are attacked by the green spruce aphid a number of times during the rotation.

There are of course very many other insects which attack Sitka spruce besides the two which have been discussed above. None of these however, at present, constitute a serious threat to Sitka spruce production, although many such as needle miners (*Epinotia* spp.) do become locally abundant from time to time. It is important to keep an eye on these, at present, unimportant insects. They may at some time in the future become abundant. The reasons for insect pests reaching outbreak status are not clearly understood. There are many examples of insects which have been of little or no significance for long periods suddenly erupting into outbreak status Examples of these are the outbreak of the larch sawfly (*Cephalcia alpina*) on larch in Wales in the early 1970s which is still continuing. More recently, the Pine Beauty (*Panolis flammea*) which has been in Great Britain for at least 50 years erupted on Lodgepole pine in Scotland in 1976. On spruce, the European Spruce Sawfly (*Gilpinia hercyniae*) has reached epidemic proportions in Canada (1930) and in Wales (1971), having been in both countries for many years before reaching outbreak status.

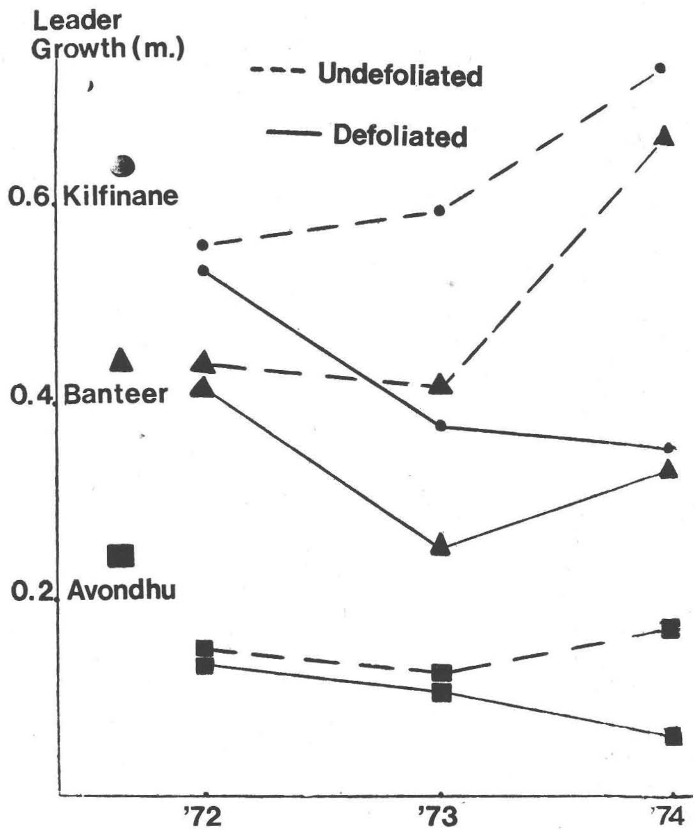

FIGURE 1: Influence of Green Spruce Aphid defoliation on height increment (m) of Sitka spruce at Kilfinane, Banteer and Avondhu forests.

The point here is that one cannot make assumptions that because an insect is at a low population level it will remain so. We cannot therefore ignore the possibility of low level pests occurring in Ireland at present assuming economic significance in the future.

Mention has been made of the European Spruce Sawfly. This insect does not occur in Ireland. It has proven ability to be severely damaging on Norway and Sitka spruce. Among other European insects which do not occur in Ireland are European bark beetles, *Dendroctonus micans, Ips typographus, Ips amitinus* and *Ips sexdentatus*. These bark beetles on their own or in combination with other harmful organisms such as the Green Spruce Aphid or the Honey fungus (*Armillaria mellea*) would constitute a very serious threat to Sitka spruce in Ireland.

Apart from these European insects there are many potentially harmful North American insects. Among them may be mentioned the spruce budworm (*Choristoneura fumiferana*), the black headed budworm (*Acleris variana*), the western hemlock looper (*Lambdina fiscellaria lugubrosa*), *Hylobius* spp, the Sitka spruce weevil (*Pissodes sitchensis*) and the Engleman spruce beetle (*Dendroctonus obesus*).

It is obvious that adequate protective measures to prevent the inadvertent introduction of these and other insects and diseases must be taken. The measures which have been adopted are reviewed later in this article.

Diseases

Natural forests have their own inbuilt system of checks to guard against the ravages of disease epidemics. It seems that the interspecific and intraspecific diversity of natural ecosystems provide a broader genetic base that greatly enhances the capacity of the forest to withstand threats from the major pathogens. Such is not the case with our Sitka spruce monocultures. These forests are so designed to produce fast-growing uniform trees, selected to meet rather specific consumer needs. They are often located on sites chosen more for socio/economic reasons than for suitability to the biological requirements of the tree. Such intensively managed forests are therefore subject to many disease problems that differ greatly from those of their natural counterparts. Instead of heart rots for example, and other diseases associated with old age and decadence, root rots, stem cankers, foliage diseases and physiological disorders are much more common.

It is less than three-quarters of a century ago that Sitka spruce was first planted in a State forest, at Avondale, County Wicklow. Since then, many disease problems associated with intensive culture of the species have become apparent throughout the country. In its native North West America, Sitka spruce is affected by more than one hundred and twenty pathogenic fungi. By contrast, not more than ten major diseases affect the species here in Ireland. The protection afforded Sitka spruce by virtue of our island status is our natural and most important phytosanitary asset. This fact is internationally recognised and forms the cornerstone of our plant health legislation. The uniform composition of our spruce forests made up of a first generation exotic conifer makes them inherently susceptible to introduced harmful organisms. In order to maintain a relatively disease-free situation, an integrated disease control programme needs to be practiced and enforced by legislation (see Table 2).

Of the major pathogens affecting the species in Ireland at present *Fomes annosus, Armillaria mellea,* and *Rhizina undulata* may be listed as being the most damaging agents of death and decay. The greatest short-term danger to Sitka spruce as grown in short-rotation plantations in Ireland lies with these three unrelated root-rotting fungi. Members of this group are not host-specific, and their infective spores are ubiquitous. Control measures to counteract heart rot caused by *Fomes annosus,* mainly centres on stump protection. A 10% solution of Sodium Nitrite or 20% Urea applied to the stump as soon as possible after felling is the current protective measure practised in Irish forests.

TABLE 2

Principles of disease control programme for Sitka spruce

Integrated Disease Control Programme for Sitka spruce

Principle	Method
Resistance Eradication Exclusion Protection Avoidance Therapy	Regulatory Cultural Biological Physical Chemical

Biological control of this disease on Sitka spruce through the use of antagonistic microorganisms is a future possibility. Research work indicates that the fungus *Hypholoma fasciculare* could be the candidate organism. When one considers that there is over 5% loss in timber production due to *Fomes annosus,* it is economically desirable that protective measures be rigidly enforced. This is particularly true of those areas now at first thinning stage which are, as yet, free of the disease.

Restriction of burning might be expected to control the Ascomycete fungus *Rhizina undulata*. However, clearfelling of unproductive forest areas and their subsequent replanting with Sitka spruce after burning of lop and top, predisposes the replanted trees to infection. Control measures here also include cultural and physical methods whereby the lop and top is wind-rowed and left in situ. The inoculum potential of the fungus is dissipated after 2-3 years. Leaving the burned site fallow for that period of time is a control measure practiced in the Netherlands. *Armillaria mellea* causes root necrosis and rotting of Sitka spruce. The disease is more common on old hardwood sites. It is also thought to colonise root wounds and to predispose roots to infection by *Polyporus schweinitzii*. Its general role however is that of killing trees already weakened by insects, defoliation, drought or poor soil conditions. The disease has also been recorded on Sitka spruce in association with damage by barkbeetles. As yet there is no economically feasible control measure formulated to counteract this pathogen.

Polyporus schweinitzii causes a brown cubical butt rot, which is by far the most damaging fungus disease of Sitka spruce in either North America or Europe. Its incidence in Ireland is rare. As our forests mature it may constitute a serious threat. It is normally described as a parasite of middle aged and mature trees and in Europe it has been associated with extraction damage. Another potentially dangerous pathogen associated with extraction damage on spruce is the Basidiomycete *Stereum sanguinolentum*. It can cause serious butt rot damage but its disease status in Ireland is minimal at present. One of the principal root-rotting organisms of Sitka spruce in its native habitat is *Poria weirii* which again fortuitously does not occur in Europe. Only strict phytosanitary controls will prevent this potentially devastating fungus from infecting our spruce forests. It causes a laminated root rot and a method for its economical control is unknown. The fungus is not host specific and would pose a major threat to most of our forest estate.

Sitka spruce is a shallow rooting tree and heavy losses have been sustained by the species due to windblow damage. It is highly susceptible to decay when blown and is readily colonised by various cellulolytic and lignolytic decay fungi. *Odontia bicolor, Sparassis crispa* and various *Polystictus* spp. are the major decay organisms concerned. The objective of forest management in such windblow situations with this species should be to harvest the timber as soon as possible to prevent further degrade. Another feature of Sitka spruce outplanted on our oligotrophic peats and Old Red Sandstone areas is its tendency to go into check. This problem is associated with nitrogen unavailability and general lack of biological activity in the rhizosphere. Could this problem be due to lack of the appropriate mycorrhizal symbiont? Although there is no good evidence that mycorrhizal fungi themselves are directly involved in nitrogen fixation there is some indication that the mycorrhizal system does somehow stimulate fixation. Disease resistance against soil borne pathogens has also been attributed to the presence of beneficial mycorrhizae on Sitka spruce roots. The proper symbiont produces a very potent anti-fungal and anti bacterial chemical that inhibits the invasion of the feeder roots by disease organisms such as *Phytophthora cinnamomi.* Direct nursery inoculation of Sitka spruce seedlings with specific mycorrhizae is an area of research that shows great promise.

Looking to the future as regards disease problems of Sitka spruce it would seem that an increasing number of stem rotting fungi will become established in second rotation crops. Biological control will play a greater role in disease prevention and inevitably forestry practice will increasingly incorporate techniques for manipulating and encouraging desirable microbial systems. Stricter phytosanitary measures will have to be enforced to guard against the introduction of undesirable pathogens. Particularly in this regard may be mentioned the rust fungi *Chrysomyxa arctostaphyli, Melampsora medusae* and *M. occidentalis.* An eradication programme will have to be initiated against the soil-borne pathogen *Phytophthora cinnamomi.*

Strict adherence to an integrated disease control programme as outlined in Table 2 should help to contain any major disease problems we have with Sitka spruce at the moment. Future disease problems should be minimised when the E.E.C. Directive on plant health is operational. Provided these control measures are adopted Sitka spruce will remain our major timber producer and its most important role in Irish silviculture will be assured.

Plant Health Control of Imports

Up to the present time we have protected ourselves from unwanted insect and disease introductions by operating national import controls. These consisted primarily of import prohibitions of plants of our major tree species, including Sitka spruce. We also prohibit the introduction of conifer wood with bark from certain European countries, this provision is intended to give protection against the introduction of European bark beetles.

From the 1st January 1979 we will have to operate an E.E.C. Directive on plant health which will significantly modify our national controls, but which will afford us with greater protection in many areas. Specifically with regard to Sitka spruce the main provisions in the Directive are.

1. The importation of spruce plants into the Community from Non-European countries is prohibited.
2. The importation of wood of conifers with bark attached, into the Community from temperate regions outside Europe is prohibited.
3. The importation of wood of conifers with bark attached into Ireland from Europe is prohibited.

It is worth noting that for plant health purposes the whole island of Ireland has been treated as a unit, so that the provisions in the Directive are identical for the Republic and Northern Ireland.

The measures outlined are Community ones, but this does not prevent Ireland taking stricter precautions against countries not belonging to the Community.

Summary

The present situation in relation to the more important insect and disease problems associated with Sitka spruce in Ireland are outlined. The potential of presently unimportant organisms are discussed. The threat posed by inadvertent introductions of harmful organisms not present in Ireland is examined, together with the plant health control measures being adopted to minimise the possibility of such introductions.

Discussion following the papers of G. de Brit and D. McAree

CHAIRMAN: **C. S. Kilpatrick**

In reply to a query from **Dr. Joyce** concerning the potential risk from an introduction of *Dendroctonus,* **Mr. de Brit** said he did not see any danger of *Dendroctonus* getting into the country in the foreseeable future. There followed some discussion on the E.E.C. Directive on plant health. **Mr. Saville** asked about the possibility of biological control measures being employed against the Green Spruce Aphid. **Mr. de Brit** explained that the problem with biological control lay in the lag between attack and the introduction of the predator, making it impossible to prevent damage completely. The predator population usually does not increase until after the build up of the attack.

Mr. Deasy mentioned that Sitka spruce mycorrhizae occur naturally in most forest nurseries and questioned why nursery practice should be modified to encourage the development of these fungi. Mr. McAree agreed but mentioned that present nursery practice in Ireland is such that the growth of *specific* mycorrhizal fungi is not encouraged. Direct nursery inoculation of seedlings with mycorrhizae ecologically suited to various site types should be considered.

Nutrition of Sitka Spruce on Peat-Problems and Speculations

D. A. DICKSON[1]

Introduction

This paper deals with the problems of the mineral nutrition of Sitka spruce (*Picea sitchensis* Bong. Carr.) on peatland soils in Northern Ireland and speculates on the solutions to some of them. There are nutritional problems on the mineral soils in the country (Savill and Dickson, 1975) but on certain peat soils they are more acute and occur at an earlier stage than on any other major soil type. However not all peats are unproductive and it must be emphasised that there is as big a difference in potential productivity for Sitka spruce on low altitude valley or fen peat and upland blanket peat as there is between agricultural production on the best arable and poorest grazing soils in the country.

By far the most important group of peat soils devoted to forestry in Northern Ireland are the blanket peats; there are only relatively small areas of raised bog or fen peat and even less afforestation on them. About 80% of the blanket peat is over 1 m. deep and this type of peat has been classified into four "nutrient classes" ranging from the nutrient rich eutrophic class to the very impoverished dystrophic type. The classes are recognised by the characteristics of the natural vegetation. It is not claimed that the scheme is perfect; nor is it suggested that it necessarily has relevance outside a forestry context but it has the merits of simplicity and usefulness in practice.

There are very few nutritional problems with Sitka spruce on eutrophic peat. Only small areas of dystrophic peat have been planted in the past and this type is no longer planted with spruce. Deficiency of potassium (K) is the main nutritional problem on mesotrophic (semi-flushed peat, but this is fairly easily identified and overcome. Also it has been suggested (O'Carroll *et al.* 1973) that K deficiency may become less acute as the trees increase in size. The biggest problems both in extent and severity occur on oligotrophic peat (unflushed blanket bog) (Dickson and Savill, 1974) and the remainder of this paper deals with this topic.

Present situation regarding Sitka spruce on oligotrophic peat

The basic problem in the nutrition of Sitka spruce planted on oligotrophic peat is centred on nitrogen (N) availability. Although the total N content of the peat is relatively high, the amount which

[1] Department of Agriculture, Agricultural and Food Chemistry Research Division, Belfast, Northern Ireland.

can be utilised by the trees at any one time is limited. Provided that sufficient phosphate is made available, Sitka spruce will grow quite satisfactorily on oligotrophic peat until the mean height of the crop reaches about 2.5. m. Thereafter growth under present management techniques becomes limited by N deficiency. The onset of N deficiency appears to be independent of age and occurs at about the critical height of 2.5 m. irrespective of whether the trees have spent some years in check through having insufficient fertilizer P at planting or whether they have reached the same height without interruption in from 6–8 years. It has been suggested that the reason for this N deficiency is that as the trees increase in size so also does the total N requirement. Unfortunately, the rate at which the N in the peat is made available to the trees by the activity of soil micro-organisms cannot keep pace with this increased demand by the trees and growth rate falls. This general pattern of reduced N uptake with time either from planting or after treatment of checked trees is typical of all spruce plantations on upland deep oligotrophic peat.

The future

There are two distinct situations facing the forest manager in dealing with oligotrophic peat:

A. The existing plantations of Sitka spruce which have had sufficient P for the foreseeable future but which are liable to N deficiency.

B. Afforestation of bare ground.

The options available are different in each situation and some are discussed below.

A. Existing plantations

Nearly all state-owned plantations in Northern Ireland have been adequately fertilized with P either from ground based machine or helicopter. Courses of action to overcome future N deficiency are limited by the physical presence of the trees but include:

1. Application of fertilizer N at intervals until the end of the rotation.
2. Improvement of existing drainage pattern in the hope that increased aeration will lead to greater activity of soil micro-organisms and hence an increased rate of N mineralisation.
3. Application of lime to decrease acidity of peat for same reasons as in 2.
4. Inter-planting of existing Sitka spruce with a "nurse" crop.
5. Removal of all or some of the spruce and replanting with a less nutrient demanding final crop species.

These options will be discussed in turn.

A1. Repeated application of fertiliser N

Before embarking on a committment to repeated application of fertilizer N the manager must know (1) what fertilizer to use, (2) how soon after planting to start application, (3) how frequently to apply it and (4) how much to apply at one time.

In Northern Ireland urea has been found to be as effective as any other commercially available N fertilizer. Its high N concentration (46%) makes it particularly suitable for aerial application.

Application of N before the onset of acute deficiency, when the trees are about 2.5 m high, is wasteful. Prior to this any apparent N deficiency will probably be associated with P deficiency and both can be effectively overcome by P application.

The response of N deficient Sitka spruce to applied urea is relatively short-lived. Height growth generally reaches a maximum 2–3 years after application and falls to pre-treatment levels in a further 2–3 years. This patterns, of course, may change as crops get older. On present evidence the longest interval between applications consistent with an acceptable growth rate seems to be about 5 years.

The currently recommended rate of application is 250 kg urea/ha (115 kg N/ha). Higher rates have been tried to see if response time can be extended but excessively high rates can damage and actually kill the trees. Annual growth in a 10 year old crop of Sitka spruce in the first and second seasons after the application of a range of urea applications is shown in Table 1.

TABLE 1

Beaghs 24/75

Height growth (cm) of Sitka spruce in first and second years after urea application

Season	Rate of Application (Kg N/ha as urea)			
	0	200	400	600
First	13	19	11	13
Second	32	49	36	29

Obviously rates of urea supplying more than 200 kg N/ha are detrimental to the growth of Sitka spruce at least in the years immediately following application.

A2. Improvement of existing drainage

The digging of a drain has two results—a ribbon of spoil above and a furrow below ground surface. Until recently it appeared that the volume of spoil above the ground had a bigger effect on the growth and N uptake of the trees than had the depth or spacing of the furrow (Savill *et cl.* 1975). However some recent results suggest that the drainage effect *per se* becomes increasingly important as the crop gets older. This is illustrated in Fig. 1. By the end of the eleventh growing season the poorest growth and lowest foliar N concentration (0.93% DM) was in the plots drained at planting with only the DMB (double mould-board) plough and the best in the most intensively drained treatment—DMB ploughing with 0.9 m. deep drains superimposed at 7.5 m. intervals. The surprising fact is that growth and foliar N concentrations (1.20% DM) are so good in the SMB (single mould-board) only treatment. Have we been too cost-conscious in our attitudes to ploughing?

A3. Application of lime

The average pH of oligotrophic peat is about 3.2–3.5. In normally productive agricultural soils it is usually between 5.5 and 6. Many of the soil microorganisms active in breaking down organic matter and consequently releasing N are most active at between pH 5 and pH 6. It might be assumed that if the pH of the peat were adjusted to nearer this value then the N status and growth of planted Sitka spruce would be improved. Unfortunately, it is not quite as simple as this. It is relatively easy to raise the pH of the peat surface to the

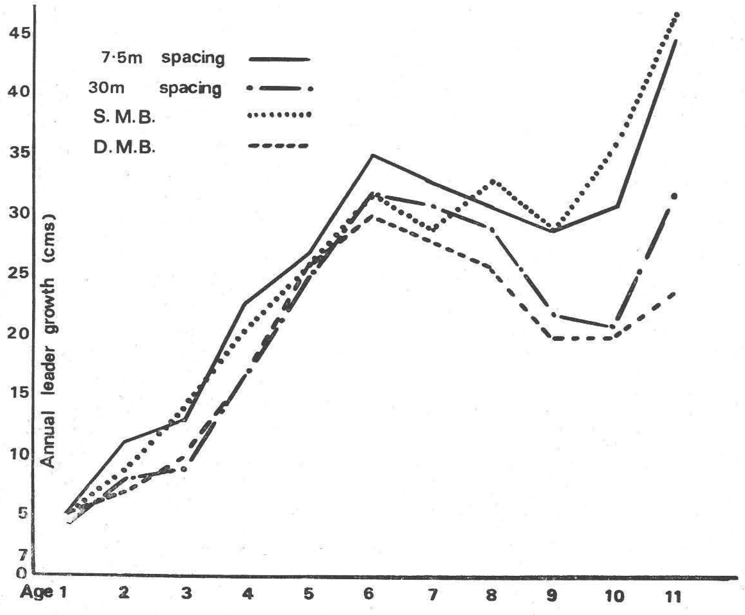

Figure 1. Effects of drain spacing and type of ploughing on growth of Sitka spruce.

required value by applying ground limestone at rates from 5–10 tonnes/ha (Dickson, 1972) but the trees take a long time to respond favourably to this treatment. A series of experiments has established that lime applied at planting reduces annual height growth of Sitka spruce on oligotrophic peat for about 6 years but there are indications that after this period, growth is increased by liming. The results of one such experiment are illustrated in Fig. 2.

A4. Inter-planting with "nurse" species

A traditional method of dealing with the establishment of a nutrient demanding species on a "difficult" site was to inter-plant a "nurse" species with the eventual maincrop species. This practice has largely died out because of practical management difficulties but there is evidence that admixture of N-fixing species such as broom, whin or alder and deciduous species such as Japanese larch leads to a considerable increase in N uptake and growth of Sitka spruce (see Carey, M. L., this issue). However attractive the idea of getting "free" N from a nurse crop may be it is unlikely to be a final solution because of management difficulties and the fact that the spruce crop will probably need supplementary N through to the end of the rotation by which time most nurse species will have been shaded out.

A5. Removal of the Spruce crop

The ultimate choice is to regard the Sitka as a total loss, write-off its establishment costs and replant in whole or part with the less nutrient demanding coastal lodgepole pine (*Pinus contorta* Dougl). Experiments testing various ways of doing this have been established in Northern Ireland but no results are yet available. Such a course of action could be contemplated only after very careful consideration of all the factors involved—economic, scenic and even psychological.

These then are the options open to the manager in dealing with established plantations of Sitka spruce on oligotrophic peat. All involve considerable capital outlay—some more than others—but each involves a conscious management decision which must be adhered to. The difficulties in making the right decision now are made greater by the fact that the final outcome is not even yet known. Most plantations of Sitka spruce correctly managed since planting on oligotrophic peat are still relatively young. Statements to the effect that N will have to be applied every five years until the end of the rotation or any reference to eventual Yield Class can with present knowledge be little more than intelligent guesses.

B. New Planting

The question as to the afforestation of virgin oligotrophic peat is simple—should we continue to plant Sitka spruce or should we plant a vigorous strain of coastal lodgepole pine which is known to be able to produce a worthwhile crop on this peat type with considerably less fertilizer input. From our experience in Northern Ireland we know that it will be expensive to grow Sitka spruce on these sites but how does a high input—high output enterprise using Sitka compare with a low input–low output system using lodgepole pine?

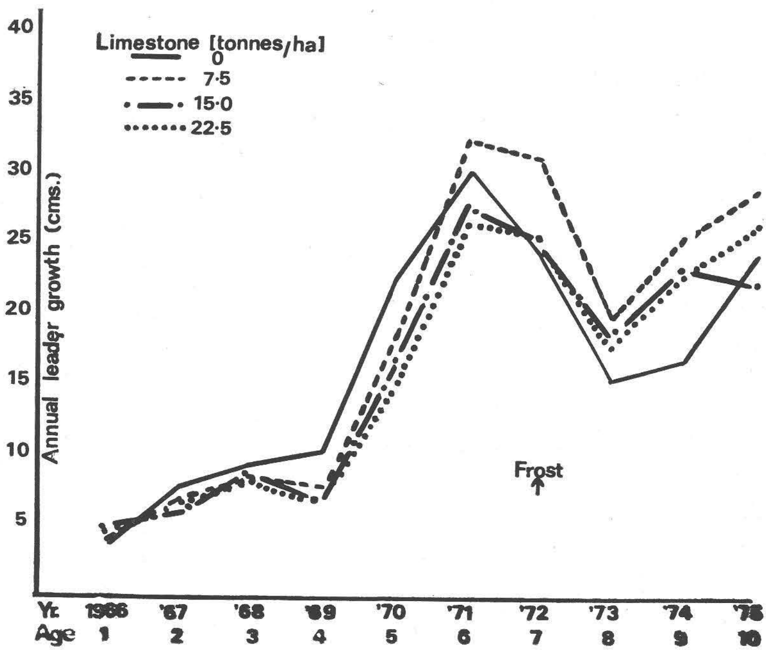

Figure 2. Effect of ground limestone on growth of Sitka spruce.

There is considerably more information on the growth of lodgepole pine on oligotrophic peat in the Republic than in Northern Ireland. However most of this information relates to low altitude bogs in the western counties. From the little information available it seems that lodgepole pine on most of the high altitude blanket peats in Northern Ireland is growing at a rate corrseponding to Y.C. 12 rather than Y.C. 16 or 18 which seems possible in Mayo or Galway. Such a difference has obvious economic implications.

If we make assumptions common to both species and use current fertilizer and applications costs the Net Discounted Revenue (N.D.R.) from plantations of Sitka spruce and lodgepole pine can be compared at different timber prices and Yield Classes.

From such calculations it can be shown that when the price per m^3 for the two species is the same, N.D.R. is higher with the pine at all Y.C.s from 10 to 18. However, given a price difference of £1 per m^3 in favour of its timber, N.D.R. is higher with spruce at Y.C. 16 and above. If the price difference reaches £2 per m^3 in favour of Sitka N.D.R. is bigger at Y.C. 12 and above. These conclusions of course are dependent on certain assumptions and on the fact that a rotation of 45 years can be achieved with both species on oligotrophic peat without serious windthrow damage.

So if Sitka spruce can be grown at least at Y.C. 16 and if the timber fetches at least £1 per m^3 more than lodgepole pine then it is cheaper to grow the former—even with a high input of fertilizer N. How much cheaper would it be if this input of fertilizer N could be avoided? Before this can be achieved a great deal more will have to be done to improve the physical and chemical conditions of the peat than has been done in the past or indeed is being done at present. In brief, the water-logged, acid and practically sterile virgin peat will have to be changed into a better aerated non-acid medium with an active population of soil microorganisms which can mineralise the native organically bound N in the peat and make it available to the trees. How best can such improvements be obtained?

The individual benefits of liming and deep intensive drainage on the growth of Sitka spruce on oligotrphic peat have already been outlined. Although both treatments increase growth, neither alone has brought about the dramatic changes required. The results of an experiment at Springwell forest suggest a technique which may just achieve the desired breakthrough.

The experiment was laid down in 1962 when hydrated and ground lime were applied at rates of from 0–25 tonnes/ha. Half of the area was rotovated just after lime application. All plots were ploughed with a S.M.B. plough at planting in 1968. In 1971 rock phosphate was applied at 500 kg/ha and after visual symptoms of severe K deficiency developed in 1973, 250 kg KCI/ha was applied.

Annual height growth in the non-limed and 5 tonnes/ha hydrated lime treatments over the first 8 years is shown in Fig. 3. In the ploughed only plots, liming had the effect previously described *i.e.* an initial reduction in growth over the first 6 years followed by a slight increase over the unlimed treatment. The exciting feature of the data in Fig. 3 is the very good growth of the trees in the lime plus rotovation treatment. Although rotovation without lime has improved growth over the standard treatment. in the combined treatment the annual height growth in the eighth season is over 75 cm. and foliar N concentrations are considerably higher (1.42% D.M.) than in the unrotovated control plot (0.88% D.M.).

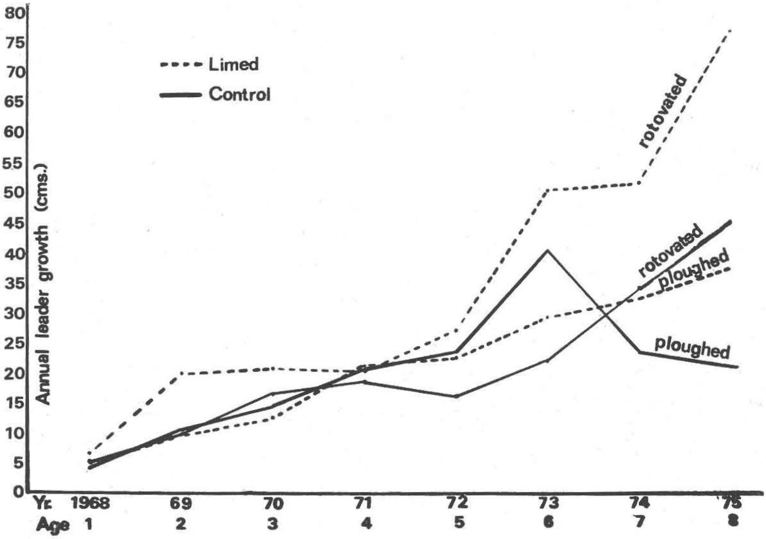

Figure 3. Effect of liming and rotovating on annual leader growth of Sitka spruce, Springwell Forest.

Admittedly this crop is still too young to speculate on the ultimate effect of the lime plus rotovation treatment but in conjunction with deep S.M.B. ploughing it is certainly a considerable improvement on previous establishment techniques. An interesting fact is that the vegetation in the lime plus rotovated plots is largely dominated by soft grasses and herbs whereas in the non-rotovated plots *Calluna* and associated species have largely re-colonised the ground, even where high rates of lime were applied. This suggests that a fairly profound change in the physical and chemical conditions of the peat has taken place. Hopefully the change is big enough and will last long enough to allow the crop to reach maturity without repeated inputs of fertilizer N.

Conclusions

1. On present evidence and using current techniques Sitka spruce will not form a merchantable crop on oligotrophic peat without repeated inputs of fertilizer N.

2. Given a price differential of at least £1 per m^3 of timber in favour of Sitka spruce compared with lodgepole pine the former species will give a higher N.D.R. if it can be grown at Y.C. 16 and above.

3. It *may* be possible to grow Sitka spruce on oligotrophic peat without repeated N fertilization to Y.C. 16 if enough ground preparation work is done before planting.

4. Tentative prescription for growing Sitka spruce on oligotrophic peat.

(a) Apply lime+P (as Superphosphate)+KCl.
(b) Plough deeply with S.M.B. plough (or tunnel plough if suitable).
(c) Rotovate between plough ribbons.
(d) Plant at no less than 2.4×2.4 m. or equivalent.

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Nutritional Disorders in Sitka Spruce in the Republic of Ireland

M. L. CAREY[1]

THE main nutritional problems that are encountered in growing Sitka spruce (*Picea sitchensis* Bong. Carr.) are associated with the three major nutrients, nitrogen, phosphorus and potassium. In general the species can be successfully established on a range of site types, from the oligotrophic peats of the West (blanket bogs) and Midlands (raised bogs) to the podsolised soils derived from Old Red Sandstone in the south of the country, providing phosphorous is applied at planting. The present recommendation (O Carroll, 1975), is to broadcast 500 kg/ha of rock phosphate, supplying 72.5 kg of P/ha, on land which, prior to afforestation, was unenclosed and was never used for intensive agriculture. On land which had been used in the past for agricultural cropping, but which had deteriorated somewhat in fertility due to being abandoned for a number of decades or to some other cause, the recommended rate of application is reduced to 250 kg of rock phosphate per hectare (36 kg P/ha). Such sites frequently carry a vegetation dominated by *Ulex* or *Pteridium*. On areas where agricultural cropping has been abandoned only in recent years, phosphate application is not considered necessary. A further series of experiments has recently been established across a wide range of sites in order to refine these prescriptions.

Although good growth of Sitka spruce can persist even on the more impoverished sites, such as the oligotrophic peats and the Old Red Sandstone podsols, it often falls off markedly, ultimately reaching a checked condition after 6-7 years. In most situations the reason for this decleration in growth can be attributed to the low level of available nitrogen in the soil resulting from such factors as high acidity, low biological activity or, in the case of the mineral soils, an almost complete lack of organic matter. The problem appears to be accentuated in some situations by the presence of *Calluna vulgaris* which may decrease the availability of whatever nitrogen is present (Handley 1954). Although in some instances a second application of phosphate has had the effect of reviving such crops and taking them out of the checked condition, this treatment was effective only in situations where the original quantity of phosphate applied was less than the present recommended rates.

1. Research Branch, Forest and Wildlife Service, Dublin.

The problems of nitrogen nutrition of Sitka spruce on oligotrophic peat are in many respects similar to those in Northern Ireland but perhaps not quite as acute. The lower elevation of the western bogs and the higher input of cations in precipitation, relative to more inland areas in Northern Ireland, ultimately results in a tendency towards less acidity and a greater "flushing effect" in the peat, reflected perhaps in the widespread occurrence of *Schoenus nigricans*. This species is normally associated with fen conditions. Whatever the reasons, in practice the forester may succeed more often in growing Sitka spruce satisfactorily relative to his counterpart in more northern, and climatically colder areas.

Before leaving the problems of nitrogen nutrition on oligotrophic peat, it is worthwhile to refer briefly to a plantation of Sitka spruce established in 1970 on what was formerly a raised bog near Ballinasloe in east County Galway. This bog, which varies in depth from 2-5 metres was drained, fertilised, rotovated and sown with a grass clover sward by the Irish Sugar Company in the late nineteen fifties (see *Irish Forestry* 19 (2) 1962, p. 175). During the 1960s grass was harvested from the area and it was also used for sheep grazing. In 1970 the bog was abandoned for agricultural usage, acquired by the Forest and Wildlife Service and planted with Sitka spruce, following double mouldboard Cuthbertson ploughing. Although the crop suffered severe damage from autumn frost in September 1973 it has recovered remarkably and now has a top height of 3.7 metres and a projected yield class of 24m^3/ha/annum. Although one can be criticised for estimating production after 7 growing seasons, a smaller strip of the same bog which was planted with Sitka spruce in 1962 has a similar yield class now after 14 years. The performance of this plantation to date, and its present healthy condition, (N concentration of 1976 needles, 2.3% D.M.), clearly illustrates that the problem of nitrogen deficiency on oligotrophic peat can be solved and that high production rates are attainable. Although the inputs necessary to achieve these may appear prohibitive they must be weighed against the fact that the projected yield is 4-8m^3/ha/annum above that obtainable for Lodgepole pine (*Pinus contorta* Dougl.) on oligotrophic peat.

After oligotrophic peat the biggest nutritional problem affecting the growth of Sitka spruce arises on soils derived from Old Red Sandstone. This formation dominates the geology of the south an south west of the country and soils derived from it account for about 25% (75,000 ha), of the present forest area. In general, soils derived from Old Red Sandstone that are acquired for afforestation, are very impoverished. They are strongly podsolised and compacted, very acid in reaction (pH 3.5-4.0), and extremely low in available nitrogen and phosphorus. Due to the low levels of organic matter, the result very often of scrawing activities by man over the years for fuel, the total reserves of nitrogen are also generally extremely low.

In practice the problem of compaction is dealt with by tine ploughing or ripping to a depth of 60-90 cm. This has the effect of shattering the indurated layer and the iron pan, where present and generally loosens up the soil profile, thereby improving aeration and drainage. Phosphorus deficiency is remedied by broadcasting ground rock phosphate at a rate of 500 kg/ha. These operations, that is cultivation and the addition of phosphate, ensure the successful establishment of the crop but within a short number of years growth falls off, as on the oligotrophic peats, due to a lack of available nitrogen. Although it would appear to be a relatively easy solution to apply fertiliser nitrogen and restore tree growth to a satisfactory level, the cost of such an operation is high and, because of the porous sandy nature of the soils, the response would very likely be even more short term than on oligotrophic peat. In practice it has been found that the addition of fertiliser nitrogen in the year of establishment may result in high plant mortality.

The alternative to applying fertiliser nitrogen on these soils and for that matter on oligotrophic peat, is to grow leguminous plants, such as clover and broom, in association with the trees in order to improve soil nitrogen status. This nitrogen may then be passed on to and utilized by the trees. An experiment, which was designed to test this hypothesis, was laid down by O'Carroll (1972) at Cappoquin forest on a peaty podsolised gley soil derived from Old Red Sandstone in 1961. The treatments, which are given in detail by Dillon *et al.* (1977) included different combinations of liming, complete ploughing, basic slag and potash magnesia. The legume species tested included a mixture of broom (*Cytisus scoparius*), and the tree lupin (*Lupinus arboreus*). Although the lupins grew well in the early years and bore large root nodules, they were all dead by 1966 and their place was taken by the broom which continued to grow vigorously. By 1970 the trees in the experiment, which had shown promising results in the early years, had reached a checked condition irrespective of treatment. In 1971 the whole area was treated with 625 kg/ha of rock phosphate and 250 kg/ha of sulphate of potash. This had the effect of increasing tree leader growth very significantly in the legume plots only (Table 1). Because of the fact that Sitka spruce does not respond to potassium application on Old Red Sandstone derived soils, it is assumed that the response in growth was due to the phosphate application. Furthermore, the reason why the growth response was obtained in the legume plots only is because of the fact that the other factor limiting growth on this site, nitrogen, was in adequate supply in these plots. The trees in the plots without legumes did not respond to phosphate application because they

Table 1: The effect of legumes on the growth of P/61 Sitka spruce. Cappoquin Forest.

	Leader Growth (cm)	
	1973	1974
No legumes	20	27
Legumes	41	69
L.S.D. (5%)	5	

were still limited by nitrogen deficiency. The overall conclusion to this experiment so far is, therefore, that Sitka spruce can be grown satisfactorily on Old Red Sandstone soils, providing adequate phosphorus is applied and a continual supply of nitrogen is available.

The common furze or whin, *Ulex gallii,* a naturally occurring species, also has the capacity to fix atmospheric nitrogen. Invariably where phosphorus has been applied and *Ulex* is present on Old Red Sandstone soils, the growth of Sitka spruce is vigorous. This is presumably due to the increased nitrogen supply resulting from the presence of the Ulex. It is not known yet to what extent the species can, in fact, fix atmospheric nitrogen or indeed if it is achieving its maximum potential in this respect on these soils. If the experience of the agriculturalist with clover is anything to go by then a lot remains to be learned. At the experimental level *Ulex*, broom and white clover are now being tested further as sources of nitrogen for not only Sitka spruce, but also the even more demanding species, Douglas-fir (*Pseudotsuga menziesii*), on these soils.

Finally, before leaving the problem of nitrogen nutrition on Old Red Sandstone soils, reference must be made to the possibility of using nurse tree species such as alder (*Alnus*), birch (*Betula*), larch (*Larix*) or pine (*Pinus*) in order to improve the environment for Sitka spruce. Although *Alnus incana* has been tested experimentally, and is known to have nitrogen fixing properties, it has so far failed to improve the growth of the spruce and if anything tends to decrease it due to its own vigorous nature. It is intended to test another species of alder, *A. crispa,* for its potential in this regard. This is a pioneer species in Alaska where it is usually succeeded by Sitka spruce naturally. The only other species which has been tested and has actually produced positive effects on the growth of Sitka spruce is Japanese larch (*Larix leptolepis*), although it is not known to fix nitrogen (O'Carroll, N., Forest and Wildlife Service, Bray, Co. Wicklow, personal communication). Although the Sitka spruce/ Japanese larch mixture is not put forward as a solution to the nitrogen problem on Old Red Sandstone forest soils it does provide the forest manager with an alternative to Lodgepole pine in these situations.

The other areas that have presented nutritional problems in the early stages of the rotation for Sitka spruce are the eutrophic or fen-type peats, which are mainly confined to Midland areas. Here the main soil factor limiting growth is potassium and neither nitrogen nor phosphorus application are necessary. In fact it has been found on a number of these sites that phosphorus application decreases growth significantly (Table 2), for reasons which are so far unclear. Induced zinc deficiency has been suggested as a possibility. The eutrophic peats, which have a pH in the region of 4.5-5.0, are extremely low in available potassium. Their susceptibility to drying out during the growing season, occurrence in areas with a low content of potassium in the rainfall (O'Carroll and McCarthy, 1973), and relatively high calcium levels, probably accentuate the problem. Excellent responses in growth are obtained when potassium is applied, the recommended rate of application being 250 kg/ha of muriate of potash supplying 125 kg of potassium (O'Carroll, 1975).

Table 2: The effect of Sulphate of Potash (K) and Ground Rock Phosphate (P) on the leader growth (cm) of Sitka spruce, in the fourth growing season on eutrophic (fen) peat.

	0 kg P/ha	87 kg P/ha
0 kg K/ha	14	14
100 kg K/ha	24	22
200 kg K/ha	27	35
300 kg K/ha	34	28
S.E. 2.9.		

There are few nutritional problems associated with the establishment and early growth of Sitka spruce on the other major forest soils, where the levels of available nutrients appear adequate for tree growth. On the gley soils in the north west (Cavan/Leitrim) there are some indications, after three years growth, that Sitka spruce may respond to both phosphorus and potassium application. However, the effects are small and may be short term. Dillon (1968) found that a high yielding 15 year-old crop of Sitka spruce growing on a heavy gley soil did not respond to either nitrogen, phosphorus or potassium application.

The possibility of increasing production through fertiliser application in semi-mature or polestage forest crops can be a highly attractive economic proposition because the return from the money invested comes much sooner compared with an investment made at the establishment stage. Because of the fact that a large area of the

Sitka spruce present in the country was established over the period 1930-1950, before the use of fertilisers as establishment became standard practice, it was thought in the early nineteen seventies that such crops might show a large response to fertiliser application. This was despite the fact that the land acquired in those years was probably of a somewhat higher quality than that acquired more recently. The problem was to find out what areas would respond best to fertiliser application and, secondly, what nutrient and quantity of that nutrient was best applied. No relevant soil maps were available to serve as a basis for laying down the experiments representatively. Accordingly O'Carroll (Forest and Wildlife Service, Bray, Co. Wicklow, personal communication) decided to establish a series of 26 experiments at random across the yield class range of the species for all stands greater than 4 ha in extent planted between 1925 and 1940. Although the processing of the results from this series of experiments is incomplete, there are some very encouraging and somewhat unusual trends in the data so far.

The reason why fertiliser application increases growth in certain polestage crops, and not in others, raises a number of important questions. First of all, are those crops that are responding positively doing so because of the fact that their basic soil nutrient reserves are exhausted, or, is it because large quantities of nutrients previously taken up, are being immobilised within the forest floor in the litter layers? Measurements in typical Sitka spruce polestage crops have shown that the litter layers may contain up to 1000 kg of nitrogen, 50 kg of phosphorus and 150 kg of potassium (Carey, 1977). The litterfall in comparable crops arverages about 4500 kg DM/ha/annum and contains approximately 68 kg of nitrogen, 6 kg of phosphorus and 14 kg of potassium. The interesting feature with regard to these figures for litterfall, when considered in conjunction with the input from precipitation, is that they coincide reasonably well with the estimated annual uptake of N, P and K in a 33 year polestage crop of Sitka spruce at Glenmalure forest in Co. Wicklow (Carey, 1977). Do these data suggest therefore, that if the reserve of nutrients in the soil is adequate in the early stages of the rotation, Sitka spruce will ultimately satisfy its own nutritional requirements through recycling? The answer to this question depends on the rate with which the litter in the forest floor decomposes and releases its nutrients. In the relatively mild climatic conditions which we experience in Ireland this is probably influenced by stand density as much as by any other factors. Work carried out by Wright (1957) on Norway spruce in Britain is interesting in this regard. He showed that the heavier the grade of thinning the greater was the decomposition of the litter on the forest floor.

Because of the steep rise in fertiliser prices and the limited nature of soil nutrient resources, it is essential that a better understanding be achieved of the nutrient cycle in man-made forest crops and of the degree to which it can be influenced by various silvicultural operations. If Wright's figures are anything to go by, then clearly there is considerable scope for manipulating the accumulation of litter and its rate of decomposition by thinning operations alone. This has also been found by Miller *et al* (1975) working with Douglas fir in America. However, the hypothesis needs testing under tightly controlled circumstances for Sitka spruce growing under Irish conditions and the best management system for these crops must also take into account other factors such as harvesting policy and the price of the end product in addition to the cost of fertiliser materials themselves.

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Discussion following the papers of D. A. Dickson and M. L. Carey

CHAIRMAN: **N. O'Carroll**

Mr. Kilbride asked Dr. Dickson how long a dressing of 7.5 tonnes/ha of lime would influence the pH of the peat. **Dr. Dickson** said that the effects of lime were very marked 13 years after application; he considered that one or perhaps two applications over a rotation would be enough.

Mr. Duane thought that the method of deep ploughing recommended by Dr. Dickson could lead to considerable problems of access in later years. **Dr. Dickson** agreed with this, but said that if nitrogen were to become available to the trees deep ploughing is necessary. **Mr. Carey** added that evidence from Glenamoy indicated that where tunnel ploughing had been carried out, tree rooting was much deeper than with conventional methods, the trees remained healthy and access was not a real problem.

Mr. Brosnan wondered why Dr. Dickson had not recommended heather control as a method for stimulating Sitka spruce growth on peat. In reply, it was stated that killing heather, like applying urea, can improve growth but the main nutritional problems arise after canopy closure when all ground vegetation is dead.

In discussing the relative merits of Sitka spruce and Lodgepole pine on oligotrophic peats, **Mr. Condon** asked whether, as had been suggested, there was firm evidence that pine could be successfully grown on these sites. **Mr. Carey** replied that the oldest coastal pine was planted in 1952 at Cloosh Valley. The crops seemed to be growing successfully but tended to have rather undesirable form. **Dr. Gallagher** considered that pine could be grown well on low elevation peats but at higher elevations there might be more problems as these sites are windier and form might suffer more. One of the supposed advantages of Lodgepole pine is its ability to root more deeply than Sitka spruce, but **Dr. Farrell** stated that in recent work at Glenamoy he had been unable to detect any difference in the rooting depth of the 2 species, though it is difficult to measure this with any great degree of accuracy.

Dr. Gallagher said that if, due to instability, reduced rotations were necessary, the effect of this on net discounted revenue favoured Lodgepole pine. He added that Mr. Carey's observation on the effect of stocking density on the rate of litter decomposition was a field which needed more research.

Mr. Carey had indicated that the growth of Sitka spruce on some soils could be improved if it were planted in mixture with other species and **Mr. Maher** suggested that mixtures of pine and spruce would be valuable pioneer crops on peat. Several speakers thought that such mixtures would be very difficult to manage however. **Mr. Bulfin** suggested that on some soils Sitka spruce/larch mixtures might be better. They would be easier to manage and had the advantage of allowing more light to reach the forest floor.

Utilisation of Sitka Spruce in Ireland

G. KNAGGS[1]

Introduction

IF one accepts that the primary purpose of forestry is to produce a crop of timber giving maximum returns to the grower, one must select a tree species which will both grow rapidly on available sites and produce material which is readily sold. In Ireland, Sitka spruce has occupied this role as a high-yielding species on poor soils and is now the dominant species in our forests. As these forests mature the output of spruce will increase greatly. Productivity forecasts clearly demonstrate the longterm importance of spruce to Irish wood-using industries (see Purcell, this issue). I therefore propose to look at the outlets for this material vis-a-vis its properties and necessary processing. To do so, the value of the final product must be considered. Whereas pulpwood may fetch up to £10/m^3, the value of sawlogs can be up to £30/m^3, yielding structural saw timber worth £90–£100/m^3.

Markets

1. Pulpwood. The major outlet for small diameter logs, thinnings and sawmill residues is as a raw material for the production of chipboard, hardboard and paper pulp. The turnover in these industries, almost entirely based on homegrown raw material, was approximately £10m. in 1976.

For all these industries, Sitka is an ideal raw material, being readily pulped or chipped, and pale in colour. While chipboard, hardboard and mechanical pulp plants can be expanded in stages at a reasonable cost, the introduction of a chemical pulp plant, comparable to the installation at Fort William in Scotland, would require some 300,000m^3 of raw material to produce 80,000 tonnes of pulp per annum. This, regarded as the minimum size for economic operation, is equivalent to almost the entire spruce smallwood available in 1982/83. Bearing transport costs and the competition for supplies with present plants in mind, it will clearly be quite some time before an investment of this nature can be considered. Investment in the other pulpwood industries will thus be essential to ensure full utilisation of the supplies becoming available in the near future.

2. Posts and Poles. In the past, Sitka spruce has been considered

1 Forest Products Department, Institute for Industrial Research and Standards, Dublin.

unsuitable for this market due to (a), in common with most species, its inherent lack of durability when in moist conditions, and (b) the difficulty of successfully treating it with preservatives. Recent work at I.I.R.S. (Institute of Industrial Research and Standards) has succeeded in developing a method whereby spruce can be pre-treated so that full sapwood penetration with creosote or water-borne preservatives can be obtained. In this process, bacteria are introduced into the poles while in water storage. Pectinolytic enzymes secreted by these bacteria break down the pit membranes in cells, thus providing pathways through which the preservative can subsequently travel. It is confidently hoped that this will enable the imports of Scots pine poles for transmission lines to be entirely replaced by homegrown spruce. This could result in an import reduction of £750,000 annually.

3. Sawn Timber. At present the market for sawn "white deal" which includes the spruces, hemlock and true firs, is, at 424,000m^3, 68% of the total sawn softwood market, and is broken down as follows:

Category ...	Volume (m^3)	% of total market
Construction	310,000	47
Furniture	16,000	22
Pallets & Packaging	49,000	12
Do-It-Yourself	10,000	1.5
Fencing	20,000	3
Miscellaneous	14,000	2

This should be compared to the availability of sawn homegrown spruces of 45-50,000m^3 at present and a forecast of 100,000m^3 in 1982/83. (This assumes a yield of 60% sawn timber from round logs). There should therefore be no difficulty in finding markets for all available sawlog material in the foreseeable future, if this is accepted as a suitable structural material.

We must therefore consider the properties of homegrown Sitka spruce in relation to its utilisation as sawn timber. Studies at I.I.R.S., sponsored by the Forest and Wildlife Service, have shown that the strength properties of this material are slightly inferior to those of the "white deal" presently being imported. As the quality of timber being imported is tending to fall, whereas that of homegrown is rising, this difference *may* diminish significantly in the future.

The strength of any species of timber is closely related to its density. Much homegrown Sitka has a relatively low density, probably attributable to its often rapid rate of growth. In this instance, therefore, the requirements of a rapid growth for volume production, and a slower growth for maximum strength, are in opposition. Under visual stress grading rules a minimum of 4 growth rings per inch is specified for structural grades, more rapidly grown material being rejected for such purposes. Of necessity, however, these visual stress grading rules are conservative to ensure that all weak material is rejected. On testing, much of this material was found to be of adequate strength. To overcome this difficulty mechanical stress grading can be utilised. In this, the stiffness of each piece of timber is measured directly and due to the close correlation between stiffness and strength, the strength of each piece is measured. Thus any characteristics unacceptable under visual rules but found not to affect strength are ignored. Machine grading studies in Britain have shown that a yield of up to 70% of M75 grade can be obtained from Sitka spruce. This can compete directly with existing grades of imported material for such exacting end-uses as trussed rafters. In contrast, if visual grading were carried out, little if any material would reach 75 grade and up to 40% would be rejected entirely. (Grades: The prefix M indicates a machine grade and 75 indicates that the material has 75% of the strength of defect-free material).

Processing

To gain access to the high-value structural timber market for homegrown Sitka spruce market, it must be presented in a form in which it can stand comparison with imported timber. Three factors are of paramount importance in achieving this:

(a) *Moisture Content*. The moisture content of freshly felled spruce can exceed 200%. This must be reduced to a maximum of 22% for structural use in order to prevent subsequent excessive shrinkage and distortion and to prevent fungal attack. This can be achieved either by air or kiln drying. Air drying will take from 3-9 months depending on the timber thickness and time of year. Kiln drying, on the other hand can be completed in less than two weeks but necessitates the use of expensive plant and considerable quantities of heat energy. The processor must balance the cost of holding large stocks for considerable periods of time against these kiln-drying costs. Normally it will be found that kiln-drying is preferable where consistent quality is essential.

(b) *Sawing*. The building industry is today working to closer tolerances than ever before. Poorly sawn timber, which may need to be re-sawn or trimmed to fit, will not be accepted by the builder. Hence accurate sawing is essential for the co-ordination of structural timber with other building components. This is in the sawmillers own interest as his yield in log conversion will fall dramatically if excessive tolerances must be allowed. The utilisation of modern band-saw equipment, properly maintained and operated will do much to ensure a quality product at an economic processing cost as compared to out of date or poorly maintained machines.

(c) *Grading*. The purchaser must be able to rely on the consistent quality of the timber he obtains in order to utilise it to advantage. Inconsistency in this respect can only reflect on the quality of homegrown timber in general and will retard its general acceptance. If, however, these steps are conscientiously carried out then there is no doubt that homegrown Sitka spruce will replace imported timber to the extent that supplies permit.

Discussion following the paper of G. Knaggs

CHAIRMAN: **T. Clear**

To **Mr. Parkin's** inquiry about the relationship between the number of rings per inch and timber strength, **Mr. Knaggs** replied that visual grading may only class 4-8% of fast grown spruce as suitable for structural grades. Mechanical grading would give a higher percentage of suitable timber, He said there was a good correlation between density and strength of timber. **Dr. Dunleavy** commented that the more rings per inch (or laminations per inch, as in plywood) the greater the strength of the timber. He added that future research would include an examination of density patterns for different sites and environments. **Mr. Mooney** inquired about the effect of spiral grain on timber quality and asked whether spiral grain was pronounced in Sitka spruce timber supplied to I.I.R.S. for testing. In reply, **Mr. Knaggs** said spiral grain caused deviations from straightness, fissures on drying and twisting. Some evidence of spiral grain had been observed in lots of small-sized timber recently received for testing. However, in moderation, spiral grain was tolerable. In reply to a query from **Mr. O'Kelly, Mr. Knaggs** said that the cutter knife angle was critical in the planing of Sitka spruce. **Mr. Quinn** asked about the effect of knots on timber strength. **Mr. Knaggs** said that the effect of knots on timber strength depended to a large extent on whether the knot was under tension or compression when the timber was in position.

General Discussion

Chairman: **T. McEvoy**

Mr. Gallagher asked what was the reason for the high average yield class in Northern Ireland. In reply **Mr. Parkin** said that while a high proportion of plantations were on peat, there were some on clay soils giving very high productivity. **Mr. Wright** added that many of the younger stands on peat were growing at a fast rate, having not yet reached the stage when nutritional problems begin to arise. To a question from **Mr. Condon** concerning the best provenances for areas with a risk of Spring frost, **Mr. O'Driscoll** said that there seemed to be little variation in frost sensitivity *per se*, but it was hoped that the faster growing southern provenances would emerge earlier from the danger zone near the ground. **Mr. Bulfin** asked if fast grown crops were less prone to disease? **Mr. de Brit** in reply said that this depended on the organism involved. Generally plants growing in an optimum regime were more resistant to a wider range of organisms. In further discussion, **Mr. Dillon** observed that Sitka spruce was not basically a shallow rooting species. This impression is gained from observing wind blow trees in wet soils. Using a deep tunnel drain in peat rooting depth was more than twice that attained with orthodox ploughing. **Mr. O'Kelly** asked what were the consequences of planting on large ribbons and **Mr. Duane** suggested planting on top of the ribbon. In reply **Dr. Dickson** said that the young plant on top of the ribbon would be subject to exposure, and there might be difficulties about stability as the ribbon decayed. Some foresters had tried planting in a slot at the base of the ribbon. Stepping down the ribbon was regarded as too expensive. In a reply to a question from **Mr. Drea, Mr. Carey** said that experiments on complete ploughing in the Old Red Sandstone region had been disappointing. There followed a discussion on wood quality. **Mr. Glennon** inquired about the relationship between fertilization and quality. **Mr. Knaggs** said there was no direct evidence on this but very rapid growth produced a weaker timber, possibly of a lower grade. To a question from **Mr. Campbell, Mr. Knaggs** said that no more than about 10% of home grown Sitka spruce was below acceptable structural grades.

In his concluding remarks, the Chairman, **Mr. McEvoy,** pointed out that there was great scope for improving the efficiency of our forests in utilising solar energy by combining the efforts of various specialists. He referred to the value of pooling the information obtained in Northern Ireland and the Republic, and congratulated the Council of the Society and the organisers of the symposium.

Attendance List for Symposium

Antrim (9)
Dr. D. Dickson
J. E. K. Ellis
K. Hutchman
C. S. Kilpatrick
S. Milner
K. F. Parkin
J. M. Sanderson
P. Savill
W. T. Wilson

Cavan (5)
S. Carney
M. Friel
E. Johnson
M. Leonard
M. Walsh

Clare (4)
S. Carew
G. Tottenham
Mrs. J. Tottenham
R. Tottenham

Donegal (7)
C. J. Boyle
P. Doolan
J. Dufficy
N. Foley
J. J. Gatens
C. Jeffers
T. Mannion

Down (3)
P. J. McElroy
J. McEwan
W. McCloskey

Dublin (38)
T. Almack
I. Booth
G. de Brit
M. Bulfin
Professor T. Clear
P. Clinch
M. Collins
J. J. Deasy
J. Dillon
Dr. J. Dunleavy
Dr. E. P. Farrell
Miss L. Furlong
Dr. G. Gallagher
Dr. J. Gardiner
E. Hendrick
I. F. Products
Dr. P. Joyce
B. Lawler
J. J. Maher
D. Mangan
T. Moloney
O. V. Mooney
F. Moriarty
D. McAree
Dr. R. McCarthy
C. A. McCormack
T. McEvoy
D. McGlynn
M. MacSuirtain
M. O'Brien
Dr. N. O'Carroll
J. O'Driscoll
T. Purcell
F. Shekleton
M. Skehan
M. Swan
D. Sweetman
D. Ward

Fermanagh (3)
P. Carlin
M. J. Devine
C. I. Farmer
J. C. Phillips
W. J. Wright

Galway (6)
J. Cronin
J. Desmond
E. Lynagh
P. McArdle
E. McGuinness
M. O'Neachtain

Kerry (1)
J. Maguire

Kildare (3)
T. A. Barry
P. Crowe
J. D. Robinson

Kilkenny (4)
L. Condon
A. Finnerty
J. Healy
J. O'Riordan

Laois (2)
B. Collins
J. Prior

Limerick (3)
E. Larkin
M. O'Donovan
P. White

Longford (4)
L. Diffley
P. Glennon
C. Little
K. McLoughlin

Louth (2)
D. Brassil
T. J. McCarthy

Mayo (4)
M. Costello
A. O'Keeffe
P. O'Rourke
V. Ryan

Meath (2)
G. Harney
M. Cosgrave

Monaghan (3)
J. Finley
P. Fitzgerald
J. Fleming

Offaly (1)
M. Byrne

Roscommon (2)
J. Duane
J. McLoughlin

Sligo (2)
F. Drea
J. Freeman

Tyrone (3)
T. G. Archibold
J. Mackin
Maj. Gen. D. Moore

Waterford (2)
J. M. Doyle
N. Kavanagh

Westmeath (7)
P. Kelleher
J. J. Kelly
S. McNamara
L. O'Flanagan
J. Quinlivan
A. Schmidt
M. Sheridan

Wexford (8)
Dr. J. Durand
M. Fogarty
C. P. Kelly
J. Kilbride
E. Kingston
E. Morrissey
G. Murphy
J. O'Reilly

Wicklow (31)
J. Brosnan
P. Butler
M. Carey
W. F. Collins
J. Connelly
J. Crowley
M. Doyle
J. Duffy
J. Fennessy
J. Gillespie
S. Hayes
A. P. Higgins
P. Howell
E. Joyce
J. Kelly
E. Lynch
D. McGuire
J. Neilan
C. Nyhan
D. O'Brien
T. Ua Cearbhaill
C. O'Dea
P. O'Grady
P. O'Halloran
P. F. O'Kelly
G. Patterson
A. Pfeifer
W. Phelan
S. Quinn
C. Tottenham
F. Watson

Obituary

JAMES O'BRIEN
(1943—1976)

James O'Brien, Kilree, Bennetsbridge, Co. Kilkenny, was killed tragically in a motoring accident on the Athy–Castlecomer road on December 24th last. Jimmy, as he was popularly known to his family and friends, was born in Kilkenny City in 1943. He was the second eldest of a family of nine. He attended Sheestown National School and St. Kiernans College, Kilkenny. He later went to University Colleges Galway and Dublin where he obtained his B.Agr.Sc. (Forestry) degree. He joined the Department of Fisheries, Forest & Wildlife Service in January 1975 and served with Inventory Section, Research Branch up to the time of his death.

Like most of his countymen he had a keen interest in the game of hurling. During his school days at St. Kiernan's, he won junior and senior All Ireland Colleges medals as a corner back.

His colleagues and friends will always remember him for his sincerity and charitableness. At his burial Service the celebrant very aptly described him "as a person who went through life with a smile". His lightheartedness was always obvious.

On behalf of the Society of Irish Foresters and on my own behalf, I offer sincere sympathy to his family.

Thomas J. Purcell

Letter to the Editor

Dear Sir,

Statistics, it is said, can be manipulated to prove anything. The same it could be said to hold true for quotations. With this in mind I cannot allow the editorial comment in *Irish Forestry* (Vol. 33, No. 2) to lie fallow without comment.

Let me too, start with a quotation—a quotation from William James' book—*The Varieties of Religious Experience*—"Our normal consciousness, rational consciousness as we call it, is but one special type of consciousness whilst all about it, parted from it by the flimsiest of screens, there lies potential forms of consciousness entirely different".

Applied logic has its place: It is however not of greater importance than other means of perception. Many discoveries in science were spawned not from the application of scientific principles but through flashes of insight beyond the realms of logic. With vaulting righteousness we hold firmly to the belief that until an event can be proven mathematically it must be held suspect. Yet we accept that mathematical reasoning itself rests on the soft ground of supposition.

On the question of landscape, response to beauty appears to be a reflex action towards the recognition of symmetry and proportion—hence as the editor suggests, a modern aeroplane can be considered beautiful. On the question of function, a primeval forest is truly functional in the intricate workings of its tightly woven fabric. A modern forest block has an arrested function where the full expression of that landscape is suspended for the production of a limited objective. The amenity work carried out in these production forests, and which is so shallowly referred to in the editorial as a "sagging boundary here . . ." etc., are developments to relieve some of the visual starch of these production forest stands.

On the matter of forests and the general public the answer is unguardedly simple—the public are looking for "Beauty". We come to play. We come seeking the opportunity to be raised above our ordinary existence and to swirl around ourselves the great evolutionary tapestry at least for a few hours. And we come to walk the lonely forest roads with the wind and rain on our faces and to reflect in this honest and uncompromising world, on ourselves and on our private circumstances. And last of all, we come because we know not why—but we come for reasons beyond logic, for reasons that lie in our hearts beyond the expression of words.

And as I began, let me conclude with a quotation, a quotation from the German poet Goethe: "We should do our utmost to encourage the Beautiful, for the Useful encourages itself'..'

Yours faithfully,

P. MacOscair

Editor's Note: Due to the length of the Symposium proceedings other features have been held over to the next issue.

Society Activities

ANNUAL STUDY TOUR 1976

Tuesday 1st June

The first stop was at Coolnamuck property of Thomastown Forest (Forester in charge: S. O'Sullivan; Deputy: S. Doyle; Assistant: P. J. Walsh) where the group was welcomed on behalf of the Minister by Mr. L. Condon, Divisional Inspector, and Tour Leader.

Coolnamuck was planted in 1928-30, mainly with Douglas fir giving crops with yield class ratings of 16-20. The main output at present is electrical power transmission poles and a discussion centred on the costs of this activity.

Next, to Woodstock, to see the current developments in the restoration of the gardens and pleasure grounds formerly owned by the Tighe estate. We were joined by Messrs Chris Kelly (Arboriculture Section, Research Branch) and Ian Sherriff (Amenity Officer) who passed around coloured post cards showing the gardens in the full glory of their Victorian flowering. Unfortunately there are no plans to restore the flower beds.

The large pigeon house attracted great attention; the ranks of genuine pigeon-holes may have struck a note of sympathy in the hearts of the assembled Civil Servants.

After lunch the party stopped at Jerpoint Abbey, a monastic ruin founded in 1158, and partially restored in recent years. The local guide, Miss Hegarty, provided all the information that was needed.

The main business of the afternoon was the Castlemorres property of Knocktopher forest (Forester in charge: P. Crowley; Assistant: D. Magner). This area surrounds the great house (now in ruins) formerly owned by the de Montmorenzy family, and afforestation took place in the years after 1935. The fertile soil led to the use of a high proportion of broadleaved species and the resulting crops are now highly interesting, even if only for their rarity. They also present interesting silvicultural problems, for instance, how to prevent the development of epicormic branches on oak. Underplanting with western hemlock was suggested, but the continental European practice, involving the use of beech, was preferred for a number of reasons.

Cases of ink disease in Spanish chestnut were seen. Diarmuid McAree gave an account of the disease caused by the fungus *Phytophthora cambivora* which attacks the roots, causing the tree to wilt and die. The disease is characterised by an inky exudate from the roots and is controlled by improving the drainage.

A thirteen year-old clonal trial and a seventeen year-old plantation of poplars were visited. The best growth was attained by a clone of the Tacamahaca (Balsam) group.

It was suggested that a greater production of poplar wood for pulp might be obtained with a closer spacing than the 7 m used in the plantation.

A small spacing trial with ash was also seen and discussed.

Wednesday 2nd June

That the role of the Forest and Wildlife Service has considerably diversified in the past five years or so was again emphasised on this our second day of the Study Tour. Cappoquin Forest was our first venue. At Glenshelane Property adjoining the recently developed riverside picnic site we were introduced to the local forestry staff. Our theme for the day was to be "Problems of afforestation in the Knockmealdowns". Incidental to this topic we were also to gain a considerable insight into the amenity/recreational dimension of Forestry in the region. The amenity development at Glenshelane was an example of the contribution made by the Forest and Wildlife Service to the enhancement of the landscape and the provision of facilities for rural recreation and tourist enjoyment. As a public relations exercise, someone mentioned, this type of development yielded far greater benefits than those measured in N.D.R. or £ sterling.

At an unscheduled stop near "Barry Lyndon's cottage" on our way across the Knockmealdowns the problems of land acquisition in the region were described. Besides the obvious legal and land-use problems that one encounters here, the impoverished nature of the land acquired poses its own particular difficulties. The soil is an intractable podsol derived from O.R.S. Its nutrient status is low and therefore the choice of species to work with is limited. At Boggaduff property we saw how these problems were now being researched. Considerable interest was shown in the nutrient trials and the species trials there. The main problem it seemed was one of a continual nitrogen supply to the planted crop. Sitka spruce went into check on these O.R.S. non-peaty soils due to the unavailability of N, even though its phosphate requirements were satisfied. Research has shown that N may be supplied by leguminous species such as broom, lupins or Ulex. The nutrient may also be supplied in fertiliser form but this is expensive. The main questions under examination were:

(a) How long must the N supply continue?

(b) How much needs to be supplied?

Lodgepole pine grows on these soils with phosphate but without additional N.

The relative growth performance of coastal L.P., Noble fir and Japanese larch were discussed. These three species seemed best suited to the site conditions there. The ameliorative effect of Japanese larch on the soil was discussed and its visual impact on the landscape noted.

Onwards now to The Vee where, under the shadow of Colonel Grubb s upright grave, we discussed the impact of forestry on the landscape. This traditional viewing point commanded a superb view of the Suir Valley and the Golden Vale until the newly planted forest obliterated the vista and left its enjoyment solely to Col. Grubb. Forestry came under severe criticism for this misdemeanour and steps have since been taken to rectify the situation. Amongst the remedial measures practised were the selective thinning of trees to give a see-through effect, the clearfelling of a tree belt adjacent to the road edge and an attempt to plant some native hardwoods in order to enliven the monotonous landscape pattern. We were given a remarkable account of Col. Grubb's career and never did I think that the upright stalwart behind us had been such a character in his day!

After lunch we travelled to Mount Anglesby Property, Clogheen Forest and saw quite vividly why *Rhododendron ponticum* is such a problem in this region. The successful use of 2-4-5T as an eradicant spray was described and demonstrated. Its proper use does not, we were told, constitute an environmental hazard.

A survey was now underway to quantify this problem which is one of the major constraints on forest management in the area. Yield figures quoted for two Scots pine stands in the property differed remarkably and brought into question whether soil survey data should form the basis for production forecasting. The soil here was an indurated iron pan podsol but was yet able to produce seed-stand quality Scots pine. One felt that interest in genetically proven S.P. could be restimulated on the basis of its performance here.

Our final stop for the day at Kildanoge property Knockmealdown Forest was indeed a memorable one. It started with "whatever you were having"—a small one or a bottle—laid on by courtesy of the local gun club. We were then shown how the area had been developed as a wild-fowl habitat and were given a very interesting account of grouse management in the Knockmealdowns. What practical co-operation and good-will between the F.W.S. and a local gun club can achieve was clearly demonstrated here. The area was managed for mallard rearing prior to its acquisition for forestry in 1974. There was some concern that the entire area would be ploughed and planted and that the gun club would be excluded from the property. However after an initial "grousing" session an amicable agreement was reached whereby the F.W.S. left unplanted the area adjoining the pond. An expansion of the wildlife habitat area was undertaken by artificially creating three more ponds. A wide variety of conifer and broad-leaved trees were also planted, to provide shelter and improve the insect life of the area. It is also planned to increase the pH of the water with broken limestone in order to encourage plant and insect life and thereby improve the feeding for wildfowl. The grouse development locally does not conflict with forest management. Proper heather management for grouse, we were told, and indeed for sheep also, means burning the heather on a 10/12 years rotation in narrow strips or belts not more than 30 metres in width. Our day finished, literally and physically, on a high note. We had a fly-over with dipped wings by the elusive mallard. Their plans to settle on their newly created wildfowl habitat must have been thwarted by the vocal chords of local gun club impressario Peter Butler, and of Liam Condon as they vied with one another to plough the Rocks of Bawn and praise the Bould Thady Quill!

Thursday 3rd June 1976

The President, Dr. P. Joyce opened proceedings for the day by nominating Mr. T. Mannion as Chairman of the morning session at Rocketts Castle car park and picnic site. Mr. Ned Gaffey, District Inspector, Mr. E. Cunningham Assistant District Inspector and Mr. J. P. O'Donoghue, Forester-in-Charge, Curraghmore, were introduced and the party moved on to the Wildlife Sanctuary at Coolfin.

Mr. D. Scannel, Wildlife Inspector gave a brief history of the area stating that this was originally a salt water marsh and reclaimed by building embankments along the river Suir. A flock of 110 to 160 greylag geese winter in this area and the local gun club are anxious to protect them.

The next stop was at Curraghmore Forest where Mr. Gaffey said that 2,000 acres here were leased from the Curraghmore Estate in the early thirties. Norway spruce and Scots pine were the main species planted and an interesting discussion ensued on the incidence of spiral grain in Norway spruce.

Sawn planks from a tree with spiral grain were displayed and though no particular visual defects were observed the timber had been freshly sawn and it was thought that it could twist during seasoning. Dr. G. Gallagher spoke on grading systems and though none were in force in this country at present, the I.I.R.S. have been working on grading and a mechanical stress grading machine was being installed in one large sawmill.

At our next stop, the effects of wind blow were discussed—Mr. Condon considered soil conditions a very big factor. Other speakers emphasised that silviculture was of prime importance, particularly early and heavy thinning. Mr. McAree spoke of the fact that blow timber can be degraded through fungal attack after one year, particularly where briar and heavy undergrowth cause semi-permanent damp conditions.

The party moved on to Tower Hill where Mr. J. P. O'Donoghue gave brief details of this property. A poor Scots pine stand (Yield Class 6) was seen and though soil appeared quite acceptable, Dr. Joyce wondered why this particular crop was so poor. Mr. T. Mannion suggested provenance. A long discussion ensued and Mr. Condon rang the death bell by stating that the crop would be clear felled for pulp wood as soon as market conditions permit. An equally poor Corsican pine stand was our next stop but good young Sitka spruce along-side, probably one of the top yield classes, gave some food for thought.

Mr. P. J. Morrissey, acting as chairman for the afternoon session introduced Mr. D. White, Agent for the Marquis of Waterford in the courtyard of Curraghmore House. Mr. White welcomed the party on behalf of the owner and said that the estate covered 2,500 acres of which 1,500 were farmland and 850 woodland. The mansion and courtyard, designed on the lines of a French chateau was quite unique and certainly very impressive, particularly with the show of rhododendrons in the surrounding ground.

Mr. White led the party to see part of the 350 acres of oak woodlands which Mr. Neff said were the best example of sessile oak on a good soil in Ireland. The regeneration was very good and the ground flora typical. Some oak had been felled and prices of up to £50 a tree had been obtained. Mr. White explained that the estate ran a commercial shoot which cost about £10,000 a year and typical charges were about £200 a gun day. Obviously there is some money left somewhere in the country.

Tempus fugit and the party left for the more humdrum experience of the factory floor at Munster Chipboard Ltd., Waterford, where we were welcomed by Mr. McMahon, the Chief Executive. Mr. McMahon explained that pulpwood only (mainly thinnings) was used as a raw material for this plant. The current price was £8.50 per ton at factory gate and they produced a high quality chipboard. The party had an interesting tour of the factory and saw all the relevant stages including new uses such as bonding roofing felt onto the boards.

This ended a very successful tour and the Society left for the hotel and Annual Dinner where members and guests enjoyed a pleasant night.

N. O'Carroll, D. McAree, L. O'Flanagan

Participants

Dr. Padraig Joyce (President), Liam Condon (Tour Leader), Lily Furlong and Fergal Mulloy (Meetings Committee), Paul Clinch, Monica Connelly, Maureen Cosgrave, Myles Cosgrave, Jim Dillon, Pat Doolan, Lily Furlong, John Gillespie, Pat Herbert, George Hipwell, Christie Jeffers, Dr. Padraic Joyce, John Kelly, Harry Kerr, Ted Lynch, Dermot Mangan, Tony Mannion, Fergal Mulloy, Diarmuid McAree, Tadgh McCarthy, Dr. Eileen McCracken, Evelyn McCreesh, Michael McNamara; Jim McSorley, John McSorley, Brendan D. Neill, Jim O'Brien, Michael O'Brien, Dr. Niall O'Carroll, R. O'Cinneide, Liam O'Flanagan, Paddy O'Malley, Denis O'Sullivan, Tom Purcell, Kevin Quinlan, Jim Quinlivan, Margot Robinson, Martin Sheridan, Charles Tottenham, Robert Tottenham, Dan Walsh, Harry van der Wel, Pat White, Jack Whyte, Michael Conway, Jerry Crowley, Pat Crowley, Dan Dinneen, Joe Doyle, Frank Drea, Brendan Friel, Dr. Gerhardt Gallagher, Seamus Gavigan, George Harney, John Healy, Joe Kilbride, Nicholas McCormack, John McGovern, Liam Moloney, P. J. Morrissey, Con Nyhan, Michael O'Donovan, Nora O'Donovan, Cuimin O'Fathaigh, Sean O'Laoite, Jim O'Mahony, Jim O'Riordan, Michael O'Sullivan, Bill Phelan, T. G. Riordan, Jim Vaughan, Paddy Verling, David A. T. White.