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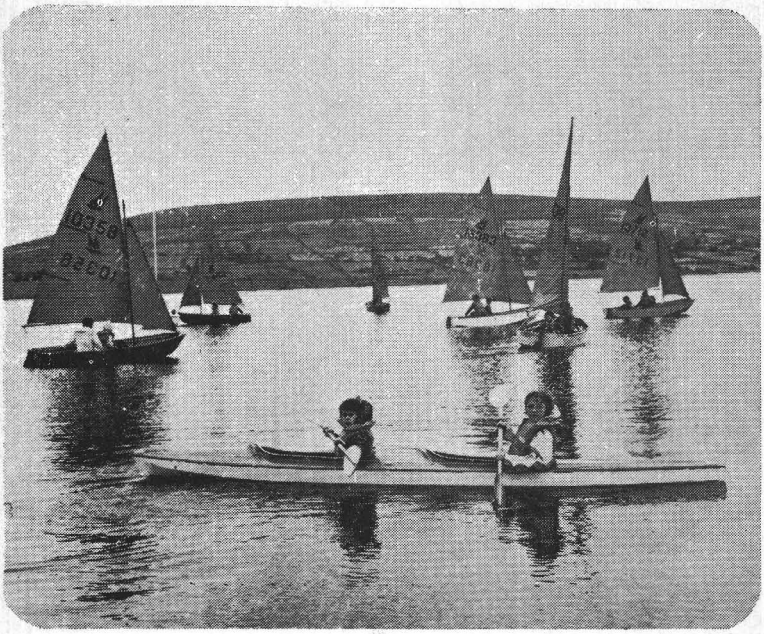

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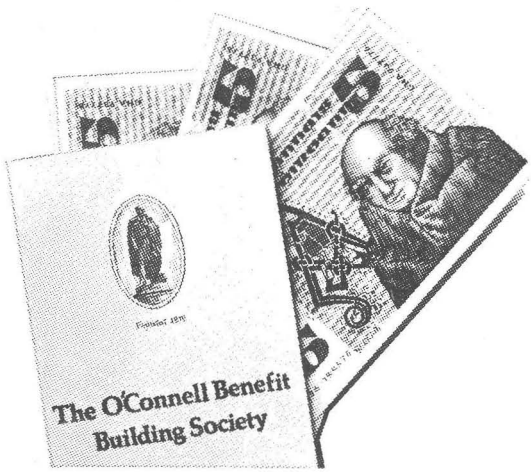

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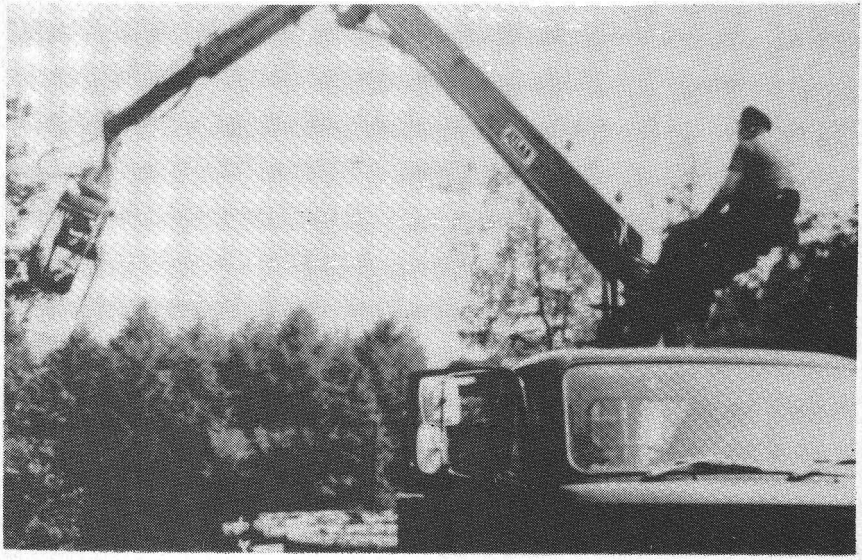

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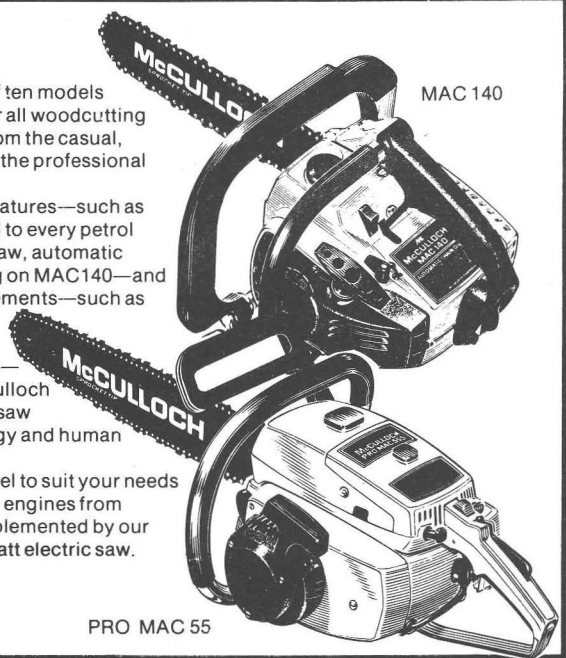

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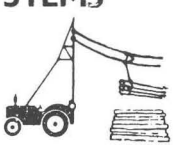

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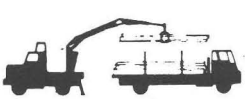

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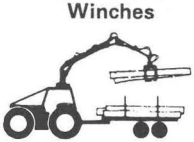

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IRISH FORESTRY

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EDITORIAL

APRÈS MOI · . . .?

MOST of us are aware of the awful problems facing man in these last decades of the twentieth century. We dance a merry jig, or so it seems, on some unseen tightrope between the frying-pan and the fire. Will we poison ourselves with the products of fossil fuel combustion or will the fuel be exhausted before that, leaving us cold and helpless surrounded by the elaborate, electronic anachronisms of our doomed civilization?

Let us not trouble our minds with such imaginings. Our involvement in forestry is, after all, evidence in itself of our confidence in the continued existence of the human race. Let us instead concentrate on things within our own sphere of influence and try to ensure that the impact of forestry on the environment will be to the benefit of future generations.

Forestry has long been associated with the conservation of nature and the minimal disturbance of natural ecosystems. Even in plantation forestry, the intensity of management is such that the forester attempts to come to terms with nature rather than to dominate it. This is less true today than formerly, however. The level of mechanical and manurial intervention, so necessary for the successful establishment and development of plantations on oligotrophic sites, has had a significant impact on energy flow and nutrient cycling in the natural ecosystems. It is important that we examine and, if necessary, control this influence.

We should not assume, for instance, on the basis of observation alone, that the current departure from the sound soil conservation principle of contour ploughing will not lead to an increase in the rate of soil erosion in mountain areas. Again, it would be foolhardy to accept the results of one or two isolated experiments in order to assure ourselves that significant fertilizer phosphorus losses, however unlikely on theoretical grounds, do not occur in peatland forests. We have not yet, in Ireland, had to deal with the problems of large-scale nitrogen fertilization in forestry. It is well known in other countries that leaching of nitrogen following the application of nitrate-nitrogen

fertilizers, can lead to groundwater concentrations of nitrate which exceed health authority safety standards. More disturbing is the recent finding, in Sweden and other countries, that the loss of nitrate following clear-felling *(even on unfertilized, acid soils)* is almost as great as that following the application of ammonium nitrate fertilizer.

What is clear-felling doing to our environment? The answer is that we do not know and we cannot afford to be complacent until we have found out.

Obituary

WILLIAM PHELAN (1951-1977)

Bill died tragically following an accident in December last. A native of Windgap, County Kilkenny he graduated from University College Dublin in 1974 with the degree of B.Agr.Sc. (Forestry). He joined the Forest and Wildlife Service early in 1975. In his short, though already quite full career he worked in Forest Management for a time, in both Donegal and Wicklow, before joining Inventory Section, Research Branch.

He was, in his heart, a forester with a distinct leaning towards mechanical engineering. Those who knew him well will remember that his imagination was forever fired by the prospects of increased mechanisation in Forest Utilisation and, in fact, in all aspects of Forestry and Agriculture in general. During his last year, being based in Wicklow meant being able to travel home most weekends to lend a hand and work on all things mechanical.

To his friends, as with everyone, his manner was consistently jovial and generous — and this, I feel, captures the essence of a man who is sorely missed by all who crossed his path.

On behalf of the Society of Irish Foresters I extend our deepest sympathy to his family.

Declan Ward

FIONAN MORIARTY

We regret to note the death of Fionan J. Moriarty which occurred while this issue was in press. We hope to print an obituary notice in our next issue.

The Recreational Use of Forest Land

UNA E. BAGNALL, DESMOND A. GILLMOR AND JACQUELINE A. PHIPPS[1]

Abstract

Forests are making an increasing contribution towards meeting the growing demand for outdoor recreation and this is compatible with timber production in the context of multiple use management. Development in the Republic of Ireland came late but there are now 9 forest parks and 350 other sites open to the public. The results of two surveys of visitor profiles, recreational use patterns and the opinions of users are presented, one relating to Lough Key Forest Park and the other to seven sites in Dublin and Wicklow. Use is mainly by family groups for walking in the forest environment and there is a high level of visitor satisfaction. The paper concludes with a consideration of topics relevant to forest recreation planning and development, including publicity and signposting, facility provision and the locational characteristics of sites.

Recreation and Forests

FOREST land is playing an increasingly important role in catering for the huge growth in demand for outdoor recreation. It is used mainly for walking, sightseeing, picknicking and camping but it also accommodates specialist activities such as hunting, fishing, swimming, orienteering, pony trekking, car rallying and nature study. Many people seek the seclusion, tranquillity and freedom to walk without traffic, which the forest environment affords. This paper focuses on the use of forest land for recreational activity but there is also the important related effect of forests on recreation scenery, their role as visual amenities in the landscape.

A great advantage of forest land as a recreational resource is its capacity to absorb large numbers of people, together with their cars and accommodation, because the trees provide visual and sound screening, so that its psychological carrying capacity is high. The physical carrying capacity can also be substantial without causing severe ecological damage, particularly where traffic is challelised along designated routes through the provision of trails. Forests provide sheltered conditions and their recreational usage is less dependent on season and weather conditions than alternatives such as the seaside or open country. The fact that there is usually a high proportion of state ownership of forest land facilitates public access and unified planning and control.

Forest land has always served multiple functions, such as wood production, food gathering, hunting, grazing, living space and watershed protection, but although some forests were reserved for royal hunting long ago, large scale recreational use is a very recent

1. Department of Geography, Trinity College, Dublin 2, Ireland.

phenomenon. Many foresters, whose training and traditional attitudes had been oriented exclusively towards wood production, were slow to react to the increasing public demand for recreation. They feared widespread damage through fire and vandalism and severe impairment of the productive capacity of forests. Gradually a new outlook has developed, as the viewpoint of foresters is broadening and recreational provision becomes recognised as an essential part of integrated forest management. Through experience it became realised that the fire risk is not so great, with forest users often being an asset in the detection and extinguishing of fires, and that wood production and recreation are highly compatible uses provided that there is careful planning and that minor concessions are made on both sides. Intensive recreational use is limited to a very small proportion of forest land and over most of the forest there is minimal interference with wood production. Bordering car parks, picnic sites, trails and places of general interest, it is necessary to have some manipulation of planting and felling programmes, including elements of age and species diversification and of tree spacing. The main recreational use of forests is at weekends when forestry operations cease but this raises problems through the demand on foresters' leisure time for supervision. Advantageous side-effects of recreational use for forest interests are that evaluation of such non-market benefits strengthens the bargaining position of forestry relative to competing land uses and that favourable public attitudes towards forestry are promoted.

The need for information as a basis for planning forest recreation has prompted studies in several countries, including the Netherlands (Sidaway, 1974), Great Britain and the USA. Because of space limitations, references in the bibliography to this paper are confin ed to British studies, which include those by Mutch (1968), Countryside Commission (1970), Colenutt and Sidaway (1973), Hall (1974) and Collings and Grayson (1977). Many American studies are listed in the *Bibliography of Forest Service outdoor recreation research publications* covering the period 1942-66 and the eight supplements to the bibliography compiled by the US Department of Agriculture. During 1964 a study was made of visitors to Tollymore Forest Park in Northern Ireland (Kilpatrick, 1965).

Forest Recreation in the Republic of Ireland

The development of forest recreation in the Irish Republic has been very recent. The public was not encouraged to enter the state forests until the mid 1960s. Although wood production remains the primary objective of forestry policy, there has been a significant reappraisal of the function of forests. The Forest and Wildlife Service, as the largest landowner in the state, has become increasingly aware of the

recreational role which its properties can fulfil. The public is invited and encouraged to visit state forests on foot and, other than a prohibition on the lighting of fires, there are few restrictions on the recreational use of forest land by pedestrians. It is estimated by the Forest and Wildlife Service that there are now one and a half million visits to state forests annually.

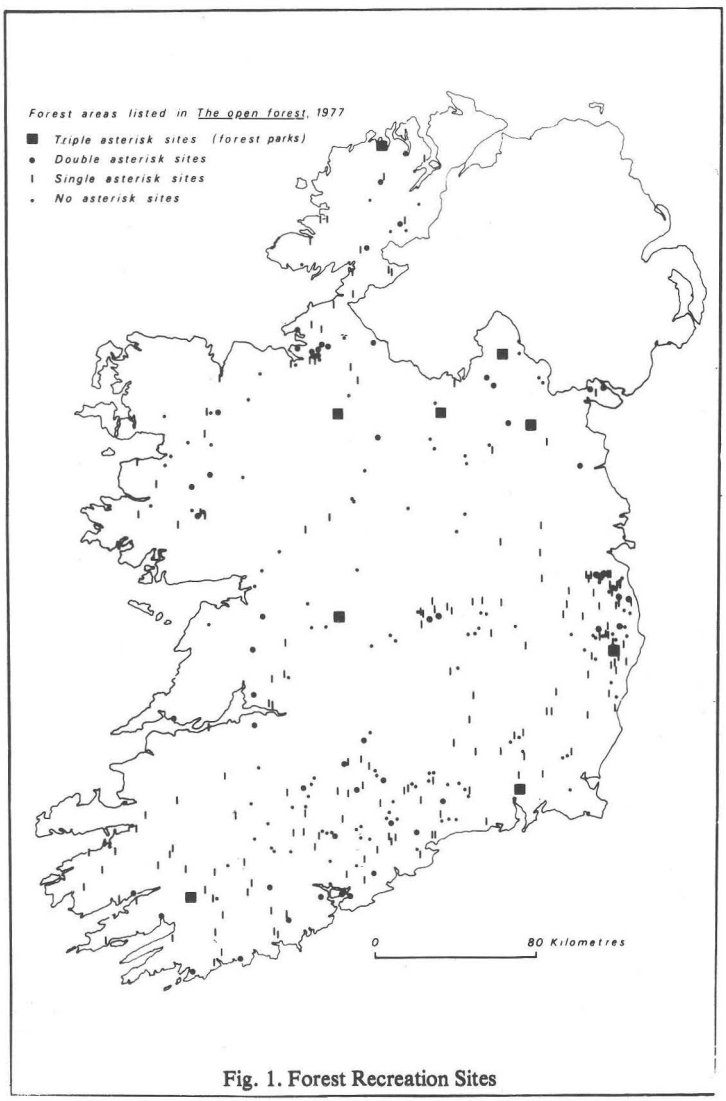

Fig. 1. Forest Recreation Sites

The recreational use of forest land focuses on the 359 sites which are specifically designated as being open to the public through being listed in the current edition of the booklet *The Open Forest* (Forest and Wildlife Service, 1977). They are quite widely distributed but with a tendency towards concentration in coastal counties (Fig. 1). The numbers of sites in individual counties range from 54 in Cork, 45 in Wicklow, 33 in Waterford and 22 in Donegal to 4 in Louth, 3 in Meath and Westmeath and 2 in Longford. The distribution is necessarily related to the spatial pattern of state forests, which in turn are associated with land of low agricultural potential on uplands or bogs and with former estate woodlands. It is also affected by the age structure of forests and by their scenic and other interest characteristics.

A fourfold grading of sites based on the amenities provided is adopted in *The Open Forest*, though not all sites have been developed to the state indicated. The most developed sites are the nine forest parks, identified by a triple asterisk. They are, with estimated April-September 1976 visitor figures where appropriate: Lough Key, Co. Roscommon 264,000; John F. Kennedy, Co. Wexford, 80,000; Dún A' Rí, Co. Cavan, 61,000; Guagán Barra, Co. Cork, 58,000; Ards, Co. Donegal, 52,000; Avondale, Co. Wicklow, 36,000; Portumna, Co. Galway, 22,000; Rossmore, Co. Monaghan; Killykeen, Co. Cavan. The forest parks are the only sites at which a charge is made, a car park fee of 30p with a seasonal ticket abailable at £1.00 for individual parks. Park facilities include car parks, picnic places, nature trails and forest walks and at individual parks there are features such as water-based activities, historical remains, gardens, shops and restaurants. Forest sites with particular attractions such as nature trails are indicated in the booklet by a double asterisk, other developed places by a single asterisk and those at which there are only forest walks and viewing points have no asterisks. It has been necessary to introduce into the forest man-made features such as picnic tables, litter bins, seats, paths, signposts, gates, stiles and footbridges. The design of these artefacts has generally been of a very high standard and their rustic appearance harmonises with their surroundings.

Studies elsewhere indicate that there are similarities between countries in the patterns of recreational use of forests, but it is important that investigations should be made in the Irish context. As no such studies in the Republic of Ireland have been published, the two surveys whose findings are summarised in this paper were undertaken as an initial contribution to a greater understanding of forest recreation in the state. The surveys focused on visitor profiles, recreational use patterns and the opinions of forest users. Interviewer-administered questionnaire surveying at the recreation sites was adopted as the means of obtaining uniform information with a very high response rate. Although the

surveys were conducted independently by different authors, the areas investigated were selected in order to represent different circumstances. One study (Bagnall, 1977) was of the use of Lough Key Forest Park, which is the most developed of the forest parks and accounted for 46% of their total visitors in 1976. The park is in a region with few urban centres and little tradition of outdoor recreational development. The other study (Phipps, 1977) was of a number of sites in Counties Dublin and Wicklow. This area is accessible to the major urban concentration in the country and forest site provision with respect to population is only half the national average.

Lough Key Forest Park

Lough Key Forest Park is situated in north Co. Roscommon, 110 miles from Dublin and 25 miles from Sligo. It is sited on the southern shore of Lough Key, in an area of considerable scenic, wildlife and historical interest. The park is within the former Rockingham estate, which was sold to the Department of Lands in 1959 following a disastrous fire in the mansion two years previously. In 1966 a joint development of the park by tourism and forestry interests was agreed; the Forest and Wildlife Service has had responsibility for timber production and park management, and amenity design, tourist information and promotion have been allocated to Bord Fáilte and the Midland Regional Tourism Organisation.

A design strategy in general accordance with the international concept of a recreational park was adopted. A threefold division of the park according to levels of recreational usage was assumed. A small area was allocated for high intensity use, comprising part of the lake shore, boating facilities, visitor centre, viewing tower, car park and surrounding open parkland, together with a detached camping and caravan area. Outside this zone is one of commercial forestry integrated with recreational development, which contains nature and tree identity trails, general forest walks, bog gardens and wildlife reserves. In addition to the 400 acres accessible to the public, there are 450 acres used only for commercial timber production. Particular problems faced in design planning were the extent to which elements of the original estate should be preserved and the introduction of new structures into the mature landscape. Estate features which were retained included the parkland and woodlands, church ruins, subterranean tunnels, ice house, gazebo, harbour, canals and stone bridges. The most controversial feature of development was removal of the mansion ruins and their replacement by the Moylurg viewing tower, a concrete structure of modern design and 70 feet height. Good design standards and low profile timber construction were adopted for the visitor centre, which comprises a restaurant, shop, toilets and seating, and the reception office of the

caravan park. The car and caravan parks were landscaped and camouflaged by using earthworks and tree planting.

The questionnaire survey of Lough Key Forest Park users was conducted during the first three weeks of August, 1976. Of the 253 interviews conducted, 174 were with day visitors, and the remainder were with resident visitors, of whom 65 were campers in the park and 14 were persons who had arrived by cabin cruiser. A constant daily rate of interviewing was adopted, although there was consequent undersampling on days of peak usage. The area of the visitor centre and harbour was selected as the interview point on the basis of its offering a wide cross section of park users.

A distance of less than 30 miles to the park had been travelled by 68% of day visitors. Counties Roscommon and Sligo were the sources of 61% of journeys, with the towns of Sligo and Boyle being the largest points of origin. With regard to place of home residence, there were distinct differences between day and resident visitors. Dublin was the home of 32% of all visitors, 21% of day visitors and 58% of resident visitors. Conversely, 39% of day visitors lived in the north-west of the country but only 4% of resident visitors; 28% of all visitors lived there. The significance of the park as a local amenity is indicated by the fact that residents of Co. Roscommon accounted for 20% of day visitors. Of all visitors, 8% were from Northern Ireland and 14% were overseas tourists, Britain being the major source. People holidaying in the area accounted for 58% of visitors to the park, 40% of the day visitors and all of the resident visitors.

The modes of travel of visitors were: motor car 87%, boat 6%, tour bus 3%, public transport 2%, other modes 2%. The dominance of the private car was less amongst resident visitors, of whom 18% arrived by boat and 6% by public transport but no day visitors used these means of travel. Family groups comprised 75% of those interviewed, 13% travelled with friends and 3% alone. The average party size was 4.8 people. As two-thirds of parties contained children, with an average of 3.1 per group, the typical party consisted of two adults and three children. Persons under 19 years old comprised 47% of the members of respondent parties and only 6% were aged over 55 years. The most common adult age category was 35-44 years. Head of household occupations may be classified according to socio-economic groups: AB (upper middle and middle) 20%; C1 (lower middle) 30%; C2 (skilled working) 26%; DE (other working etc.) 13%; F (farmers) 10%.

The most common means of visitors first hearing about the park were through the recommendations of friends 42% and local information 26%, with 6-7% for each of newspapers/magazines, guide books, signposting and tourist offices. Local information was

particularly important for people from the adjacent area and guide books ranked second as a source of information for resident visitors. This was the first visit to the park for 40% of all visitors, 35% of day visitors and 49% of resident visitors, with 25% of each category making their second visit. Repeat visits were most common amongst local people, 51% of Co. Roscommon residents having been to the park at least seven times previously, as compared with 17% of both all visitors and Dublin residents.

The average length of stay in the park by day visitors was 3.8 hours, with most parties staying 2-4 hours. Afternoon use predominated, most people arriving at 2-3 p.m. and leaving by 6 o'clock. The activities or visits in which people engaged while in the park were: general walking 87%, shop 73%, sitting outside 70%, viewing tower 50%, restaurant 45%, boat trip 44%, bog garden 40%, historic sites 38%, nature trail 30%, sitting in car 15%, tree identity trail 14%, fishing 10% and other pursuits 30%, which included boating, swimming, picnicking and visiting the wildlife reserve. Day visitors engaged in an average of 4.8 activities and resident visitors in 6.6 activities. The main reason for visiting the park was given as general relaxation and enjoyment by 41% of visitors, followed by sightseeing 20%, the attraction of the lake 12% and the desire to see the park 11%. Camping and caravanning was the principal attraction for resident visitors. When asked what they would have done on the day in question if they had not come to the park, 25% felt that they would have stayed at home, 21% would have visited the seaside and 15% would have gone for a drive.

A high level of visitor enjoyment of the park was expressed, 93% enjoying their visit very much, 6% fairly well and 1% not very much or not at all. The most attractive aspect of the park for 38% of visitors was its general atmosphere, which was described as peaceful, relaxing and non-commercialised. Other features which appealed to people included the layout of the park, walks, general upkeep, lake, boats, lack of cars and suitability for children and family groups. The car entrance fee was considered low by 45% of respondents, particularly the seasonal rate, and reasonable by 55%, with only one person assessing it as too high. With regard to adverse criticisms, signposting to the park on the Dublin-Sligo road was the weakest feature, 34% of visitors evaluating it as only fair or worse. Signposting within the park was the second most criticised aspect, 15% of visitors considering it to be fair or worse, though 44% assessed it as very good. The park guide book had been seen by 49% of visitors, almost all of whom thought it good or very good. The walks and the campground received particularly favourable comment. When asked for suggestions concerning changes or

improvements in the park, 64% of interviewees responded. The most common proposals related to the provision of sporting facilities, especially for swimming, to general development and to the provision of amusement and childrens' play facilities, together with recommendations concerning the restaurant, park maintenance, viewing tower, boating and walks.

Dublin and Wicklow Forest Sites

In the 1974 edition of *The Open Forest* 9 sites were listed as being open to the public in Co. Dublin, all in the south of the county, and 34 in Wicklow, mainly in the east. The sample of sites for survey was not selected randomly because of the small total number of sites and a desire to investigate forests of different grades widely distributed over the area of study. Those sites surveyed were: Curtlestown and Kilmurray as examples of no asterisk forests, Knocksink and Trooperstown as single asterisk forests, Cruagh and Devil's Glen as double asterisk sites and the only triple asterisk site in the area, Avondale Forest Park. For each of the categories except Avondale, one of the sites was selected as being comparatively near to Dublin and the other further away. The survey was conducted between mid July and early September, 1976. Interviewing was done in the vicinity of the car park at each site on one weekday, one Saturday and one Sunday. There was a complete response by those approached, the 461 questionnaires representing 69% of the parties who visited the sites on the days concerned. The numbers of interviews conducted at each site were: Curtlestown 8, Kilmurray 11, Knocksink 65, Trooperstown 59, Cruagh 100, Devil's Glen 69 and Avondale 149.

The number of parties visiting the forests increased with the range of facilities available, from an average of 9 for the three-day period at each of the no asterisk sites, through 62 and 108, to 312 at the triple asterisk site. Only at the double asterisk sites was there a substantial difference with distance from Dublin, the number of parties visiting Cruagh, 9 miles from Dublin, being more than double that at Devil's Glen which is 30 miles from the city. The daily distribution of total party visits was: Sunday 406, Saturday 153 and weekday 113. Afternoon use predominated, with 55% of parties arriving between 2 and 5 p.m., though there was an indication of proportionately greater morning and evening usage near to Dublin.

Family groups comprised 74% of parties interviewed, 11% of people coming with friends, 10% with family and friends and 4% alone. The average party consisted of 3.9 people, including 2.6 children. Children were present in 59% of parties, two being the most common number. The age structure of party members was: under 15

years, 39%, 15-24, 7%, 25-44, 32%, 45-64, 18% and 65 and over, 4%. There was a tendency for young adults to visit the forests with their children and for middle aged adults to come in pairs or with friends of their own age. The occupational structure of respondents was: professional and semi-professional 21%, sales and commerce, 19%, administrative 19%, skilled and semi-skilled 19%, unskilled 8%, farmers 2%, others 12%.

Counties Dublin and Wicklow were the place of residence of 88% of forest visitors, 71% from Dublin and 17% from Wicklow, together with 6% from other parts of the Irish Republic, 1% from Northern Ireland and 5% from overseas. Only 20% of Dublin visitors came from north of the River Liffey, despite the lack of access to forest sites on the north side of the city. Wicklow residents comprised 38% of visitors at Devil's Glen but only 1% at Cruagh. The tourist attraction of Avondale was reflected in the fact that 21% of its visitors were not residents of Dublin or Wicklow. Only 4% of visitors travelled more than 40 miles to the forest site, 40% travelling 10 miles or less. The tendency at each site was for the predominant travel distance to be that from Dublin. Motor cars were the mode of transport for 94% of visitors, with 2% travelling on foot, 1% by motor cycle and 1% by public bus. Knocksink was the only survey site located on a bus route and there 8% of the visitors used public transport.

People on day excursions from their homes comprised 87% of forest visitors. Those on holiday away from home were proportionately more significant at sites further from Dublin and at higher grade sites, accounting for 0% of visitors at no asterisk sites, 6% at single asterisk sites, 10% at double asterisk sites and 24% at the triple asterisk site. When commencing their journeys on the interview day, 72% of parties had intended to visit the forest site concerned, the intention to visit increasing from 47% at the no asterisk forests to 80% at Avondale. No previous visit to the interview site had been made by 31% of respondents, with 15% having been there once before, 12% 2-5 times, 9% 6-10 times and 33% had been there on more than 10 visits. The frequency of previous visits was highest at sites near to Dublin, at Cruagh and Knocksink combined the first-time visitors comprising only 18% of the total and 55% being on more than their tenth visit. There was an inverse relationship between frequency of visit and distance travelled, people tending to visit more often those forests which are located convenient to them. With respect to all forest sites in Dublin and Wicklow which are visited frequently, Cruagh and Bellevue received the highest scores for amount of usage, followed by Tibradden, Avondale, Djouce, Devil's Glen, Glendalough, Knocksink,

Trooperstown, Hell Fire Club and Three Rock Mountain. The frequency of visits increased with the grade of site and with proximity to Dublin.

The original sources of information about the interview sites being open to the public were: family and friends 48%, chance 36%, newspapers and magazines 7%, *The Open Forest* 5%, information centres 3% and books 1%. Only 13% of visitors to Avondale discovered it by chance but 19% read about it in newspapers, magazines and books. The principal means of finding the route to the forest on the day of the interview was given as prior knowledge by 71% of visitors, chance by 13%, maps 5%, told in advance 4%, enquiries on the way 3% and *The Open Forest* 2%. The main reasons given for visiting the forest sites were an interest in nature and trees, for peace and quiet, for physical exercise, for the scenery and for fresh air; these together accounted for 64% of the reasons given. At Avondale, historical interest, the pleasant facilities and the purpose of showing family or friends were significant motives, accounting for 39% of the reasons given there.

The average duration of forest visit was 2.5 hours, the proportions being: less than 1 hour 18%, 1-2 hours 34%, 2-4 hours 31% and over 4 hours 17%. The duration of stay increased with the grade of forest, the proportion of visitors remaining for 2 hours or longer being 5% at no asterisk sites, 31% at single asterisk sites, 41% at double asterisk sites and 75% at the triple asterisk site. Walking was the most common activity, engaged in by most people during their forest visit. Of all activities recorded, forest walks accounted for 35% of the total, walking a nature trail 8% and taking a dog for a walk 5%. The role of the forest walk declined from 63% of all activities at the no asterisk sites to 30% at the triple asterisk site. Picnicking ranked as the second activity, 23% of the total, though the wide range of interpretation of the term which is possible must be borne in mind. Sitting and watching accounted for 9% of stated activities, its incidence being highest at those sites with a good view. Visiting the house was an important activity at Avondale and the rivers at Trooperstown and Knocksink had minor attractions for swimming and fishing.

The opinions of visitors on a variety of site characteristics were sought. Advance signposting at the only two sites at which it was present was considered to be bad by 61% of visitors to Devil's Glen and 44% at Avondale, with an additional 16% and 28% assessing it as only reasonable. The evaluation of car parking facilities was: excellent 26%, good 47%, reasonable 21% and bad 4%. Curtlestown, Kilmurray and Knocksink received the lowest assessment and the most highly rated was Avondale, where 65% of

visitors considered the parking facilities excellent. Litter bins were provided at sites with one or more asterisks and were evaluated excellent by 7% of visitors, good by 45%, reasonable by 24% and bad by 18%, 5% having no opinion. Knocksink and Cruagh combined were considered bad by 45% of their users in this respect and Avondale had the highest rating. The assessment of picnic table provision at sites with one or more asterisks was: excellent 9%, good 51%, reasonable 27%, bad 6%, no opinion 7%. Again Knocksink and Cruagh were rated lowest, 12% and 23% considering them good or excellent, compared with 97% at Avondale. No opinions on the nature trails and pamphlets were held by 27% of the visitors at the three sites where they occur but they were evaluated as excellent by 9%, good by 60%, reasonable by 5% and bad by nobody. Directions within these forests were considered good or excellent by 64% of visitors but only 36% at Devil's Glen.

When asked about what additional facilities they would like to see provided in the forest, 38% of visitors did not indicate any desired further development. Toilets were the facility most often mentioned, accounting for 30% of the suggestions at sites other than Avondale, where toilets have been provided. The other most desired facilities were water points, educational displays, restaurant, shelter huts and more litter bins and picnic tables.

When visitors were asked what they had particularly enjoyed in the forest, no feature was listed in 89 instances. There were 162 references to the peace and quiet and this constituted the major attraction. Other references were to scenery 105, trees 77, scope for walking without cars 57, river 53, fresh air 47, naturalness 39, house and grounds (Avondale) 28, relaxation 26 and safety for children 21. There were few aspects of the forests which people particularly disliked, 87% of visitors indicating that there was no such feature. Of the small number of dislikes, the most general was litter with 24 references, followed by bad forest roads 16 and the allowance of cars into Trooperstown and Knocksink 10.

The high degree of satisfaction among visitors is further reflected in the fact that 92% intended to visit the forest again. Only 2%, mainly tourists, indicated that they would not return and most of the 5% who were uncertain stressed that they enjoy visiting and exploring different forests. The strong intention to return combined with the fact that almost one-third of people were visiting the forest for the first time suggest high rates of recruitment and growth in forest recreation. Furthermore, a very favourable attitude towards the landscape impact of state forestry is indicated by 91% of the visitors feeling that it added to the appearance of the landscape and

5% being of the opinion that it added in some areas and detracted in others, with 3% feeling that the overall effect was detraction.

Conclusion

There are major difficulties in the design of sampling schemes and the execution of surveys for the investigation of the recreational use of forest land. These include the distribution of sampling by the day of the week, the season, the weather conditions and the type of site and also the location, intensity and technique of surveying visitors at the specific sites. The surveys reported in this paper were of limited scope and their results are valid only for the sites, days and nature of the surveys concerned; they were conducted in the summer months during uniformly fine weather conditions. It cannot be said to what extent the results are indicative of the total situation in the Republic of Ireland, but it is obvious that surveying should be done at other types of sites, during other seasons and under different weather conditions. There is a need for much information on different aspects of forest recreation, including the numbers and characteristics of visitors and of foresters, the ecological effects of recreational use, the carrying capacities of sites and appropriate resource management practices. More general recreation surveys of the whole population or sectors of it are needed also, so that forest recreation and its users can be compared with other recreational activities and the total population.

The two surveys have demonstrated something of the extent and nature of the large recreational demand in the Republic of Ireland for which forest land is now catering and they have shown that there is a high degree of satisfaction amongst visitors. The Forest and Wildlife Service is to be very highly commended for the way in which it has adapted and responded to the need for recreational facilities, for the amount of provision which has been achieved in a short period and for the high quality of the development which has been done. Some users feel that there might be changes and improvements, there are locational aspects which need consideration, and, as in any such development, it is important that there should be consultation and forward planning.

The users surveys and inspection of sites indicate that there are deficiencies in publicity and signposting. Most people discovered the forest sites through the recommendations of friends, local information and chance, with publicity and signposting playing very minor roles. *The Open Forest* is in many ways an admirable booklet but most visitors did not know of its existence and many had difficulty in using it; it seems likely that the inclusion of a map or maps and clearer direction descriptions would be of assistance. More effective publicity

and signposting would lead to greater public participation in forest recreation but it must be recognised that this would not always be an unmitigated desirability. The peace and quiet which the forest environment affords is one of the major attractions for present users and their recreational enjoyment would be likely to lessen as participation levels increase. At some sites overloading of facilities already exists and in such instances a deliberate policy of not promoting additional usage might be adopted. Access to the forests would be facilitated by greater use of display maps and printed maps, with scales, and by more signposting of walks with indications of their length.

Some visitors felt that improved facilities and additional developments should be provided. One aspect of this is the problem of peak loadings which is experienced at many recreational sites. Some criticism was prompted by maximum Sunday usage levels, raising the question of whether the provision of facilities should be geared to the demand on a few fine Sunday afternoons in summer or whether some congestion should be tolerated. Also present usage patterns suggest that the provision of extra facilities at sites which already tend to be overloaded would promote a further increase in the number of visitors. With regard to additional developments, there was a strong user appreciation of the non-commercial atmosphere of the forest sites and a desire that this should not be altered. Some visitors sought sporting and amusement opportunities and wet weather facilities; the provision of such in specific sites might be considered or alternatively, developments located outside but convenient to major forest sites might be encouraged. The educational role of forest properties could be exploited more fully through the provision of interpretation and information centres. The allocation of space for camping and caravanning has proved to be a very successful component of the facilities at Lough Key Forest Park but this has not been done elsewhere. The forest is a very pleasant camping environment and the trees afford shelter from winds and visual screening of the site. The popularity of forest camping is evident in North America and on a smaller scale at 27 Forestry Commission campsites in Britain, the latter also providing cabins and holiday houses in 12 forests. Scenic forest drives have also proved popular elsewhere. Most forest users do not favour increased car accessibility and almost all of the forest land should be kept free from motor traffic but the possibility of developing some scenic drives at a few specific sites in addition to the existing car trail in Guagán Barra Forest Park should be investigated. Forests in Dublin, Wicklow and Cork are used for competitive orienteering but the potential of the forests has not been exploited for the related activity of wayfaring,

whereby people use a map to find their way around a route marked by fixed control points and for which permanent courses could be established. In all matters of facilities and development some consideration should be given to provision for minority as well as majority interests and a diversity of treatment is desirable. Also there is the question as to what extent the views of those who do not use the forests should be determined and accommodated; reasons for non-participation may not be solely ignorance of the attractions which the forests afford but also the knowledge that the forest sites do not provide for the recreational experiences desired.

The spatial distribution of forest recreation sites has major implications for the planning of facility and new site provision. Although much visitor data would be necessary in order to establish a typology of forest sites, it is evident that sites in some areas are used very largely by the local resident population and that in other areas there is proportionately greater use by people on holiday away from home. The spatial distribution of forests is better suited to meet the recreational demands of tourists, as there has been much afforestation in the upland areas and other localities of low agricultural productivity which have major tourist attraction. The accessibility of sites to the main tourist routes and resorts should be considered in planning. Forest sites can also alter tourist patterns, as has been clearly demonstrated in the extent to which Lough Key Forest Park has promoted tourism in its area, so that they can be used to enhance the attraction of a region.

In many countries the major forests are distant from the main urban centres which tend to be located in productive lowland areas, so that their distribution is not suited to providing for the daily recreational needs of the bulk of the population. This is true to some extent in the Republic of Ireland, though all of the urban centres have some forest sites within the 30-40 miles which people are prepared to travel on daytrips. It is particularly fortunate that there is extensive forest and 56 open sites in south Dublin and Wicklow accessible to the one-third of the national population in the Dublin region concentration, though there is gross underprovision relative to the remainder of the country and very strong pressure on sites near to the city. The north Leinster area in general has fewer sites relative to its population, the eight counties in the state having less than one site per 10,000 population being Dublin, Meath, Louth, Westmeath, Longford, Limerick, Kildare and Offaly. Total population is not the only consideration, as it seems likely that the forest recreation demand would be greater amongst urban people given equal accessibility and they have more need for outdoor recreation space. Priority in planning should be given to the provision of forest

recreation opportunities within easy reach of the major urban centres; the emphasis in management in some forests near to cities might be on recreation and the possibility of planting forests specifically for this purpose might be considered.

There are locational aspects other than distance from resident and tourist populations. The fact that most forest sites are in rural areas poorly served by public transport renders them inaccessible to most people who do not own motor cars, particularly the populations of inner city areas. While something might be done to organise transport to forests for such people, the access of sites to public transport routes should be considered in planning. General road accessibility and conditions affect site selection. The availability of alternative recreational opportunities might be a consideration. Thus in midland areas distant from the coast the need for forest recreation might seem all the greater and unfortunately some of these areas are poorly served by existing sites. Conversely, in areas near to beaches which are very heavily used it might be desirable to provide forest recreation as a counter-attraction in an attempt to relieve pressure on the coast.

Forests vary in their inherent recreational potential, depending in particular on the age, spacing and nature of the trees and on the topography of the site. As young forests are not suited to recreational use and as the emphasis in afforestation has shifted towards the west, an increasing proportion of the maturing forests which could be developed will be in western counties. The scenic quality of the potential sites and the presence of specific attractions are important considerations. Water is a great attraction, as can be seen in the extent to which water frontages have acted as focal points in some of the forest parks. The possibility of incorporating the coast, lakes and rivers should be an important element in site selection and development. The inclusion of some open areas has proved a considerable attraction for people, as in Lough Key and John F. Kennedy Parks. Features of historical and other human interest can add greatly to the recreational and educational value of a site, a factor which might influence selection and should be given adequate recognition in development.

The demand for forest recreation in the Republic of Ireland is certain to expand greatly in the future. It is most desirable that there should be research, consultation and systematic planning for this development. Such planning could best be done with reference to national surveys, policies and plans relating to resource management, land use and recreation. It is unfortunate that no such national guidelines and framework exist.

REFERENCES

Atkinson, N. H. 1972. Orienteering in British forests. Scot. For. 26:56-9.
Bagnall, U. E. 1977. A study of the recreational use of Lough Key Forest Park and its impact on the local area. B.A. thesis, Department of Geography, Trinity College, Dublin.
Clawson, M. 1975. Forests for whom and for what? Johns Hopkins, Baltimore.
Colenutt, R. J. and R. M. Sidaway. 1973. Forest of Dean day visitor survey. For. Comm. Bull. 46, London.
Collings, P. S. and A. J. Grayson. 1977. Monitoring day visitor use of recreational areas. Forest Record 112. For. Comm. London.
Countryside Commission. 1970. Scenic drive survey: Dovey and Gwydyr Forests, July 1969. London.
Department of Lands, Forest and Wildlife Service. Annual report of the Minister for Lands. Stationery Office, Dublin.
Douglass, R. W. 1975. Forest recreation. Second edition. Pergamon, New York.
Duffield, B. S. and M. L. Owen. 1973. Forestry policy — recreation and amenity considerations. Scot. For. 27: 114-34.
Flannery, M. 1976. Sanitation, conservation and recreation services in Ireland. Institute of Public Administration, Dublin.
Forest and Wildlife Service. Avondale, Dublin.
Forest and Wildlife Service. Lough Key Forest Park, Dublin.
Forest and Wildlife Service. 1977. The Open Forest, Dublin.
Forestry Commission. Recreation policy, Edinburgh.
Forestry Commission. 1972. Forestry policy, London.
Gillmor, D. A. 1973. Orienteering as an activity in recreation and geographical education. Geographical Viewpoint 2: 397-411.
Grayson, A. J. 1972. Valuation of non-wood benefits. Research and Development Paper 93, For. Comm., London.
Grayson, A. J., R. M. Sidaway and F. P. Thompson. 1973. Some aspects of recreation planning in the Forestry Commission. Research and Development Paper 95, For. Comm., London.
Hall, J. 1974. Forest recreation. Chapter in Lavery, P. (ed.), Recreational geography. David and Charles, Newton Abbot, 145-66.
Kilpatrick, C. S. 1965. Public response to forest recreation in Northern Ireland. Irish For. 22: 3-15.
Mawhinney, K. A. In press. Recreation. Chapter in Gillmor, D. A. (ed.). Irish resources and land use. Institute of Public Administration, Dublin.
Mutch, W. E. S. 1968. Public recreation in national forests. Forestry Commission Booklet No. 21. For. Comm., London.
Parkin, K. F. Multiple use of forests in Northern Ireland. Forestry White Paper. Paper A9.
Phipps, J. A. 1977. An investigation of the use of forests for recreation in Counties Dublin and Wicklow. B.A. thesis, Department of Geography, Trinity College, Dublin.
Sidaway, R. M. 1974. Organisation of outdoor recreation research and planning in the Netherlands. Research and Development Paper 107, For. Comm., London.
Simmons, I. G. 1975. Rural recreation in the industrial world. Arnold, London.
Sinden, J. A. and L. B. Sinden. 1964. A forest recreation survey: implications for future development. Scot. For. 18: 120-27.
Spencer, J. A. and R. M. Sidaway. 1972. The special contribution of forests and woodlands to recreation in an industrial society. Research and Development Paper 92, For. Comm., London.
van der Kloet, I. W. G. 1965. Forests and recreation in the Netherlands. Irish For. 22: 16-22.

Production, Accumulation and Nutrient Content of Sitka Spruce Litterfall

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Abstract

Litterfall measurement in three stands of Sitka spruce showed that on average 5,500 kg/ha was shed per annum. This contained 72 kg of nitrogen, 5 kg of phospharus and 14 kg of potassium. Because litter production exceeds decomposition large amounts accumulate. On average the litter layers had a D.M. content of 50,000 kg/ha containing 915 kg of nitrogen, 50 kg of phosphorous and 130 kg of potassium. The high figures for production and accumulation, and the variation between sites, appeared to be related to crop density.

Introduction

THE maintenance of satisfactory tree growth where fertilisers are not applied is ultimately dependent on the recycling of essential nutrient elements. Although throughfall and stemflow contribute to nutrient cycling, litterfall is by far the most important factor involved in the release of nutrients from trees. Work by Ovington (1961) on Scots pine *(Pinus Sylvestris* L.), Cole *et al* (1967) and Abee and Lavender (1972) on Douglas fir *(Pseudotsuga menziesii* (Mirbel) Franco), Mahendroppa and Ogden (1973) on Black spruce *(Picea mariana* (Miller) Britton, Sterns and Poggengerg) and Miller, Cooper and Miller (1976) on Corsican pine *(Pinus nigra* Arnold) showed that on average 87, 70 and 40% of the nitrogen (N), phosphorus (P) and potassium (K) reaching the forest floor each year was contained in the litter.

Due to the high content of cellulose and lignin in leaf tissue, the biologically impoverished nature of many forest soils and the close spacing of trees in many man-made forest crops, the decomposition of coniferous litter tends to proceed rather slowly, leading in many areas to the accumulation of large quantities of organic matter on the forest floor. The object of the study reported here was to measure the dry matter and the N, P and K contents of the litter shed over a twelve month period by representative polestage crops of Sitka spruce *(Picea sitchensis* (Bong) Carr.) and to determine the amounts of those elements in the forest floor.

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Site Description

The dry matter and N, P, K contents of the litterfall and the forest floor were measured in three polestage crops of Sitka spruce (Table 1). The crops varied in age from 34 to 47 years and were located in separate State forests in County Wicklow.

Based on forest management tables (Bradley, Christie and Johnston, 1966), the Glenmalure crop was approximately 164% overstocked, the Glenealy crop 16% overstocked and the Ballinglen crop 9% overstocked. The Ballinglen and Glenealy crops had been thinned heavily in 1973 and would have been considerably overstocked before then. The Glenmalure stand had never been thinned. The plantations were established by pit-planting on unploughed and unfertilised land. The soil at the Glenmalure site varies between a peaty podzolised gley and a blanket peat (peat depth approximately 80 cm) the parent material being mainly mica schist with a small proportion of granite. The soils at the other two sites are both Brown Podzolic but the drift at Glenealy is essentially a mixture of Cambrian shale and slate with a high proportion of quartzite whereas that at Ballinglen is comprised mainly of Ordovician shale with a significant mixture of mica schist and slate and some quartzite. The three soils are strongly acid in reaction with pH values in the top 25 cm varying between 3.8 and 5.1. Mean annual rainfall varies from 1800 mm at Glenmalure to 1025 mm at the other two sites. Mean annual temperature is approximately 10°C.

TABLE 1

Elevation, age and growth parameters for the three stands.

Forest	Elevation (m)	Age (yrs.)	Top Ht. (m)	Yield Class m^3/ha	Basal Area m^2/ha	No. Stems/ ha
Glenmalure	350	34	15.9	14	74.7	3760
Glenealy	200	39	15.7	12	35.5	1216
Ballinglen	300	47	24.6	18	38.8	583

Experimental

Three plots, 25x25 m, were selected at random within each crop for measurement of the dry matter and nutrient content of the litterfall and of the forest floor. Within each plot fifteen sampling points were selected at random. The depths of the forest floors were measured and samples taken at the end of November 1974.

The material collected included L, F and H layers only as defined by Hoover and Lunt (1952). All branch, twig and coarse (greater

than 25 mm diameter) root materials, although strictly speaking part of the forest floor, were excluded. To facilitate sampling a stiff section of P.V.C. piping 10 cm in diameter and 8 cm deep was pressed firmly into the forest floor. A sharp knife was used to cut through the layers of organic matter around the edge of the ring and the sample was then carefully removed. Each sample was placed in a sealed P.V.C. bag and transferred to the laboratory within 24 hours.

The measurement of litterfall commenced at the end of November, 1974, after the forest floors had been sampled, and continued for a period of twelve months. The litter was collected in P.V.C. plant pots (top internal diameter 25.4 cm, height 22 cm). Fine polypropylene netting was placed at the bottom of the pots to filter litter from rainwater. Fifteen pots were placed at random within each plot (total collection surface, 0.76 m^2 per site). The litter was harvested every two months and transferred to the laboratory in paper bags.

All samples of the forest floor were dried for 48 hours at 90°C and weighed. Samples were then bulked by crops prior to analysis of duplicate subsamples for organic carbon and nutrient contents using standard chemical methods. pH was determined on the bulked samples before drying using a 1:1 water sample ratio. In addition, ten samples from each crop were carefully separated to find the proportions of needles, root, bark and other material. Litterfall from each collector in each sample period was dried at 90°C, weighed and then bulked by crops for analysis of nutrient content. Dry weights for litter and forest floor are expressed on a 105°C basis.

Results

Litter Production

The quantity of litterfall and its absolute nutrient content (Table 2) both follow the pattern of stocking density, being greatest at Glenmalure and least at Ballinglen. Although significant quantities of litter fell throughout the year at each site, the months of June and July had by far the highest fall of the six sampling periods (Table 3, Fig. 1). This may be a reflection of the unusually low rainfall and high temperatures recorded in Ireland for that period in 1975. There was a general tendency for the figures for P and K (% DM) to be highest in April-May and lowest in October-November (Table 3). The high April-May figures may be due to leaching of nutrients from the newly formed foliage onto the older needles, whereas the drop in the October-November data could be due to translocation to other parts of the tree prior to senescence or to leaching out by rainwater. Both of these processes are known to take place in trees (Tamm, 1951; Madgwick and Ovington, 1959; Tukey, 1970). Alternatively, the

high April-May data may represent movement of these elements from roots and stem to shoots prior to bud-break (Miller, 1977, personal communication), the low figures for October-November being the reverse. It is apparent from Figure 2 that the variation in nutrient concentration of the litterfall throughout the year follows very similar patterns for the three sites. Similar patterns were found by Wright (1957) for N, P and K in Norway spruce, and by Miller *et al* (1976), for N concentration in Corsican pine.

TABLE 2

Mean dry matter and N, P and K contents of litterfall (kg/ha/annum)

Forest	DM	SE*	N	P	K
Glenmalure	8860	204	117.6	7.8	21.9
Glenealy	4040	138	54.2	4.1	13.6
Ballinglen	3850	55	45.0	2.3	7.4

*Standard error of the mean.

Although the values in Table 2 are generally higher than those cited in the literature they are quite comparable with the figures given by Wright (1957). The dry matter, N and K contents given by Owen (1964), for Sitka spruce are considerably lower than those reported here; his data for P are quite comparable. All data for the Glenmalure plots are extremely high when compared with those in the literature. Apart from the figures by Spain (1973) for Douglas fir in Australia, the N data here are considerably higher than those reported in the literature.

Litter Accumulation

The forest floor samples were all extremely acid (Table 4) with pH values varying between 3.7 and 4.5, the average being 4.1. The Glenmalure forest floor was more acid than that at the other two sites. Organic carbon contents were high, averaging 48.4%, resulting in high carbon/nutrient ratios.

The figures for dry matter and nutrient contents of the forest floors in Table 4 are in general considerably higher than those cited for conifers by other workers, with the exception of the data for 100 year old Douglas fir given by Youngberg (1966). It should be borne in mind however that in the present study all branch twig and coarse root material was excluded from the samples. A feature of the composition of the forest floors (Table 5) is the occurrence of many small (less than 2.5 mm diameter) tree roots. Mycorrhizal fungi were also observed but not quantified. The average dry matter content of the small roots for the three sites was 1450 kg/ha.

TABLE 3

Bi-monthly dry matter and nutrient contents, per cent of dry weight and absolute quantities (kg/ha), of litterfall at the three forests. Each figure represents a mean of three plots.

Collection Period	Forest	DM kg/ha	DM (SE)	%Tot	%DM	N kg/ha	N %DM	P kg/ha	P %DM	K kg/ha
Dec-Jan	Glenmalure	1100	280	12.4	1.32	14.5	.09	1.0	.23	2.5
	Glenealy	440	200	11.2	1.39	6.1	.10	0.4	.36	1.5
	Ballinglen	300	120	7.5	0.94	2.8	.06	0.2	.12	0.3
Feb-Mar	Glenmalure	999	210	11.3	1.39	13.8	.08	0.8	.22	2.1
	Glenealy	150	70	3.8	1.39	2.1	.10	0.1	.31	0.4
	Ballinglen	340	120	8.6	1.16	3.9	.08	0.2	.16	0.5
Apr-May	Glenmalure	1400	240	15.8	1.37	19.2	.10	1.4	.36	5.1
	Glenealy	710	180	18.1	1.49	10.5	.13	0.9	.57	4.0
	Ballinglen	430	100	10.8	1.23	5.2	.09	0.3	.28	1.2
Jun-Jul	Glenmalure	2630	510	29.7	1.28	33.6	.08	2.1	.23	6.0
	Glenealy	1700	380	41.7	1.32	22.4	.11	1.8	.30	5.1
	Ballinglen	2280	450	57.7	1.14	26.0	.08	1.8	.21	4.8
Aug-Sept	Glenmalure	1660	380	18.8	1.46	24.2	.09	1.4	.24	4.9
	Glenealy	390	140	9.9	1.46	5.7	.10	0.4	.28	1.1
	Ballinglen	390	120	9.8	1.42	5.5	.09	0.3	.13	0.5
Oct-Nov	Glenmalure	1040	300	11.7	1.10	11.4	.06	0.6	.13	1.3
	Glenealy	530	200	13.5	1.12	5.9	.07	0.3	.16	0.8
	Ballinglen	210	50	5.3	1.42	3.0	.09	0.1	.12	0.2
Annual Total	Glenmalure	8829				116.7		7.3		21.9
	Glenealy	3920				52.7		3.9		12.8
	Ballinglen	3950				46.4		2.9		7.5

Discussion

The results show that the rate of litter accumulation beneath polestage crops of Sitka spruce far exceeds its rate of decomposition. If the forest floors beneath the crops had reached a stage of equilibrium, or as Reiners and Reiners (1970) term it a "steady state", the input of organic matter and nutrients to the forest floor would equal the output. However these crops of Sitka spruce, with the possible exception of the Ballinglen stand, have not yet reached this stage and work by Page (1968) would suggest that they are unlikely to do so until they are 55 to 60 years old.

The wide variation between sites both with regard to litterfall and forest floor characteristics raises the question as to why such large differences exist. It is probable that the main factor contributing to the wide variation in both litterfall and forest floor characteristics is crop density. The Glenmalure stand had both the highest litterfall and the greatest quantity of organic matter present in its forest floor whereas the Ballinglen site, which was also the most productive, had the smallest amounts. Although the Glenmalure stand was the

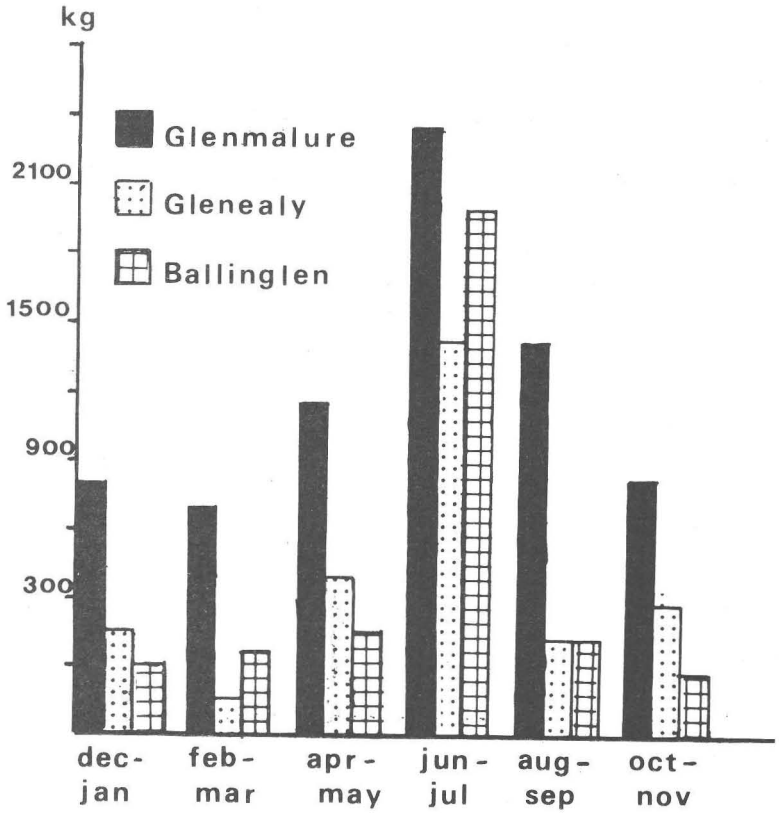

Figure 1. Seasonal variation in Sitka spruce litterfall. (kg ha^{-1}, D.M.

younger of the two it was also the most overstocked. While the confounding effect of age on stand density makes it impossible to isolate the significance of either factor, crop density is very likely the over-riding one. Wright (1957) working in a Norway spruce *(Picea abies* (L.) karsten) thinning experiment showed that forest floors beneath heavily thinned crops contained 66% less organic matter compared with lightly thinned plots, twenty five years after the treatments were imposed. Although he found that thinning resulted in a slight reduction in litterfall, Wright attributed the large decrease in litter accumulation on the forest floor to a considerable increase in its rate of decomposition following thinning operations.

Results from research on spacing experiments carried out in Sitka spruce in Ireland have been published by Jack (1971) and Gallagher (1973). From these it appears that growth was not affected, at least

on the better sites, at spacing up to 2.4 metres but production is severely reduced with further increases in initial spacing. However, a balance would have to be found between the beneficial effects of a faster circulation of nutrients and the straightforward adverse effects of a heavy reduction in stocking on increment, a balance that would probably vary with the nutrient capital of the site.

In the context of the overall nutrient budget, both the quantities of nutrients being shed annually in the litterfall and the amounts immobilised in the forest floors are substantial. More detailed studies at the Glenmalure site (Carey, 1977a) showed that 45% of the N and 35% of the P present in the ecosystem were in the forest floor. The quantity of K present in the forest floor on the other hand represents

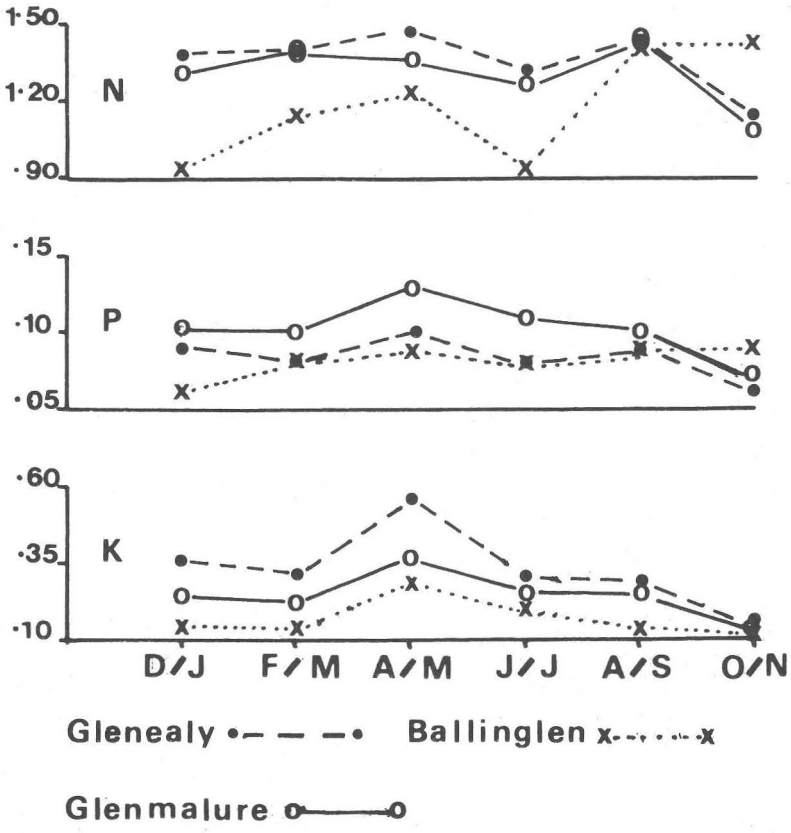

Figure 2. Seasonal variation in the N, P and K concentration of Sitka spruce litterfall (% D.M.).

only 7% of the total present in the system. This nutrient is held in inorganic form whereas most of the nitrogen and phosphorus are organically bound. Further studies also indicated that the quantities of nutrients reaching the forest floor in the litter represented the greater proportion of the annual uptake by the crops concerned. This suggested that the nutrient requirements could be almost totally satisfied through recycling, but that the process was being interrupted by the slow rate of decomposition (Carey 1977b).

The accumulation of litter and the immobilisation of nutrients within the forest floor will be of practical significance only when the supply of nutrients is incapable of satisfying the demands of the crops. Although there are indications of impending deficiency in some crops, recent work by O'Carroll, Dillon and Carey (1976) suggests that these are by no means widespread under Irish conditions. Under these circumstances, the accumulation of litter on some sites might offer certain advantages, serving as a reservoir of nutrients for future forest rotations. However, on nutrient-poor sites, the immobilisation of nutrients in the forest floor may have serious consequences for tree nutrition and fertiliser inputs might be required to sustain growth.

TABLE 4

Depth, pH, organic carbon (% D.M.) dry matter content, and concentration and mass of nitrogen, phosphorus and potassium in the forest floors

Site	Glenmalure	Glenealy	Ballinglen
Depth (cm)	6.0	4.8	3.6
pH	3.7	4.4	4.4
Organic carbon (%)	53.7	47.8	43.8
D.M. (tonnes/ha	55.46	50.65	45.67
Standard error	7.42	8.60	13.15
N% D.M.	2.04	1.63	1.73
kg/ha	1131	825	790
P % D.M.	.09	.09	.11
kg/ha	49	47	51
K % D.M.	.06	.28	.47
kg/ha	33	142	216
C/N	26	29	25
C/P	596	531	398
C/K	895	170	93

The occurrence of many fine mycorrhizal roots within the forest floor suggests that the trees are obtaining some of their nutrient supply directly from these layers as has been suggested by Gessel *et al* (1973). Further research is required in order to establish the extent to which Sitka spruce obtains N and the other essential nutrients directly from the forest floor. Results from such studies would provide the forest manager with a greater understanding of the nutrient cycle in forest crops and of the extent to which it can be manipulated in the interests of greater wood production.

TABLE 5

Composition of the forest floors (kg/ha)

Forest	Small roots	Twigs	Bark	Needles and non identifiable material
Ballinglen	950	180	220	44,320
Glenealy	2,080	2,220	20	45,580
Glenmalure	1,320	1,100	—	54,040

Acknowledgements

Acknowledgement is made and grateful thanks extended to the Forest and Wildlife Service, Department of Fisheries for financial support, and to Prof. D. M. McAleese, in whose Department the study was carried out. Also to W. F. Collins and W. B. Luddy for assistance in the field measurements and to Miss Rachel Reid for assistance in the laboratory.

References

Abee, A. and D. Lavender. 1972. Nutrient cycling in throughfall and litterfall in 450-year-old Douglas fir stands. In Res. on Coniferous For. Ecosystems. US/IBP. (Franklin, D. F., L. J. Dempster and R. H. Waring, eds.) U.S. For. Ser. Pacific N.W. Expt. Station.

Bradley, M. A., J. M. Christie and M. A. Johnston. 1966. Forest Management Tables. Booklet 16, For. Comm., London.

Carey, M. L. 1977a. Nutrient cycling and forest fertilisation in Sitka spruce *(Picea sitchensis* (Bong). Carr). Ph.D. Thesis, University College, Dublin. 140 pp. Unpubl.

Carey, M. L. 1977b. Nutritional disorders in Sitka spruce in Ireland. Irish For. 34(1): 40-47.

Cole, D. W., S. P. Gessel and S. F. Dice 1967. Distribution and cycling of nitrogen, phosphorus, potassium and calcium in a second-growth Douglas fir ecosystem. In Symp. on Primary Productivity and Mineral Cycling in Natural Ecosystems. (Young, H., ed.), 197-232. College of Life Sciences and Agriculture, Univ. Maine.

Gallagher, G. 1973. Spacing trials in Sitka Spruce. Research Communications No. 11. Forest and Wildlife Service, Dublin, 13 pp.

Gessel, S. P., D. W. Cole and e. Steinbrenner, 1973. Nitrogen balance in forest ecosystems of the Pacific Northwest. Soil Biol. and Biochem. 5: 19-34.

Hoover, M. D. and H. a. Lunt 1952. A key to the classification of forest humus types. Proc. Soil Sci. Soc. Amer. 16: 368-70.

Jack, W. H. 1971. The influence of tree spacing on Sitka spruce growth. Irish For. 28 (1): 13-33.

Madgwick, H. A. and J. d. Ovington 1959. The chemical composition of precipitation in adjacent forest and open plots. Forestry 32: 14-22.

Mahendroppa, M. K. and E. D. Ogden, 1973. Effects of fertilisation of a black spruce stand on nitrogen contents of stemflow, throughfall and litterfall. Can. J. For. Res. 3: 54-60.

Miller, H. G., J. M. Cooper and J. D. Miller 1976. Effect of nitrogen supply on nutrients in litterfall and crown leaching in a stand of Corsican pine. J. Appl. Ecol. 13(1): 233-48.

O'Carroll, N., J. D. Dillon and M. L. Carey, 1976. Fertiliser requirements of Sitka spruce. Forest and Wildlife Service, Dublin. Unpubl.

Ovington, J. D. 1961. Quantitative ecology and the woodland ecosystem concept. Adv. in Ecol. Res. 1: 103-197.

Owen, T. 1954. Observations on the monthly litterfall and nutrient content of Sitka spruce litter. Forestry 27: 7-15.

Page, G. 1968. Some effects of conifer crops on soil properties. Comm. For. Rev. 47: 52-62.

Reiners, W. A. and W. M. Reiners. 1970. Energy and nutrient dynamics of forest floors in three Minnesota forests. J. Ecol. 58: 497-520.

Spain, A. V., 1973. Litterfall in a New South Wales conifer forest: a multivariate comparison of plant nutrient element status and return in four species. Jour. Appl. Ecol. 10: 527-556.

Tamm, C. O. 1951. Seasonal variation in composition of birch leaves. Physiol. Plant. 4: 461-69.

Tukey, H. B. 1970. The leaching of substances from plants. Ann. Rev. Plant Physiol. 21: 305-24.

Wright, T. W. 1957. Some effects of thinning on the soil of a Norway spruce plantation. Forestry 30: 123-33.

Youngberg, C. T. 1966. Forest floors in Douglas fir forests: 1. Dry weight and chemical properties. Proc. Soil Sci. Soc. Amer. 30: 406-9.

The Effect of Wide Espacement on Wood Density in Sitka Spruce

(Picea Sitchensis. (Bong.) Carr)

J. J. GARDINER[1] AND P. O'SULLIVAN[2]

IN modern plantation forestry wide espacement is attractive because it leads to lower establishment costs, it dispenses with uneconomic thinnings, it gives greater individual tree vigour and it concentrates the final volume production on a smaller number of more uniform trees. Numerous reports (Ward and Gardiner, 1976; Brazier, 1970; Cown, 1973) have suggested that one of the effects of vigorous tree growth is to cause a decrease in wood density as vigour of growth increases. The evidence for this is, however, conflicting since some investigators (Maeglin, 1967; Paul, 1963) have reported that within the limits of normal silvicultural practice, initial spacing has very little effect on the density of the wood produced. Furthermore, it has been shown (Larson, 1969) that when species such as pines and spruces are pruned artifically, they produce wood of a non-uniform quality, characterised by a rapid increase in latewood percentage with increasing age.

This report gives some results of a study carried-out in two stands of Sitka spruce *(Picea sitchensis* (Bong.) Carr) with very wide planting espacement, and shows the distribution of density variation in trees with artifically reduced crowns.

Materials and Methods

The spruce stands from which the samples were taken were located at Drumhierney Plantations, Co. Leitrim. They were established in 1954 at spacings of 2.4mx2.4m and 4.5mx4.5m respectively.

Neither stand has been thinned since establishment but all of the stems in both crops have been consistently pruned from an early age to leave approximately $\frac{1}{3}$ of the live crown. The trees in the more widely spaced stand are just closing canopy but there is fairly intense competition amongst trees in the stand established at 2.4mx2.4m. Further particulars of these stands are given in Table 1.

Eight trees were sampled in each stand. Sample trees were located by dividing the stems into four diameter classes and randomly selecting two trees within each class. Each selected tree was climbed and a 5mm core was taken at heights corresponding to 10%, 25%,

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TABLE 1
Some Characteristics of two Sitka spruce stands at Drumhierney Plantations, Co. Leitrim

	STAND 1	STAND 2
Soil Type	Surface Water Gley	Surface Water Gley
Espacement	2.4mx2.4m	4.5mx4.5m
Age	23 years	23 years
B.A. per ha	54.5m²	27.9m²
Top Height	17.5m	16.0m
Mean D.B.H.	22.75 cms.	28.63 cms.

40% and 60% of the total height. A core was also taken at breast height. All cores were taken on the south side of the trees. Whole core density was determined using the water displacement method. The mean wood density as derived from four cores was compared with wood density as estimated from one core taken at breast height.

Results

The estimates of wood density obtained from single cores taken at breast height were in almost all cases greater than those obtained from 4 cores taken at various heights in the stems (Table 2). The correlation coefficients were 0.946 and 0.896 for the 2.4mx2.4m and 4.5mx4.5m stands respectively. The overall correlation coefficient for both stands sampled was 0.934. These coefficients were found to be significant at the 1% level. Statistical analysis also showed that there was a significant
difference (1% level) in mean wood density between the samples taken from trees established at 2.4mx2.4m and those established at 4.5mx4.5m (Table 3).

The pattern of wood density variation was also traced and compared in three sequences for each of the stands (Figs. 1, 2, 3).

While the characteristic patterns of density variation were apparent, the differences in estimated wood density between the two stands did not appear to be located in any specific area in the trees but was found to be evenly distributed throughout the stems. The density of the wood from the 4.5mx4.5m stand was found to be at all heights and in each sequence, lower than that of the 2.4mx2.4m stand.

Discussion

Although increment cores have been used to give estimates of wood density in standing trees for many years, there is very little

TABLE 2
A comparison of mean density of 16 trees as calculated from 4 cores and density of the same trees as estimated from 1 core taken at breast height.

2.4mx2.4m Spacing

Tree No.	Mean Density from 4 cores (gm/cc)	Density from 1 core (gm/cc)
1	0.3798	0.3915
2	0.3416	0.3509
3	0.3325	0.3560
4	0.3535	0.3545
5	0.4052	0.4252
6	0.3371	0.3612
7	0.3611	0.3809
8	0.3440	0.3566

4.5mx4.5m Spacing

Tree No.	Mean Density from 4 cores (gm/cc)	Mean Density from 1 core (gm/cc)
1	0.2912	0.2842
2	0.3214	0.3355
3	0.3162	0.3167
4	0.3300	0.3081
5	0.3633	0.4012
6	0.3076	0.3289
7	0.3010	0.3176
8	0.2928	0.3089

information available as to how many cores should be taken and the optimum location of these in the tree. Results obtained in this study indicate that the estimate of wood density obtained from a single increment core taken at breast height is closely related to mean wood density as derived from a series of borings taken at various heights in the stem. Thus, the evidence from this study suggests that whole stem wood density can be accurately predicted using a single 5mm increment core taken at breast height. In addition, examination of the data showed that mean wood density for these stands could be predicted (_+ 10% at the 95% confidence level) by taking borings from seven trees in each stand.

Since the spacings found at Drumhierney plantations were not replicated it was not possible to directly compare wood density

TABLE 3
The estimated wood density in trees planted at wide espacements

Tree No.	Mean Wood Density (g/cc) of 2.4mx2.4m trees	Mean Wood Density (g/cc) of 4.5mx4.5m trees
1	0.3798	0.2912
2	0.3416	0.3214
3	0.3325	0.3162
4	0.3535	0.3300
5	0.4052	0.3633
6	0.3371	0.3076
7	0.3611	0.3010
8	0.3440	0.2928
	$\bar{X}_1 = 0.3569$	$\bar{X}_2 = 0.3154$

$\bar{X}_1 - \bar{X}_2$	=	0.0415 gms/cc
Pooled S^2	=	0.000584
t value	=	3.4326
Probability of Type II Error	=	26%

between the two stands. However, the results indicate that the wood produced at the wider spacing is lower in density than that growing in the 2.4mx2.4m stand. The actual difference found was 0.045 g/cc or 45 kg/m^3. Nevertheless, it appears that the wood produced in these widely spaced stands at Drumhierney compares very favourably, as regards density, with spruce wood produced in plantations managed under more conventional silvicultural regimes (Table 4).

It was not possible to isolate the effect of green pruning upon wood density in this study. However, it is probable that green pruning,

TABLE 4
Wood density in some Sitka spruce plantations in Ireland

Location	Age (yr.)	Yield Class	Density Range G/cc	Mean Density g/cc
*Camolin Forest	44	22	0.29-0.44	0.35
*Aughrim Forest	39	18	0.23-0.45	0.35
*Killarney Forest	48	24	0.28-0.45	0.36
Drumhierney				
2.4mx2.4m	23	24	0.33-0.41	0.36
4.5mx4.5m	23	—	0.29-0.36	0.32

**Sources:* I.I.R.S. Reports, 1, 2 and 3. "The properties of Irish Grown Sitka spruce".

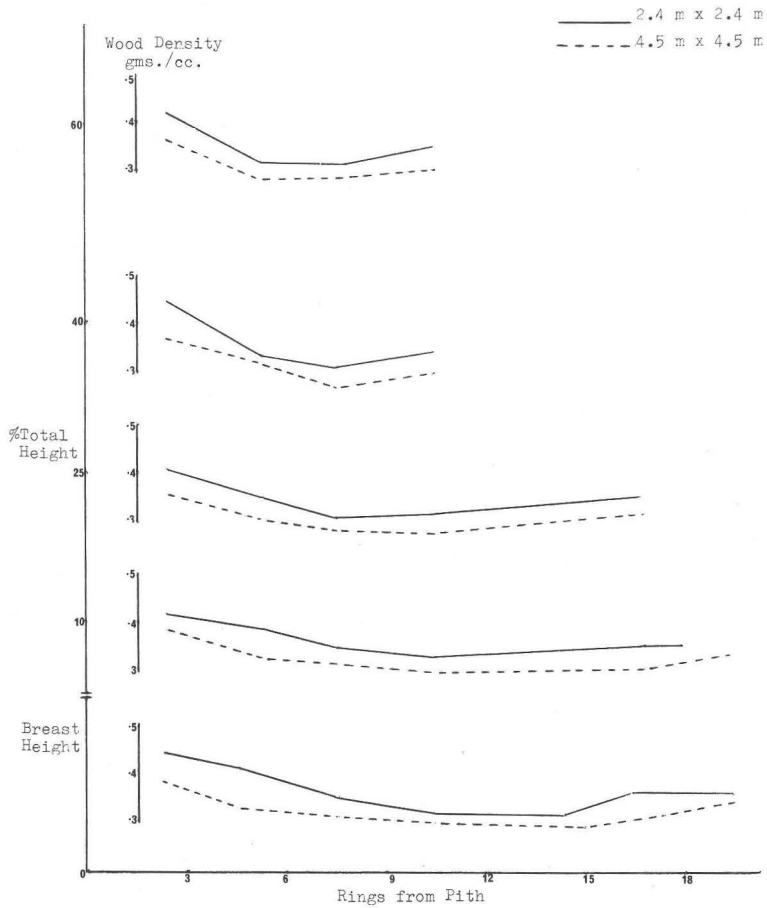

FIG. 1
Wood density variation in the horizontal sequence at five height levels.

which is analogous to artifically creating stand grown trees from open grown trees, was responsible for the even distribution of density variation in the stems of the more widely spaced stand.

In conclusion, it may be said that these results indicate the presence of a significant difference in wood density in the stands examined. However, it does seem that this effect has been modified considerably by the green pruning.

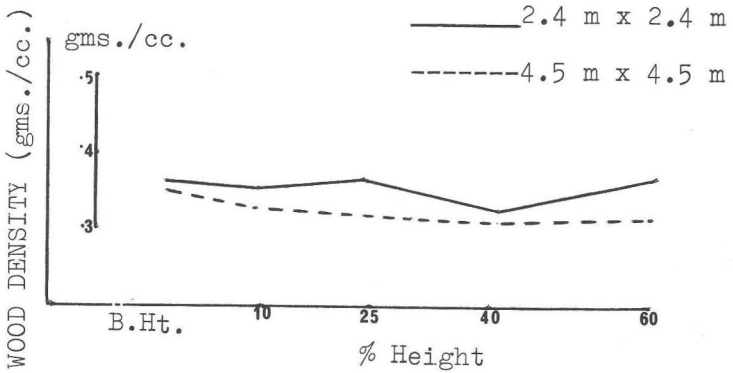

FIG. 2
Wood density variation in the vertical sequence at 10 rings from the pith.

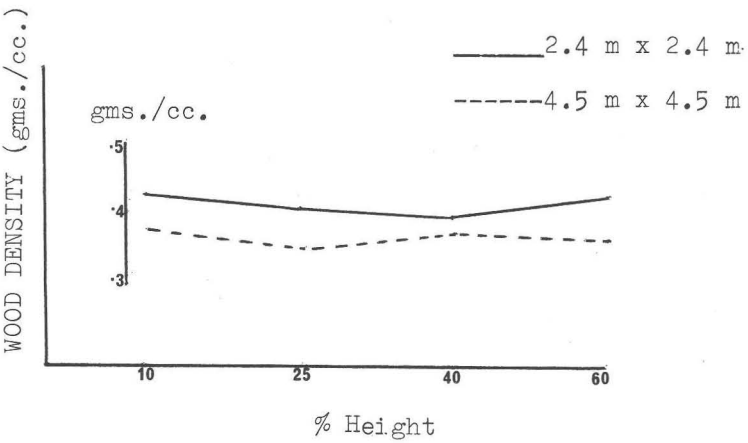

FIG. 3
Wood density variation in the oblique sequence at 10 rings from the bark.

References

Brazier, J. D. 1970. Timber improvement II. The effect of vigour on young-growth Sitka spruce. Forestry, 43; 135-150.

Cown, D. J. 1973. Effects of severe thinning and pruning treatments on the intrinsic wood properties of young Radiata pine. New Zealand For. Service. Rep. 725.

Larson, P. R. 1969. Wood formation and the concept of wood quality. Yale Univ. Sch. For. Bull. No. 74.

Maeglin, P. R. 1967. The effect of tree spacing on weight yields for Red pine and Jack pine. J. For. 65; 647-650.

Paul, B. H. 1963. The application of silviculture in controlling the specific gravity of wood. Tech. Bull. 1288, U.S.D.A. For. Prod. Res. Lab., Madison, Wisconsin, U.S.A.

Ward, D. and J. J. Gardiner 1976. The influence of spacing on tracheid length and density in Sitka spruce. Irish For. 33; 39-56.

The Forest Worker: Aspects of Selection and the Consequences of a Heavy Work Load

J. H. WILSON[1]

Abstract
Job analyses of forest workers suggest that more attention should be paid to aptitude testing in the selection process. The paper discusses this point and outlines a range of related tests. The particularly high level of physical effort required in much forest work is also discussed as are the effects of vibrations and jolting on the operators of forest machinery. It is concluded that in the interest of safety and satisfaction much could be done in testing prospective forest workers and in incorporating greater ergonomic awareness into the design of forest machinery.

Introduction

THE proposed new Health and Safety at Work Order N.I. has already had the desirable effect of focusing attention increasingly on the human and subjective aspects of work. It is all too easy to carefully design a job from a mechanistic viewpoint and to ignore human aspects. Furthermore, it is possible, having recognised the significance of human aspects, to fail to consider the extent to which people vary as we slot them into the working situation. Hence if we are to be seen to improve the safety record among any work force we must design around human capacities and aptitudes and we must recognise that people vary widely in these aspects. People must be selected for certain jobs with care if we are to avoid designing working situations around the lowest common denominator of skill and capacity.

It needs to be stressed that care with selection is always in any worker's best interest. It means that people are directed to work which they can do well. Job satisfaction inevitably involves this prerequisite.

Clearly a proven record of ability in a skill which you wish to employ is excellent, but one is often dealing with potential trainees whose ability must somehow be assessed with respect to the proposed job. Analysis of the job is essential in order to establish a hierarchy of capabilities, aptitudes and attitudes commensurate with it.

The significance of such a hierarchy is simply that not all aptitudes have equal importance in selection. Take, for example, a hoist operator

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or someone operating forwarding machinery in a forest. It could be argued that such a person should possess:

(i) Good stereoscopic vision (depth perception)
(ii) Good eye-hand co-ordination
(iii) Good speed of reaction
(iv) Good distributed attention qualities
v) Good sense of balance.

The list may vary in detail but the idea of a hierarchy of aptitudes may be seen in the fact that if the potential employee has not got *good stereoscopic vision* it does not really matter what other qualities he has; he is unsuitable for this particular work. If one is selecting from a group then only those with acceptable scores at each test in the hierarchy would pass on to the text.

Several leading firms in the U.K. and in Europe test their whole work force over a range of aptitudes. Having related these aptitudes to specific jobs within the organisations, work force development and placement is greatly facilitated. A pilot study has been carried out in Northern Ireland to determine the correlation between the actual performance of some forest workers and their test scores. This has been partially successful and more work is planned.

Types of Test

In testing for skill potential there may be something to be said for simulating the job in mind by grouping the skills required into some specially designed test. Such simulation often incorporates confused learning criteria and may be unsatisfactory as an early predictor of training potential. It can be readily argued that simulation is more advantageous in the training function then in the selection function.

Several standard tests have been devised to measure the specific aptitudes into which the requirements of the majority of jobs can be divided. Some of the most widely applied tests are designed to measure the following:

1. Visual Performance — Standard tests have been developed to measure such aspects of vision as acuity, stereopsis, colour discrimination and phoria.
2. Eye-hand Co-ordination — A variety of simple tests have been devised which require the subject to keep an object on a moving route or target.
3. Speed of Reaction — This is normally related to the time interval required to cancel an audio or visual signal.
4. Distributed Attention — Such tests are an extension to testing speed of reaction. In this case the signals are varied in their location and nature.
5. Hand Steadiness — This is often indicated by one's ability to hold

a probe in a small ring or trace a very narrow path without making contact with the periphery.

6. Body Balance — Tests for body balance normally require the subject to stand on a small platform about 40 cm square. The platform is capable of tilting in any direction, within limits, and balance is related to the extent to which it can be maintained in the horizontal plane.
7. Manual Dexterity — The location of small dowels, bushes and washers on a simple pegboard can be used to give a measure of manual dexterity.
8. Hearing Sensitivity — Straightforward tests may be carried out under the correct conditions to measure a subject's threshold of hearing over the normal audio frequency range.
9. Physiological energy consumed can be measured using an "ergocycle" to gauge the mechanical work and a respirometer and oxygen analyser to determine the oxygen consumed. Other indicators of a subject's capacity for physical work are changes in heart rate, blood constituents and urine concentrations.

Of course while physical and physiological tests may indicate whether a person could do a particular job, such issues as willingness, motivation and vocational preference may also have to be considered. In these areas psychologists have developed several effective tests of the questionnaire type. Certainly information on attitudes and preferences is important in the selection of forest workers as with other workers.

The Forest Worker

The drop out figures among forest workers would suggest the need for a very serious look at selection. A recent bulletin (Scott and Cottell, 1977) of the Forest Engineering Research Institute of Canada (FERIC) indicated that only between 29% and 43% of those passing through training courses on logging in Canada were still on the job after one year. The same article suggested that in order to retain 3,300 loggers, 10,000 would have to be drawn into the basic training programme.

FERIC refers to some recent Canadian research on performance variations among logging machine operators which categorically concludes that it is possible to measure factors which influence such variations. The particular attributes singled out for attention are visual depth perception (i.e. good stereoscopic vision), manual dexterity, motivation and length of experience. It is suggested that the greatest motivation for increased productivity, from the operator's point of view, is an awareness and a recognition that he is capable of doing the job; surely an observation which underlines the importance of careful selection.

Among the suggestions for eliminating the unsuitable applicant in the Canadian context was to charge a fee for training — hardly an acceptable idea here. It is also suggested that a thorough exposure of prospective candidates to forest operations in action in poor weather might drive off the lazy and fainthearted.

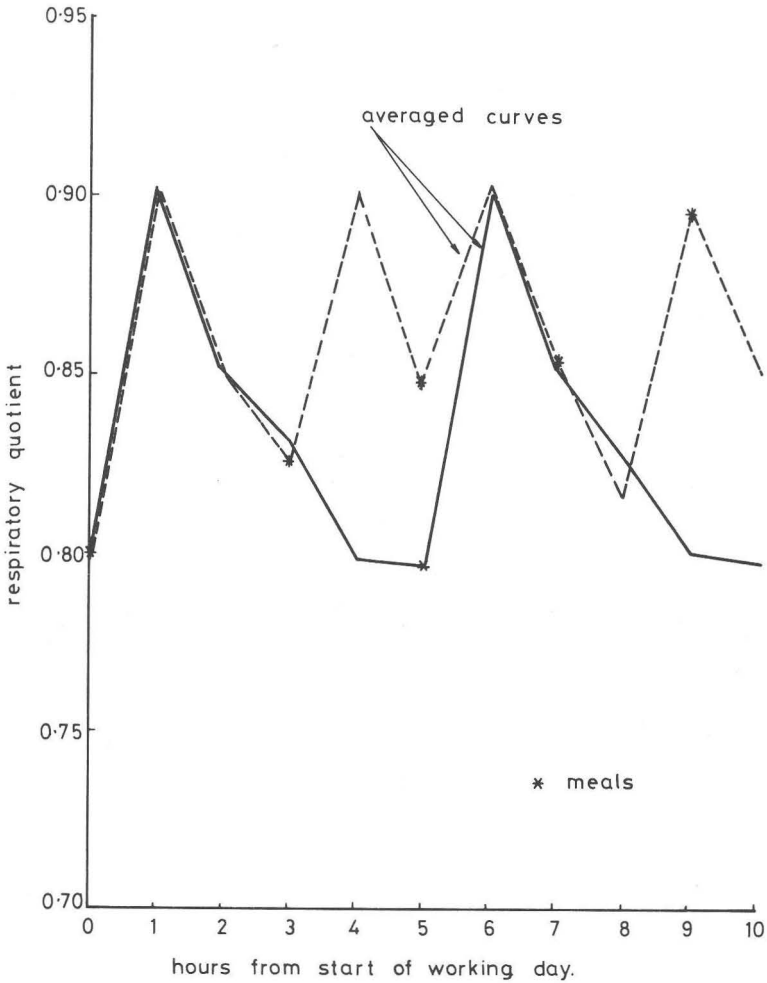
Early classical investigations in Sweden and Norway have shown that in traditional forest work the daily energy production of the forest worker was 6,000-7,000 k cal per day. Of course, with improved conditions and increased mechanisation, study within the last decade has shown that the energy production of manual forest workers was within the spectrum 2500/5000 k cal per day. Since work-scientists are generally agreed that the maximum energy expenditure recommended in industry for an 8 hour day should not exceed 5 k cal/min or 2400 k cal per day, one can see that forest work is rightly regarded as very heavy work. Of course, the concept of yearly averaging must be applied to forest work as with farming where extremely heavy work loads are experienced during harvesting. Also a correction must be made to the recommended norms for the age of the worker. It is also worthy of consideration here that man's capacity to convert the energy consumed into mechanical work may vary from around 5% to 30%. There can be little doubt that fatigue in forest work is a most significant factor in the context of safety criteria. Vigilance and speed of reaction data can demonstrate some of the hazardous affects of fatigue.

Clearly, in any attempt to combat fatigue, a worker's diet and the frequency of food intake is significant. Respiratory quotient (i.e. the ratio of CO^2 produced to O^2 consumed) has been found to relate to muscular efficiency and fatigue (Figure 1). This indicates the advantages of spreading the intake of food more evenly over the working day. Respiratory quotient is thus kept from falling too low.

Vibrations and Jolts

Together with the fatiguing affects of a high energy expenditure, forest machine operators are subjected to low frequency vibrations of considerable magnitude. This may have superimposed upon it substantial and not infrequent jolting. These aspects were the subjects of papers delivered at the World Congress of the International Union of Forest Research Organisations in Norway, 1976 (Hansson, 1976); Woulijoki, 1976).

The vibrations have to be damped in the body by absorption of the kinetic energy by the skeleton, joints, ligaments and muscles. The muscles play a vital role. This increased muscular activity is tiring although largely involuntary. The reaction to a jolt or vibration is to stiffen the body and the stiffer body is less able to effectively absorb



EFFECT ON RESPIRATORY QUOTIENT OF EATING TWICE PER WORKING DAY COMPARED WITH EATING FIVE TIMES. (AFTER HAGGARD AND GREENBERG (2))

Fig. 1

energy. One may perhaps draw the analogy with the rigid novice and the relaxed, experienced horse rider.

Horizontal vibrations were found, in the Norwegian work (Hansson, 1976), to be critical and yet there is a tendency to devise seats from the point of view of damping vertical vibrations. Seats tend to have the sides and backs with cushions into which the driver sinks, all of which effectively convey the effect of any horizontal vibrations present. High amplitude, low frequency vibrations are not healthy at the best of times but when the body is also twisted as shown in figure 2 the affect must be aggravated.

Finnish researchers (Woulijoki, 1976) have been looking with others at the effects of vibrations upon visual acuity and have discovered that between 3 and 5 Hz vertically and 23 and 34 Hz horizontally there is substantial loss of focusing ability. These frequencies were found in forest machine operations. Since the natural frequency of the eyes is said to be abovce 60 Hz it is suggested that this loss in focusing results from other tissues and organs in the head resonating.

Psychological Aspects

Much of the above has been about fatigue because fatigue in its turn can be a significant contributor to the causes of accidents.

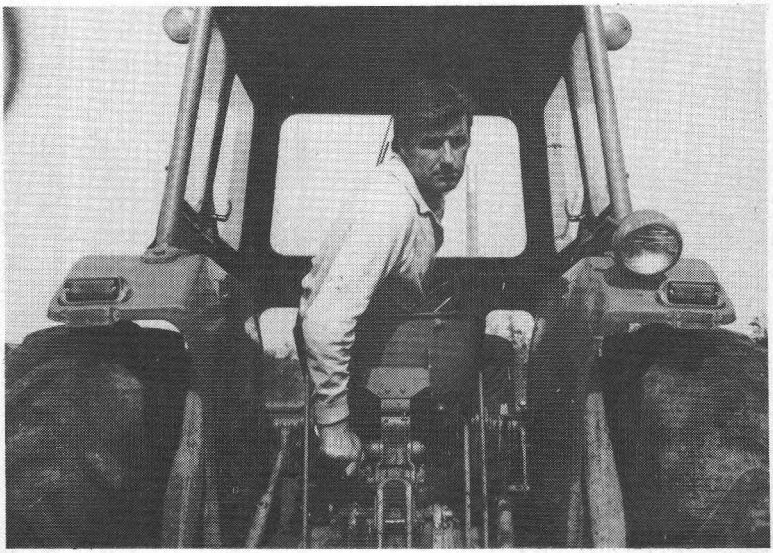


Fig. 2. Common tractor working position

However, it would be wrong to conclude that fatigue arises exclusively from environmental or physiological sources. Professor Grandjean (1969) summarises the various sources of fatigue as:
(a) Monotony
(b) Intensity and duration of physical and mental work
(c) Environment (climate, light and noise)
(d) Responsibilities, worries, conflicts
(e) Illness, pain, nutritional state.

Stress leads to fatigue in humans as well as in metals and important qualities which influence stress in most people are:
(i) Level of stimulation
(ii) Degree of control over working situation.

Aronsson (1976) studied two groups of sawmill workers, some sawyers and some maintenance workers. The sawyers worked on jobs with short repetitive cycles; there was rigid control over methods and too much noise to chat. The maintenance men had long non-cyclic work, personal control over methods and the opportunity for conversation. Of the sawyers, 74% complained of boredom, where only 8% of the maintenance men did so. None of the latter group complained of tiredness before work or nervousness afterwards, whereas almost half of the sawyers complained of both. It is often unwise to generalise, but much evidence suggests that there is a need to leave a degree of control as to how a person works in his or her own hands. Too often, allegedly improved production techniques result in repetitive, machine paced working with severe mental and physical restraints. This in turn induces stress, contributing to fatigue and accident proneness.

Conclusion

A paper such as this may reasonably be criticised for a lack of specific concrete proposals. However, it would be sheer arrogance for the writer who is not expert in forest matters to pontificate in that context.

It is clear that more could be done to facilitate good selection by introducing some related aptitude testing. Breaks and eating habits of our forest operatives could be looked at closely. The anthropometry and general ergonomics of harvesting machinery could be improved.

The forests have a good safety record but it is interesting to note that nearly all the forest workers one speaks to have had minor accidents and near misses. These are serious accidents in embryo. Let us not become fanatics, i.e. those who, it has been said, redouble their efforts after they have forgotten their aims. People in forest work are

in business to grow trees and to provide timber and amenities but how much better if those employed to do so do it as safely as possible.

References

Aronsson, G. 1976, Work Conditions, Subjective Work Experience and Psychosomatic Health: an explorative study of two groups of Sawmill Workers. Proceedings of XVI IUFRO World Congress, Norway, Div. III, pp. 188-198.

Grandjean, E. 1969. Fitting the Task to the Man. Taylor and Francis Ltd., London.

Haggard, H. W. and Greenberg, L. A. 1935. Diet and Physical Efficiency. Yale University Press.

Hansson, J. E. 1976. Vibrations in Forestry Machines. Proceedings of XVI IUFRO World Congress, Div. III, Norway, pp.206-219.

Scott, D. A. and Cottell, P. L. 1977. Survey of Logger Training. FERIC Report.

Woulijoki, E. 1976. Effects of Jolting of Forest Machines. Proceedings of XVI IUFRO World Congress, Norway, Div. III, pp. 231-239.

The Nursing of Sitka Spruce

1. Japanese larch[1]

NIALL O'CARROLL[2]

THE establishment of plantations of mixed species has been traditional in forestry for many decades. The purpose of mixing has been variously given; to protect against frost, to improve growth, to prevent soil deterioration, and others, but I have seen no record of a rigorous field experiment to examine the effects.

Sitka spruce *(Picea sitchensis* (Bong) Carr.) is the desired species over much of the land being afforested in Ireland. Its growth has not always been successful, and it has frequently been planted in mixture with lodgepole pine *(Pinus contorta* Douglas ex Loudon).

In 1960 an experiment was begun to test the effects on Sitka spruce of nursing by lodgepole pine and Japanese larch *(Larix leptolepis (Sieb. & Zucc.)* Gordon).

The Site

The experiment is located in Lackendarragh, in Avondhu Forest, Co. Cork, at an elevation of about 225m. The soil is a podzolised gley, derived from sandstone of the Old Red Sandstone formation, with a thin layer (less than 2 cm) of peat. It is probable that, as with most of the Old Red Sandstone-derived soils of this region, a layer of peat of perhaps 30 cm had been removed for fuel during the nineteenth century. Prior to afforestation the site had been used for rough grazing, and carried a vegetation dominated by *Molinia caerulea* Moench and *Calluna vulgaris* Hull. In preparation for planting the area was ploughed with a single mouldboard Cuthbertson plough, without a tine, with furrows at 1.5m. The trees were planted 1.5m apart on top of the upturned ribbon and each was given a spot application of 85g of ground rock phosphate supplying 55kg P per ha.

The Experiment

Mixtures were formed in two ways: intimate, in which alternate plants in each row were of the two species; and by bands, where two rows of spruce alternated with two rows of the nurse species. In effect, since the plants were regularly spaced, the intimate mixture was also an alternate one-row mixture with the rows at an angle of 45° to the planting lines.

1. Part 2, on nursing by leguminous species, will be published later.

2. Forest and Wildlife Service, Research Branch, Sidmonton Place, Bray, Co. Wicklow.

There were five treatments:-

1. *Control.* Pure Sitka spruce
2. *Spruce/larch. Intimate.* Sitka spruce and Japanese larch in intimate mixture.
3. *Spruce/larch. Bands.* Sitka spruce and Japanese larch in alternate double rows.
4. *Spruce/pine. Intimate.* Sitka spruce and lodgepole pine in intimate mixture.
5. *Spruce/pine. Bands.* Sitka spruce and lodgepole pine in alternate double rows.

All treatments were replicated three times in randomised blocks.

The lodgepole pine used in this experiment had been raised from seed collected in the region of Lulu Island, British columbia. It is therefore not as fast growing or as heavy-crowned as the variety now used in Ireland, originating from the Washington and Oregon coastal region.

Initial growth was satisfactory, but within a few years all the Sitka spruce trees had entered a state of uniform stagnation with little or no height increment occurring. In late 1967 all plots were treated with a broadcast fertiliser mixture which supplied 65 kg N, 55 kg P and 105 kg K per ha. this caused only a slight response in the spruce, mainly in the form of increased needle length in 1968, but by 1969 this had disappeared. At that time, however, it was observed that the spruce in mixture with larch was slightly better in appearance than the spruce pure or in mixture with pine, and since then this superiority has visibly increased.

Results

Periodic assessments of mean height and height increment of the Sitka spruce are summarised in Table 1. There were no differences between treatments up to the 10th year (1969). In the following 6 year period, 1970-75, the height increment of the spruce mixed with larch was significantly greater than that either of the pure spruce or the spruce mixed with lodgepole pine. The pine did not significantly improve spruce growth compared with that in pure spruce plots until the assessment of mean height at 18 years, when a significant increase is associated with nursing by pine. This is still significantly, and substantially, less than the increase associated with nursing by larch. The Sitka spruce nursed by Japanese larch is now growing in height at a rate of about 35 cm, compared with 10 cm in the pure plots, and about 15 cm in the plots nursed by lodgepole pine.

Discussion

The general growth check which occurred in the first decade of the

TABLE 1
Effect of Japanese larch and lodgepole pine nurses on growth of Sitka spruce.

Assessments of mean height of spruce at successive ages, and height increment at selected periods. Data in metres.

	Mean height at age				Height inc.	Leader growth		
Treatment	3	10	16	18	1970-75	1975	1976	1977
Control	.43	.69	.94	1.19	.25	.07	.12	.10
Spruce/larch, intimate	.41	.93	2.23	2.95	1.30	.27	.37	.34
Spruce/larch, bands	.39	.85	1.95	2.71	1.10	.24	.35	.35
Spruce/pine, intimate	.47	.74	1.16	1.51	.42	.10	.13	.16
Spruce/pine, bands	.47	.77	1.26	1.59	.48	.11	.15	.17
S.E.	.028	.049	.147	.072	.112	.026	.045	.037
L.S.D. 5%*	n.s.	n.s.	.48	.23	.37	.08	.15	.12

*Least significant difference at 5% significance level. (n.s.=not significant)

experiment can be ascribed to phosphorus deficiency resulting from the original spot application of phosphorus fertiliser. This became ineffective as the tree roots grew away from the treated spots. The consequent phoisphorus deficiency was corrected by the broadcast application of 55 kg/ha in 1967. After this it was possible for any potential nursing effects to be expressed, or, to put it another way, the factor which was now limiting the growth in the pure spruce and the spruce/pine plots, was overcome in the spruce/larch plots.

From other experiments and observations on Old Red Sandstone soils, I believe this factor was nitrogen deficiency. Foliar analysis carried out in October 1976 (Table 2) show that the nitrogen content of the spruce had been significantly increased in the plots mixed with larch. There was also a significant increase in the intimate mixture

TABLE 2
Effects of Japanese larch and lodgepole pine nurses on foliar nutrient contents of Sitka spruce in October 1976 (age 17 years). Data in percent of dry matter.

Treatment	N	P	K
Control	1.11	.16	1.08
Spruce/larch, intimate	1.58	.21	1.24
Spruce/larch, bands	1.47	.19	1.16
Spruce/pine, intimate	1.42	.17	1.08
Spruce/pine, bands	1.21	.17	1.05
S.E.	.071	.009	.051
L.S.D. 5%	.23	.03	n.s.

with pine, but not in the band mixture, and there was a significant increase in foliar phosphorus only in the plots mixed with larch. The differences in foliar potassium levels were not statistically significant, although their trend in general is similar to that for nitrogen and phosphorus.

Exactly how this improvement in nitrogen nutrition was brought about by the presence of Japanese larch is not clear. One possibility is through the suppression of ground vegetation. Growth check of spruce, associated with impaired nitrogen nutrition, probably caused by inhibition of mycorrhizae by exudates from *Calluna* roots, (Handley, 1963) can be overcome, at least temporarily, by killing the *Calluna* (Dickson and Savill, 1974). However in this experiment the beneficial effects of the larch on the spruce were visible before any considerable degree of vegetation suppression had taken place. The

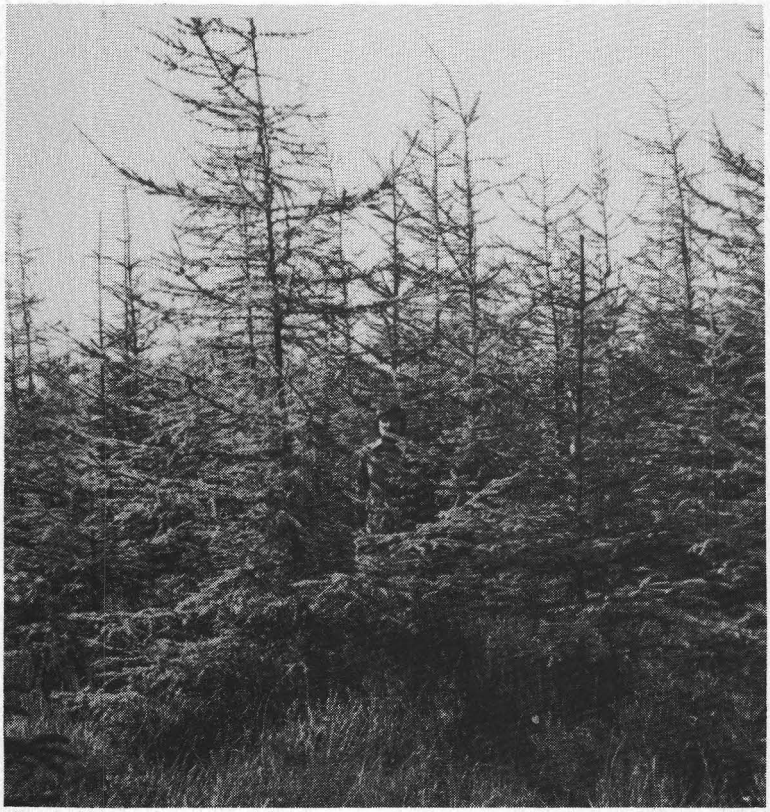


Fig. 1. Sitka spruce nursed by Japanese larch at age 18. Mean height of spruce 2.8m.

present condition (late 1977 visually estimated) is that less than 20% of the *Calluna* layer has been suppressed in the larch plots and less than 10% in the pine plots.

Another, and in my opinion more likely explanation, is the mobilisation and rapid turnover, most importantly of nitrogen, by the deciduous larch.

Practical implications

The present appearance of the Sitka spruce/Japanese larch plots (Fig. 1) is that of a reasonabl;y promising crop. Current leader growth of the dominant trees is about 65 cm. This contrasts with the condition of the pure Sitka spruce crop (Fig. 2) which shows no promise at present of forming an economic forest crop, and would probably require substantial applications of fertiliser nitrogen in order to produce harvestable material.

The use of lodgepole pine as a nurse seems to hold much less promise. While the foliar analysis indicate an increase in N due to intimate mixing with lodgepole pine, this has not so far been relfected in significantly increased height increment in the Sitka spruce, although a small increase in mean height at 18 years was detected. However, with a mean height of 1.6m, compared with 4.2m in the lodgepole pine, the spruce must at present be at a disadvantage in this relationship and liable to be eventually suppressed by its nurse. This

Fig. 2. Sitka spruce without a nurse at 18 years. Mean height 1.2m

is the case with the variety of lodgepole pine used in the experiment, which is of Lulu Island origin; with the more vigorous coastal variety of lodgepole pine now in general use the relationship would be even more unbalanced leading to earlier suppression of the spruce.

In using Japanese larch as a nurse for Sitka spruce there is scope for variation in the arrangement of the mixture. The results obtained, and the probable reasons for the effect, suggest that intimate mixture would be best, but this would be feasible only in circumstances where intensive management is possible. In practice an arrangement such as one line of Sitka spruce, alternating with two or three lines of Japanese larch, might be adopted. This would allow early line thinnign, combined with an extended nursing period before all of the larch was removed in thinning. There is considerable scope for investigation of the economic consequences of the various options available.

In conclusion it appears that a Sitka spruce/Japanese larch mixture would be an acceptable alternative to a pure crop of lodgepole pine on mineral soils not suitable for pure Sitka spruce.

Acknowledgements

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Messrs. A. Gallinagh, M. MacGiolla Coda, J. A. Mannion, D. Keane, T. Horgan and M. O'Donnell.

The chemical analyses were carried out in the Soil Laboratory, Johnstown Castle, Wexford.

I was helped by Dr. M. L. Carey in various ways.

References

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

Handley, W. R. C. 1963. Mycorrhyzal associations and *Calluna* heathland afforestation. Bulletin No. 36, For. Comm., Lond.

Letter to the Editor

Dear Sir,

For the sake of other Clare farmers, I must protest at the 1st Conclusion to "Land Drainage in County Clare", in your last issue, that: "Draining the wet land of the county can be done. The technology and techniques of doing it are there, and the proof of success is there in plenty". To make such claims after only two years trial is surely unscientific.

It must be agreed, that the biggest problem of the "32%" of the lands needing drainage, is the utilization of the crop—either by grazing or harvesting with machinery—during prolonged periods of rainfall.

I would like your readers to note figure 1. The upper graph (histogram) gives the number of wet days as recorded at Mount Callan, Inagh, Co. Clare during the six months April-September (the period when the crop is utilized) for the last 37 years. The lower graph (vertical lines) is for the total rainfall for the same periods. The dotted lines show the average in each case. The data are summarized in table 1.

Table 1. Distribution of wet days and rainfall between 1st April and 30th September at Mount Callan in relation to averages for 30 year period.

Period	1948-'57		1958-'67		1968-'77	
	+*	—*	+	—	+	—
Days with rain	4	5	9	1	1	9
Rainfall	5	5	8	2	2	8

*+ = Number of years above average
— = Number of years below average

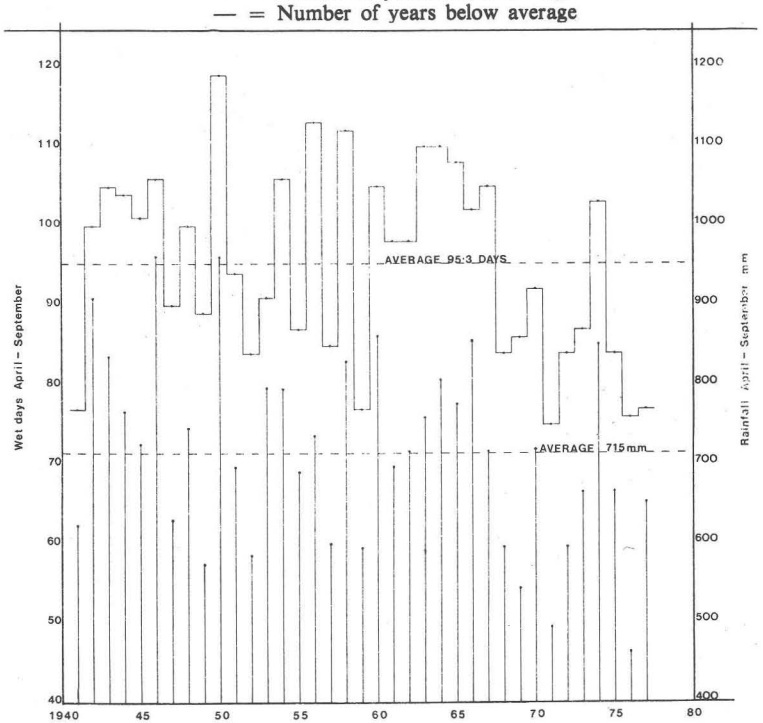

Table 1 — Distribution of wet days and rainfall between 1st April and 30th September at Mount Callan in relation to averages for 30 year period.

It will be noted that the drainage works referred to were carried out towards the end of a ten year period of exceptionally dry summers. If one looks at the previous ten years (1958-67) it will be seen that there was a complete reversal of conditions.

I was undortunate (or fortunate) enough to attempt to drain land at the beginning of this wet period and found that a drainage scheme would tolerate *one* wet Summer but that the cumulative effect of poaching during successive wet Summers caused a complete breadkdown in soil conditions and a magnificent sward of *Juncus effusus*.

I am confident that, given similar conditions to the 1958-67 period, the drainage in question will prove equally ineffective.

What a pity the "£1.8 million spent from 1949-76" was not used for planting Sitka Spruce. Some of these "Tree Farms" would now be yielding £150 per ha/per annum in thinnings, with a final crop worth £15,000 per ha only 12 years away.

Mount Callan,
Inagh,
Co. Clare

Yours sincerely,
Robert Tottenhan

P.S. — It is of interest that the County Leitrim Resource Survey was carried out during the ten year dry period referred to, and this should be borne in mind when reading the Conclusions and Development Proposals in Part IV. (c.f. Part II, p. 72, last para. and Table 51).

Dear Sir,

Beyond this brief note your former editor's letter in the last issue of Irish Forestry compels no further response. If any of your readers so wish they could read once again the editorial in question and my response to it and draw their own conclusions on matters of clarity and precision. The reader after all is the final judge on all written material!

Yours faithfully,
P. MacOscair

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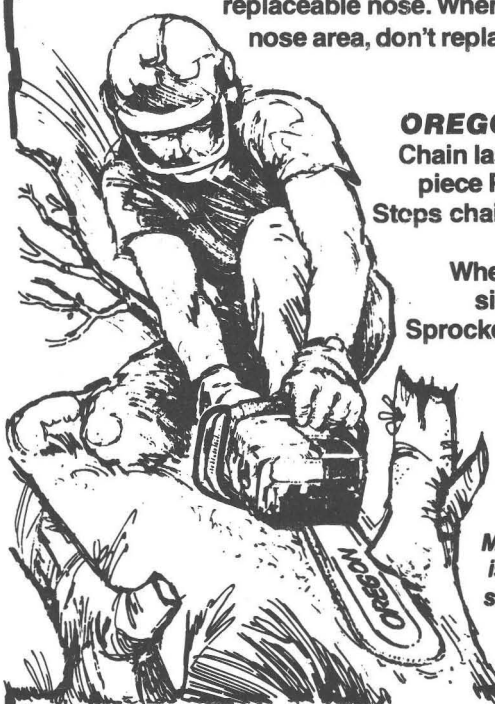

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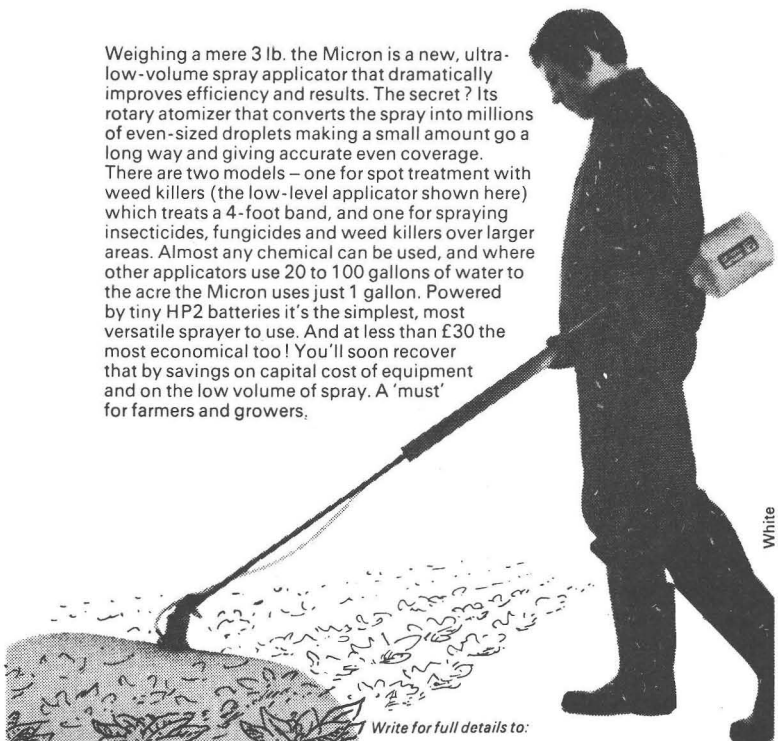

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