Vol. 36, No. 2, 1979

IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

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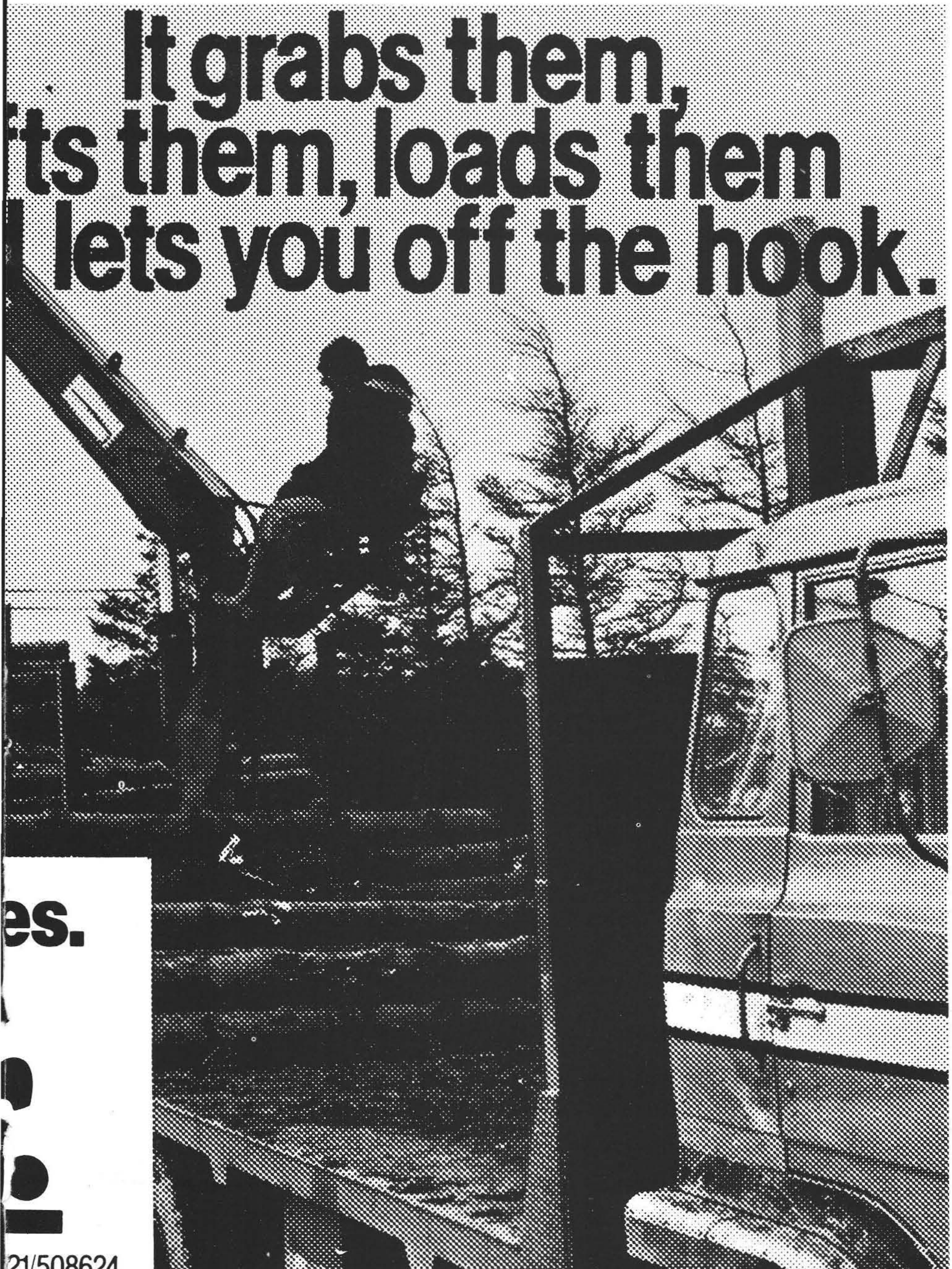
1979, Volume 36, No. 2.

Published twice yearly. Price £2

In this issue: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Young boys and girls sailing on Poulaphouca Lake, Co. Wicklow.

IRISH FORESTRY

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Notes for the Assistance of Contributors

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

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

2. Diagrams and illustrations should be clearly drawn in black ink on good quality paper. The approximate position of diagrams and illustrations in the text should be indicated in the margin.

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

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

5. References should be in the following form:
   O'CARROLL, N. 1972. Chemical weed control and its effect on the response to potassium fertilisation. Irish For. 29:20-31.
   DICKSON, D.A. and P. S. SAVILLE. 1974. Early growth of *Picea sitchensis* on deep oligotrophic peat in Northern Ireland. Forestry 47:57-88.
   Forestry Abstracts may be used as a guide in the abbreviation of journal titles. Authors should take care to see that references are correctly cited, as the editor cannot guarantee that they will be checked.

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

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

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

Contents

Note: The opinions expressed in the articles belong to the contributors.

Cover: Seed-tree stand with natural regeneration, Siljanfors.
(Photo: Jöran Fries, Swedish Agricultural University, Uppsala)

Printed by the Elo Press Ltd., Dublin 8, Ireland

Council

of the

Society of Irish Foresters

EDITORIAL

Planting for Profit

The recent publication of the National Economic and Social Council's document on Irish forest policy brings good news for all engaged in forestry here. For the first time it has been stated by an impartial expert that forestry has been a good investment for the state. It is the conclusion of Professor Convery, author of the NESC study, that "state forestry investment has been and is financially in the social interest, showing a real rate of return in the range of 3 to 6%". This is an attractive rate of return in real (i.e. net of inflation) terms, well up to the return from the best alternatives open to the government. It seems that at last we are emerging from the long shadow cast by Roy Cameron, who, as director of FAO's European Forestry Group, visited Ireland in 1950 and produced a report advocating a major expansion of forestry in the West of Ireland. That this has been carried through is obvious as are the regional benefits in employment, etc. which have been achieved. But this proposal was based on the asumption that forestry in this region could never yield a reasonable rate of return and thus was to be seen as playing a social role, providing employment in economically depressed areas. While never formally adopted by the government, the social role of forestry has provided a comfortable refuge to which harried foresters could retreat during arguments on profitability, up to the present day.

Now it is no longer necessary for foresters to be on the defensive. Forestry has come a long way in thirty years. It can make a significant contribution to the wealth of the nation. It has the potential to make a greater contribution. We can now identify the best forest land. What's more, we know what it's worth. We know that, as an investment, good land, despite the greater initial cost, is far more attractive than low quality sites requiring large expenditure to achieve adequate yields. What is required now is for the government to pursue a policy directed at concentrating forestry development, whether in state or private ownership, on high quality forest land located around centres suitable for integrated industrial processing operations. In this they should have the support, not only of foresters, but of all those interested in the prosperity of the nation.

The Society of Irish Foresters

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

The main activities of the society centre around:

(a) Annual study tour

(b) Indoor and field meetings on forestry topics

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

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

There are three types of membership:

(a) *Technical:*
Persons employed full time in forestry or in a closely connected branch of natural science, or who have been so employed for 5 years or persons who have a degree or diploma in forestry.
Annual Subscription £4.00

(b) *Associate:*
Persons not qualified for technical membership but who are desirous of promoting the objectives of the Society.
Annual Subscription £3.50

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Persons studying forestry at universities, schools or colleges.
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In all cases membership is subject to the approval of the council of the society. Enquiries regarding membership or Society activities, should be made to: Honorary Secretary, c/o Royal Dublin Society, Dublin 4.

Submissions to the journal will be considered for publication and should be addressed to: Dr. E. P. Farrell, Editor, Irish Forestry, Department of Agricultural Chemistry and Soil Science, University College, Belfield, Dublin 4. The attention of contributors is drawn to "Notes for the Assistance of Contributors" on page 70.

Sales and advertising are handled by: Mr. M. O'Brien, Business Editor, 17 Watson Road, Killiney, Co. Dublin. Tel. 01-867751.

The Challenge of the Second Rotation

Symposium held by the Society at University College Dublin, April 6th, 1979.

A list of the papers delivered to the symposium follows. Those marked * are printed in this issue of the journal.

Facing the Challenge
T. McEvoy, Chief Inspector, Forest and Wildlife Service, Dublin.

* Some Effects of the First Rotation on Site Properties
D. C. Malcolm, Department of Forestry and Natural Resources, University of Edinburgh.

* Site Amelioration for Reforestation
E. Hendrick, Research Branch, Forest and Wildlife Service, Dublin.

* Treatment of Lop and Top
B. Moloney, Work and Method Study, Forest and Wildlife Service, Dublin.

Hygiene
D. McAree, Research Branch, Forest and Wildlife Service, Dublin.

Amenity
J. Connelly, Amenity, Forest and Wildlife Service, Dublin.

* The Challenge to the Forest Manager
L. Condon, Forest and Wildlife Service, Dublin.

Some Effects of the First Rotation on Site Properties

D. C. MALCOLM

Dept. of Forestry and Natural Resources,
University of Edinburgh

INTRODUCTION

The greater proportion of the land under forest plantations in the British Isles was not carrying forest when these stands were established. Most of this land had not been tree-covered for long periods before afforestation. During the treeless period changes in soil development took place primarily owing to the climatic changes which led to our present oceanic climate, characterised by strong winds, moderate to heavy precipitation and the generally low potential evaporation of the cool summers in the west and uplands. The influence of this cool humid climate on soil development obviously varied with combinations of topography, aspect and lithology, the last being the predominant factor as it influenced both the mineralogical and physical status of the profile. On many lithologies the inheritance of glaciation was a deep layer of till of low permeability (e.g. on Carboniferous rocks) sometimes with indurated layers (e.g. on Devonian rocks) which limited the capacity of the profile to absorb and conduct water. The resulting seasonal anaerobic conditions, cool climate and poor mineralogy led to accumulation of organic debris on the surface. The result of these conditions, no doubt assisted by centuries of grazing, muirburn and extensive use, was the development of the site characterised by poor internal drainage. The important soil types are peaty ironpans, surface water and peaty gleys and peats of varying depths and kinds (Pyatt 1970).

During the 19th century these soils, which now account for more than three quarters of the afforested land in Britain (Pyatt 1979), were considered unplantable. With the gradual development of afforestation techniques from the introduction of the planting turf to the intensive mechanised drainage and cultivation of today, these apparently intractable sites have become available to forestry.

Their utilisation has also been achieved by exploiting the adaptability of Sitka spruce (*Picea sitchensis* (Bong) Carr) and Lodgepole pine (*Pinus contorta* Dougl).

The intensity of site treatment has an effect on the performance of the established stand which, in turn, influences the site conditions available for subsequent rotations. This paper is concerned with these latter effects which, although difficult to separate, may be conveniently grouped into those resulting from the physical treatment of the site and those resulting from growth and management of the stand.

Initial Site Amelioration

On the wet sites in the uplands, the minimum treatment required to establish a tree crop has been found to be a planting position raised above the surface and the provision of surface drainage to carry off surplus water. A small addition of phosphate fertiliser considerably improves the rate of establishment. These techniques were pioneered at Corrour in Invernesshire from 1909. with the introduction of the 'Belgian turf' and still form the basis of afforestation. The later developments have mainly resulted from mechanisation, an improved understanding of tree nutrition and a belief in the benefits to be obtained from greater drainage intensity. An ability to disrupt the iron-pan and sometimes underlying indurations in peaty iron-pan soils is perhaps the main advance in site amelioration practice in the last 30 years.

Most of the stands now approaching maturity were established in the 1920's with either hand-cut or primitively ploughed drains rarely exceeding 30cm depth and spaced at about 7m intervals. These shallow drains were able to remove surface water but did little to effect any drying of the organic horizons so that initial root extension of the turf-planted tree was confined to the surface of the soil as described by H. M. Steven in 1923 (Zehetmayr 1954). An important effect of this site treatment has been the radial orientation of the root systems and the ultimate crossing of the drains by roots, in marked contrast to the alignment of the roots with the plough ridge, when planting was later restricted to a continuous turf.

The main objective of these cultural treatments was the successful establishment of a tree stand, rather than a fundamental alteration of site conditions, and in this they were mainly successful. Once beyond the thicket stage the stand could be expected to continue to maturity at a growth rate appropriate to the site type. It is only recently that economic pressures and an improved appreciation of species requirements for optimal growth have led to attempts to permanently alter the physical conditions of the site.

These attempts appear to have been successful in, for example, peaty iron-pan soils of sand-loam textures, but appear to have had less success on soils of a higher clay content with poor pore size distribution (Pyatt 1973). One of the earliest studies in Britain of the effects of tree growth on a peaty iron-pan soil showed that the effect of ploughing was to increase air content of the upper profile from a very low volume percentage to 30-40 per cent throughout the year (Rennie 1962). Recently Pyatt (1978) has reported reductions in bulk density from about 2g cm^{-3} to 1g cm^{-3} in cultivated indurated soils on Old Red Sandstone in Morayshire.

Intensive drainage of gleyed sites has been shown to be of dubious value by Savill (1976) in Northern Ireland, where borehole studies demonstrated that drainage effects are limited to the drain edges on both surface water and peaty gleys developed on tills of low porosity. The development of semi-permanent fissures in lowland English clay soils (Fourt 1960) has not occurred in the drained upland of similar texture. The only way of improving aeration on these peaty gleys seems to be in reshaping the site into a 'rigg and furr' formation (Read, Armstrong and Weatherell 1973).

The almost total disruption of the existing profile and the distribution of the overlying organic horizon throughout the disturbed depth of soil can now be achieved by the rotary mould board plough (Thompson 1975). The effect of this treatment in trials on peaty iron-pan soils is dramatic, the profile remaining aerobic throughout the year to a depth of 60cm. On peaty gleys the outcome is still unclear.

Intensive cultivation clearly enhances early tree growth and root systems rapidly explore the disturbed material but are concentrated in pockets of the former surface organic material. Fears have been expressed that the improved growth rates may not persist due to the loss of the disturbed organic matter leading to either a reduced water capacity or nutrient deficiency. However, the evidence for reduction in growth rate from Europe (Van Goor 1977) and Britain (Thompson and Neustein 1973) is confined to freely drained sandy soils in areas of low rainfall.

On deep peats the effects of artificial drainage depend on the degree of humification, little effect being found on the amorphous and pseudo-fibrous types of peat, while even on the fibrous peats of raised bogs the winter water table remains at 30cm before canopy closure (Taylor and Everard 1969).

As the more intensive treatments of recent years have in general not yet shown major alterations in site properties on the wet soils, it can be concluded that the effects of the initial treatment of sites afforested 30-40 years ago were of short duration and had little influence on site development compared to the effects subsequently induced by the stand.

STAND DEVELOPMENT AND SILVICULTURAL TREATMENT

The strongest influence on the site after a stand of trees is established is the modification of the microclimate following canopy closure. This process begins as soon as the trees are planted and accelerates as the thicket stage is reached, culminating in the attainment of maximum leaf area. The ground vegetation is progressively eliminated as the new canopy intercepts more of the incident radiation. Every aspect of the climate at the soil surface is altered, temperature flucuations diurnally and seasonally are reduced, windspeed is reduced, direct evaporation is reduced and, perhaps most importantly, incident precipitation is reduced.

The data that have been collected in recent years for the interception term in the site water balance are remarkably consistent at about one-third of the incident annual precipitation. This value varies of course with rainfall intensity, season and possibly species but for both Sitka spruce and lodgepole pine about 35% of the precipitation is evaporated annually from the canopy with a tendency for lodgepole pine to have a slightly higher value than the spruce. (Institute of Hydrology, pers comm). The greatest interception occurs once the leaf surface area attains its maximum at about a top height between 9-13m in Sitka spruce at a 0.9-2.4m initial spacing (Malcolm 1977). The reduced amount of water reaching the forest floor is also spatially redistributed as throughfall, drip and stemflow such that the areas around the stems have the highest input in young Sitka spruce stands (Ford and Deans 1977) although this may change later in the rotation.

The effective reduction in precipitation influences the soil water regime so that on many sites formerly saturated for most of the year there is at least a period in summer when the water table drops (Fig. 1). The development of aerobic conditions in the profile, however, still depends on the texture. On peaty gleys and surface water gleys on Carboniferous till in Newcastleton Forest, Smith (1976) has shown that oxygen levels remain low throughout the summer, despite the fall in the water table to below 70cm. On the other hand adequate oxygen levels are detectable below the pan in ironpan soils. The occurrence of these low oxygen tensions is thought to be due to an increased respiratory demand by roots as soil temperature increases in summer.

Polestage stands appear capable, through transpiration, of drying soil profiles at depths beyond those reached by the roots (Pyatt 1973, 1978). Water has been removed from depths of about 1m on peaty iron-pans on indurated till at Speymouth Forest and from similar depths on peaty gleys at Newcastleton. The clay till in this case does not crack but increases in bulk density suggesting that seasonal drying has a cumulative effect which will not improve later root penetrability.

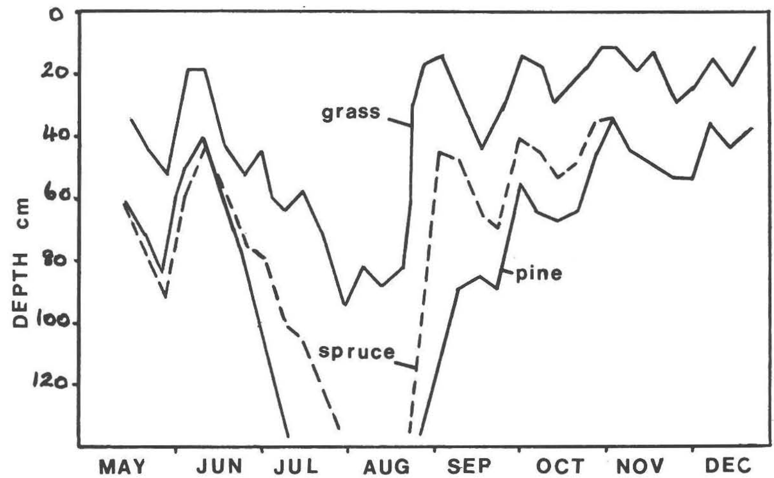

Fig. 1 — Water table levels under spruce, pine and grass, Falstone Northumberland, 1977.

(Forestry Commission Data)

The summer fall in water table levels appears to be of slightly longer duration under lodgepole pine than Sitka spruce (Fig. 1) but in any case the levels are rapidly restored in autumn, when anaerobic conditions are again present near to the surface (Armstrong et al 1976). Any roots which followed the water table down in spring are then killed giving the typical flat root plate with 'shaving brush' sinkers typical of unstable stands on gleys.

The penetration of the soil by the developing root systems forms the basis of soil drying by the transpiration of the trees and it is interesting that on nutritionally poor and wet peaty soils there is a higher proportion of the dry weight production devoted to roots than on better sites. Fraser (1966) showed for Sitka spruce that, for the structural root system, the root:shoot ratio increased from 0.39 on brown earths to 0.61 on deep peats with peaty iron-pan soils and gleys intermediate. There was also a rough negative correlation with rooting depth.

The drying effect of roots permeating the organic horizons is different to the seasonal changes in the water table. On deep peats large fissures develop due to shrinkage and irreversible drying, the effect being strongest on well humidified peat less than 2m deep (Pyatt 1979). These fissures provide lateral drainage through the peat and thus a permanent lowering of the water table. Most species appear capable of initiating this drying but lodgepole pine can induce cracking a few years after canopy closure. Large fissures have been observed at 1.5m depth on an intensively drained deep peat under a 60 year old Sitka spruce at Corrour, Invernesshire where differential species effects are also discernible on peats less than 1m depth. Drying due to the fibrous rooting of *Abies nobilis* Lindl., has led to the formation of separate hard lumps of peat, no longer rootable and completely altering the former organic horizon; the effect of spruces seems to be similar although the new structure in the former massive organic horizon is softer and less well defined. *Abies grandis* Lindl., usually confined to flushed peats, seems capable of inducing a type of peat 'mull' which is readily dispersed by drip from the canopy. Irreversible drying of the amorphous peats formerly associated with the *Molinia* dominated vegetation of gleys also occurs, becoming most obvious after windblow when the small 'gritty' fragments may be dispersed by wind from upturned root systems.

These phenomena are now being studied systematically but the full effect of the drying process is still unknown. What does seem important both to the rate of drying of the organic horizon and for subsequent rotations is the root penetrability of the underlying mineral soil. Where the roots can enter and exploit the mineral horizons as in some cut-over peats in Ireland (Carey and Barry 1975) the drying effect takes place faster and should lead to few problems for future stands. Where root penetration is restricted to the organic horizon because of high bulk density or poor pore size distribution on gleyed mineral soil, there must be serious doubts about the wind-throw stability of future rotations, as well as the ability of the site to supply water and nutrients in periods of low rainfall.

Practical aspects of the reduction in incident precipitation and the subsequent drying of peaty organic matter during the first rotation are that less maintenance of surface drains is required and the provision of a raised planting site in no longer necessary on many sites. It is, in any case, difficult to cut cohesive turves due to the old root systems.

The third main effect on the site of stand development is the initiation of a nutrient cycle within the stand, through the litterfall. The quantity of litter deposited each year on the forest floor seems to be an expression of the vigour of the stand but must reach an asymptotic level when canopy density results in continuing tree mortality. There is some inconsistency in the reported quantities of litter accumulating on the surface of soils with a peaty covering, which may reflect difficulties in the separation of the tree litter from that of the previous vegetation. Rennie (1962) gives a litter value of 37 t ha^{-1} for a 70 year old pine stand on a peaty iron-pan soil. In a recent paper Carey and Farrell (1978) found values of 45-55 t ha^{-1} for the forest floor of three middle-aged Sitka spruce stands while a mean value of 23 t ha^{-1} was given by Adams (1974) for a study of 119 plots ranging in age from 7-41 years on surface water and peaty gleys. The former authors consider there is accumulation of organic matter whereas Adams (1974) showed only a 2 t ha^{-1} y^{-1} increase on average, although there was a considerably greater depth of material on the peaty gley soils. What is important in terms of the effect on the site is the rate of decomposition of this organic matter and whether a balance is reached between decomposition and litterfall. This topic has recently been reviewed by Miller (1979) and for base-poor sites it seems clear that accumulations of mor humus may immobilise greater quantities of N and P than are contained in the stand, leading to ultimate deficiencies of uptake. To the extent that trees depend on nutrients from the soil. the supply available from the rootable organic horizons of peaty iron-pan, peaty gley and deep peat soils is inadequate and has to be made good by fertilisation. Parker (1962) suggested that even on moderately fertile peats depletion would result in eventual deficiency and a lodgepole pine stand at Inchnacardoch was shown by Binns (1968) to have removed most of the K in the upper peat. However, Williams, Cooper and Pyatt (1978) were unable to show depletion of nitrogen, phosphorus or potassium content in the upper 30cm of a range of afforested peats although decreases in exchangeable calcium, magnesium and potasium were noted, together with increased acidity related to improved aeration and decomposition. Increasing acidity with stand age has also been noted for the litter layers of Sitka spruce (Carey and Farrell 1978, Adams 1974).

Adverse effects on soil productivity, through the development of mor humus layers, have often been suggested but the evidence is usually circumstantial and difficult to substantiate because of inherent soil variability (Stone 1975). The biological decomposition of litter certainly follows different pathways under different species but podsolisation is a process depending on internal soil drainage and thus unlikely to be a problem on the soil types considered here. Surface water gleys may be an exception, where deposition of acid, unpalatable litter could reduce the populations of soil fauna, particularly earhworms, that maintain some aeration in the upper horizon. This, together with the rocking of flat root plates may lead to some physical deterioration of the soil for subsequent rotations.

The effects of stand development discussed above do not take into account silvicultural treatments. The most obvious of these is the manipulation of stand density by thinning which, by reducing the interception and evaporative surfaces, increases the amount of precipitation reaching the soil. Not surprisingly it has been shown that there is a concomitant rise in water table levels (Heikurainen and Paivanen 1970). There is some evidence that dense, unthinned stands root more deeply into wet soils (Fraser 1966) and it may be that part of the increased windblow, experienced following thinning, is due to the death of roots under the higher water table.

Reduction in canopy density allows a greater proportion of the incident radiation to reach the forest floor which is important for the rate of decomposition of the litter and recycling of nutrients (Wright 1957) so that thinning has opposing effects on these sites.

Perhaps the main change in silvicultural practice in recent years has been the introduction of large scale fertilisation of peaty sites. Much of this has been remedial in nature, acknowledging inadequate earlier treatment and resulting in marked responses in thicket stage stands. The nutrient universally used has been phosphorus but in Britain potassium has also been required on the poorer peats. It has become clear that spruce stands on these sites will also require repeated applications of nitrogen (Dickson and Savill 1974). Polestage fertilisation has produced more equivocal results, about half the Forestry Commission experiments with Sitka spruce showing little response in terms of basal area increment (R. McIntosh, pers comm). We know far too little about the mechanisms of increasing yield through fertilisation. The effects on the site are complex and depend on the materials used, the condition of the site and stand.

Coarse rock phosphate contains about 20 per cent citric acid-soluble phosphorus, which is readily dissolved at the low pH of peat soils. In distinction to mineral soils phosphorus is not strongly held by organic material so that there is some loss to drainage water. Our work, on a raised bog at Leadburn near Edinburgh, suggests an annual rate of loss of 2 kg ha^{-1} y^{-1} or about 20 per cent of the readily soluble fraction. Harriman (1979) recently published equivalent results on a watershed basis and like us, also found that most of the release is in the winter. Potassium is well known to leach freely and at Leadburn 20 per cent of that applied has been lost from the peat in two years. Canopy closure effects a change and the network of fine roots and mycorrhizal hyphae in the litter layer seems able to absorb or retain the bulk of applied fertiliser within the stand.

The effect of nitrogen fertilisation on the site is still unclear. Urea hydrolyses to ammonium which results in an increased pH and mineral nitrogen content of fibrous peat (Malcolm 1972) but the extent to which the organic nitrogen, already present in the peat, can be mineralised appears limited (Dickson and Savill 1974). It has been suggested that pretreatment of peats by heavy liming application may alter favourably the nitrogen status of peat for tree growth (Dickson 1977) but liming experiments have not usually resulted in tree responses on peaty soils. Thus the beneficial biological effects may take some time to develop and might have some influence on nutrient cycling in later rotations (Adams et al 1978). It should be noted, however, that rock phosphate is generally insoluble at pH values above 4.5 so that another form of fertiliser is required on heavily limed sites.

The long term effects of fertilisation on the physico-chemical properties of the organic-horizons of afforested peat soils is largely unknown. As at least a proportion of the added nutrient is retained on site, even if not immediately accessible to trees, it is unlikely that the effects can be other than beneficial.

HARVESTING

Removal of the tree stand attains the original objective of afforestation and presages the start of the next rotation. Economic forces and mechanisation, together with the risk of windthrow, has meant the adoption of a clearfelling system as the standard technique for harvesting on peaty soils. This process has dramatic effects on the site and the conditions available to regenerated or replanted trees.

The felling of the old stand removes in one operation the buffering influence of the canopy. Without its interception the soil is again subject to all the precipitation with an inevitable rise in the water table. On peaty iron-pans it is probable that sufficient penetration of the pan will have occurred to avoid near surface waterlogging while fissured peats are unlikely to again become saturated to the surface. The condition of peaty gleys and surface water gleys after clearfelling is somewhat different as even under full canopy the winter water table lay close to the surface. In some years clearfelled sites may have a continuously high water table as in Kielder Forest (Fig. 2). This creates problems for replanting as new turves cannot be produced by ploughing or even by hand. Planting must therefore be restricted to the better aerated areas close to residual stumps for adequate survival of Sitka spruce.

Clearfelled sites with an insulating layer of litter can be subject to extremes of surface temperature either scorching or frosting newly planted trees. Frost damage is related to the size of the felling coupe and its topographic situation.

Stand removal and the changed climate results in a rapid increase in nutrient mobilisation through biological acticity (e.g. Popovic 1975) and release of nutrients from the site. This 'flush' of nutrients does not appear to last long, disappearing again after revegetation (Likens et al 1977), although no work appears yet to have been done on this in clearfelled plantations on peat. The activation of accumulated mor humus is a strong ecological argument for the clearfelling technique in climates leading to slow organic matter decomposition. The removal of nutrients in the felled trees is unlikely to be important, unless the branchwood is taken as well as the stem. On infertile sites fertilisation is then necessary (Miller 1979). An interesting feature of current clearfelling techniques on peaty soils is the piling of brash in broad bands to improve the

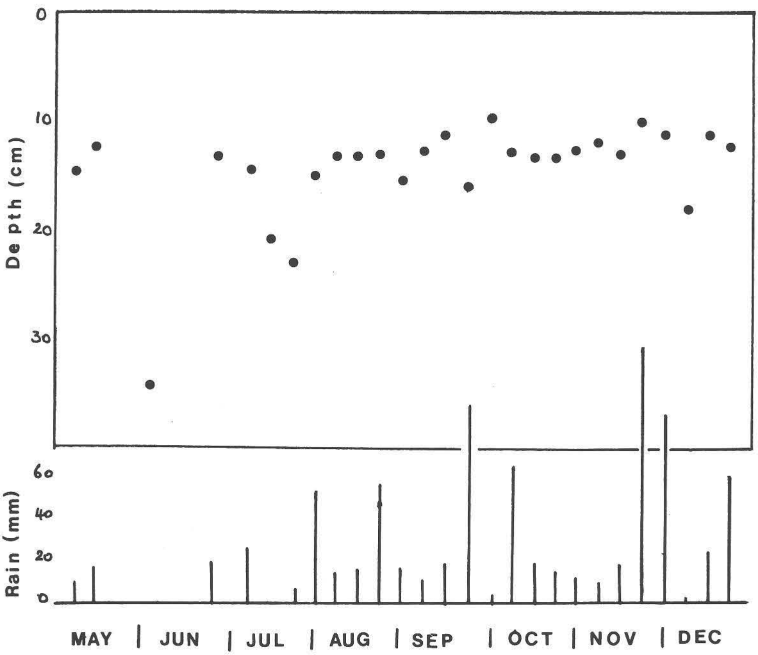

Fig. 2 — Clearfelled site, peaty gley, Kielder Forest. Depth to water table and rainfall, 1978.

traction of extraction machinery which could result in some nutrient redistribution within the site.

Currently some concern is being expressed about the use of heavy machinery to increase extraction payloads on felling sites. There is no doubt that these machines can disrupt the surface horizons on wet soils with serious consequences for the aeration and drainage of affected areas. Perhaps a longer term economic viewpoint would restrict their use to firm mineral sites.

The final effect of harvesting is to allow the reinvasion of the site by ground vegetation. On surface water gleys grassy vegetation rapidly reappears and may be more vigorous than at the time of afforestation. The inability to provide a weed-free planting position is awkward but suitable herbicides are available. On peaty iron-pan, peaty gley and deep peat soils reinvasion is slower but interestingly includes the return of ericaceous species, seeds of which may have lain dormant for up to 50 years (Hill 1979).

CONCLUSIONS

Afforestation of previously bare hill land sets in train a series of changes that reverse the processes that have been taking place on these sites, often for centuries. The major change on peaty sites is the development of an aerobic soil environment, at least in the upper horizons. This induces a more rapid cycling of nutrients and, with the stand itself assisting, leads to fundamental changes in the physical conditions which will be available for subsequent rotations. Some of these changes are irreversible and can only improve the sites for tree growth. This seems particularly so for peaty iron-pan soils where roots can explore the aerobic horizons below the pan level. Deep peats, suitably fissured, will present a rather different rooting medium to second and later rotations which may or may not offer greater stability and it will be interesting to see whether they can be occupied effectively by more exacting species than lodgepole pine. Peaty gleys however may present greater problems than at afforestation depending on the permeability of the underlying mineral horizons, on the poorer tills the drying and dispersion of the peat could lead to less regular stands as dominant trees exploit the pockets of better aerated soil. If roots can penetrate the mineral horizons the site will have been improved.

There remain some serious gaps in our knowledge of changing site conditions, in particular we do not know enough of the nutritional status of peat soils after a rotation of trees and whether we will be committed to continuing inputs of fertiliser nutrients. During the next half century fertiliser costs will increase and their availability may decrease, a possibility which should encourage greater investment in understanding nutritional processes and the utilisation of nitrogen fixation on these sites. Van Goor (1977) addressing this Society presented evidence of improved growth of second rotation Douglas Fir *(Pseudotsuga menziesii* Mirb. Franco) on a heathland soil, which had an increased nitrogen status and no longer needed additions of phosphate. Will a similar state of affairs arise on the peats? The majority of the stands about to be harvested did not benefit from the site preparation now considered desirable and, because of the stumps, no effective method is available to remedy this. If nothing is done are they then committed to low growth rates for the second rotation? Or, if this is not the case are current afforestation methods fully justified? The peaty gleys remain the major problem in this respect and demand fresh thinking about the structure and specific composition of the new stands.

The standard technique for afforesting peaty sites depended on a suitable planting position and removal of surface water with sometimes a small addition of phosphate. After a rotation these sites may not appear so uniform as they did before planting, thus second rotation stands may display greater variation than the first. The challenge for the forester is how best to exploit this variation.

ACKNOWLEDGEMENT

I am grateful to D. G. Pyatt for permission to use his unpublished data for Fig. 1.

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Site Amelioration for Reforestation

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INTRODUCTION

At present reforestation accounts for 8% of the planting programme of the Forest and Wildlife Service — around 400ha annually. During the next five years (1979-83) over 5000ha are due for clearfelling. Most of the clearfelling during this period will be confined to the east of the country. For the following five year period the pattern will remain essentially the same. It is during the following decade that the emphasis will shift to the clearfelling of those crops planted during the early fifties — notably those established on Old Red Sandstone and blanket peat sites. When these crops are being clearfelled their regeneration will involve an annual planting programme of at least 4000ha annually. Clearly although reforestation is having some impact now its importance will increase considerably in ten to fifteen years time when the annual regeneration area will have increased ten-fold.

The areas being clearfelled at present are, as already indicated, mainly in the east of the country. These crops have grown without the aid of ploughing or fertilising at planting. This is an indication of their fertility. Part of this fertility is due to their use previous to forestry. Many of them are sites of abandoned farms. These would have received cultivation and manuring while under agriculture. This phenomenon of increased growth on sites which were farmed at some time relative to those which were not is well recognised. It has been referred to as the 'Old Field Syndrome' in parts of the Southern U.S. (Haines et al 1975).

The regeneration of these areas has been progressing for several years now. There is however, an absence of clear-cut criteria on which the forester can base his decisions. This is evidenced by the fact of the large number of species being used and the use of cultivation in some instances and not in others. Part of the reason for this uncertainty is undoubtedly the absence of vegetation which is commonly used at afforestation as an aid to species selection.

IRISH FORESTRY, 1979, Vol. 36, No. 2: 89-98

SITE AMELIORATION

Before going on to deal with specific means of site amelioration it would be useful to define what is meant by this term. There are many factors which influence production at a given site. Man can modify some of these by for instance, plant breeding. The site factors most amenable to change are vegetation and soil. Site amelioration therefore usually refers to physical and chemical manipulation of the soil brought about by ploughing, ripping or some other form of cultivation coupled with additives of inorganic fertilisers, mainly P under Irish conditions. In the case of reforestation there is the additional factor of logging residues. Because they are a store of potential nutrients they can have a beneficial effect upon growth when they are broken down. In addition their shading of the soil surface may have beneficial effects such as reducing soil temperature fluctuations (Cochran 1975).

What criteria can be used in assessing the need for site amelioration during reforestation? It may be that there is no choice but to carry out some form of amelioration on some sites or the trees will simply not grow or survival will be very poor; such is the case with amelioration of blanket peats for afforestation. However, the choice is unlikely to be so clear-cut during reforestation.

A lot of the clearfelling sites will be able to support regeneration for a number of years without any form of site amelioration apart from treatment of the slash where it is heavy. Any assessment of the efficacy of site amelioration will probably be over a longer time period in reforestation as opposed to afforestation. Even now we are becoming conscious of the long term effects of amelioration for afforestation. Here for instance the disadvantages of spaced ploughing are becoming apparent when ribbons and furrows remain an obstacle to extraction right up to final harvesting.

The main criteria used in judging the need for site amelioration is whether or not the operation results in an increase in height (volume) growth which is sustained over the rotation. The resulting increase if obtained can be quantified in money terms by relating the

Table 1 — Effect of increase in Yield Class (m^3/ha/annum) on NDR of Sitka spruce

Yield Class	NDR (£/ha)
18	573
20	774
22	979

It is stressed that these figures are not intended to represent absolute NDRs and are intended only for comparison.

increase in growth to an increase in Yield Class (m^3/ha/annum). Yield Classes can be compared by looking at their NDRs (net discounted revenues). This is shown in Table 1. Clearly an increase in Yield Class results in very large increases in NDR especially for lower Yield Classes. These data also highlight the financial implications of correct species selection.

Clearfelling and Harvesting

Following clearfelling a great deal more water reaches the soil surface because of the removal of the forest canopy. This results in an increase in the moisture content of the soil especially on soils where the drainage system is not able to remove the additional moisture. In Finland (Heikurainen 1967) it has been calculated that depending upon site, the water table in peat soils rises by between 20 and 40cm following clearfelling. This has the effect of bringing the water table within the potential rooting zone of many conifers, so if growth retardation of the regeneration by excess soil moisture is to be avoided then drainage will have to be carried out. On peat sites in this country afforested with the aid of ploughing/drainage the consequences of clearfelling on the water regime are not known. It is possible that physical changes which may occur in the peat, such as cracking, will make for better natural drainage during the second rotation.

Harvesting also has large implications on the need for site amelioration. There are two main reasons why this should be so. Firstly there is the effect on the nutrient store of the site in terms of the percentage of the total crop which is removed. Secondly the actual removal of the crop will have physical effects upon the soil.

In recent years much attention has been given to the effect of total tree harvesting. With increases in demand for wood fibre harvesting limits will probably decrease so that a greater proportion of the crop is removed. Since most of the nutrients, particularly N, P and K are concentrated in the growing points — needles, twigs, bark cambium and roots — the effect of harvesting these parts of the crop will have a very large effect upon the amounts of nutrients which are removed. During normal harvesting operations (top diameter limit of 7cm) most of the nutrients are left behind on the site. What effect would decreasing the harvesting limit have on growth during the second rotation? On poor sites the removal of the total crop would more than likely entail the application of amounts of nutrients similar to those removed in material additional to the main crop. The problem lies in the identification of those sites where removal of the whole crop would result in growth retardation during the second rotation.

The spatial distribution of slash varies according to the extraction system. With full-tree skidding a good deal of the branchwood and needles will be removed to the logging deck. However, for spruce stands in Southern Bavaria it has been estimated that 20-30% of the branchwood is broken off during full-tree skidding and that in addition from 5-20% of branchwood is broken off during felling with power saws (Kreutzer 1976).

In this country the most common method of extraction is by traction of the material over the ground surface. Whether extraction is by skidder or forwarder, extraction pathways or 'skids' are used. They carry heavy traffic many times during the removal of the crop. Soil compaction often occurs as a result, especially when the soil is moist and is prone to compacting e.g. surface-water gleys. This compaction results in the poor growth which is often seen on old skidding trails. In New Zealand this effect has been demonstrated for *Pinus radiata* — trees growing on skidding trails represented a volume/ha of 5.2m^3 whilst those on an adjacent cutover area had a volume of 34.3m^3/ha (Anon. 1977). This effect remains to be demonstrated for this country but it undoubtedly exists at some reforestation sites. On vulnerable sites it may be possible to overcome the problem by confining harvesting to drier months of the year or using lower ground pressure machines. Where existing compaction is thought likely to result in delayed growth it may be possible to overcome it by ripping along the compacted skid before planting.

Treatment of Residues

The treatment of residues will be dealt with in another paper. I will concentrate on the likely effects that such treatment will have on growth.

Depending upon the previous crop, harvesting limit, extraction system and the conscientiousness of the timber merchant the amount and spatial distribution of slash will vary. For instance, Clark and Taras (1974) have shown how the amount of slash varies according to the harvesting system.

Where the slash is heavy there is the option of bulldozing it into windrows and planting in between. From a forest manager's viewpoint the chief attraction of this operation is its simplicity. The area is left clear for planting and it receives some cultivation when the slash is being pushed into piles. However, during windrowing, especially where a blade rather than a rake is used, it is inevitable that some of the top soil/forest floor will be removed into the windrow. On poor sites this will lead to irregular growth because the soil nutrient reserves or their rate of release will not be sufficient to sustain growth at the same rate obtaining near the edge of the windrow where the nutrients are now concentrated. The fall-off in growth with distance from the windrow can be quite large in some instances. This effect has been noted at several locations where windrowing has been carried out in this country. At one site in Rathdrum forest, Co. Wicklow an unthrifty pole stage crop of Scots pine was clearfelled and the slash and other residues were piled into windrows about 20m apart. The area was then planted with Sitka spruce. It is now apparent that growth is very uneven. Foliar nutrient levels have been measured and growth data obtained (Table 2). Clearly height growth is very irregular and management of this uneven growth will be a problem.

Table 2 — Effect of windrowing on foliar nutrient levels in Sitka spruce at Rathdrum forest (planted 1970).

Position	% d.m.					Mean Height
	N	P	K	Ca	Mg	(m)
Edge of windrow 1	1.52	0.134	0.55	0.30	0.06	4.5
5m from windrow 1	1.19	0.106	0.40	0.43	0.13	3.0
Midway between windrows	0.99	0.104	0.46	0.42	0.11	4.0
5m from windrow 2	1.12	0.106	0.50	0.51	0.10	2.0
Edge of windrow 2	1.48	0.134	0.47	0.28	0.17	5.0

On poorer sites it is likely that remedial fertilisation will have to be carried out some time following windrowing unless a sufficiently heavy application is made before the replanting takes place to balance the uneven distribution of nutrients. Where the slash is heavy it is likely that windrows spaced 20m apart will not decay sufficiently to allow ready access across them during early thinning stage. Large windrows can occupy up to 20% of the surface area so it should be remembered that their creation alone will involve a volume loss since the site is not being fully occupied. On better sites windrowing where the rows are 5-10m apart may be an option — but on these sites we may be thinking of removing the whole crop anyway.

An alternative to windrowing is to burn the slash. This can be accomplished through either broadcast burning or by windrowing and then burning. Since burning encourages the development of *Rhizina undulata* it has not been practiced to any great extent in this country. The main objection to burning in other countries is that it may lead to substantial losses of N and S by volatilisation. On poor sites losses of N of the magnitude usually found following burning could not be tolerated by the regeneration. Where the soil reaches sufficiently high temperatures soil organic matter can be destroyed leading to a breakdown of soil structure. This occurs especially where windrows are burned.

If cultivation is thought to be necessary then it is possible to combine it with the treatment of residues. Disc ploughs especially designed to work under reforestation conditions are used extensively in the U.S.A. and Scandinavia. The possible beneficial effects of such a treatment have been outlined already. Where the slash is heavy it may be necessary to reduce it by crushing before discing. This treatment has, I feel, great potential.

Present Work

Almost all our work to date on reforestation has concentrated on field experiments. Most of the sites chosen for these experiments have carried low yielding crops of either lodgepole pine *(Pinus contorta)* or Scots pine *(Pinus sylvestris)*. These sites have received no fertilisation at any time during the first rotation and while they may have been cultivated if they were farmed prior to afforestation there was no specific cultivation carried out for afforestation. On these sites the aim of site amelioration is to supply sufficient amounts of P and to achieve a degree of cultivation necessary for vigorous growth — this is accomplished through the addition of unground rock phosphate and by either ploughing or ripping. Ideally site amelioration treatments for reforestation should help to maximise any beneficial effects the first crop may have had on the sites. More recently slash retention/removal treatments have been included in reforestation experiments here to investigate these effects.

Table 3 — Site details of reforestation experiments*

	Avonmore	Kilworth	Shillelagh
Geology	Ordovician shale/ quartzite	Old Red Sst.	Mica-schist
Soil	Brown podzolic	Podzol	Brown podzolic
Elevation (m)	200	160	210
Previous crop	Scots pine	Lodgepole pine	European larch/ Scots pine
Treatment of slash	Left *in situ*	Removed	Removed

*Located between 52°10' and 52°50' N.

In a series of reforestation experiments laid down in 1976 (Table 3) the ameliorative measures tested (Table 4) include cultivation and P application. Different species have been included because of the almost complete lack of information on choice of species for the second rotation. There is a general belief that a more demanding species can be used for the second rotation following one of a 'pioneer' species such as lodgepole pine. This however has not been clearly demonstrated under Irish conditions and there is always the possibility, referred to earlier, of site degradation following complete tree harvesting or windrowing on nutrient-poor sites.

In all of the 1976 experiments ripping has been included as one of the ground preparation treatments. The advantages of ripping over spaced ploughing are that it leaves a relatively unbroken surface which eases future extraction and that it probably leads to deeper rooting and hence better stability. Preliminary rooting studies in an afforestation ground preparation trial at Ballyhooley forest have shown deeper rooting (to 90cm) in the ripped treatment compared with Clark tine ploughing (to 40cm).

Table 4 — Treatments in 1976 series of reforestation experiments

Main treatments:	I	Clark tine ploughing; spaced ploughing at 2m spacing with a furrow depth of 40cm and a tining depth of 60-70cm
	II	Ripping at 2m spacing to a depth of 60-70cm
	III	Control, no cultivation
Sub treatments:	1	Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco)
	2	Sitka spruce (*Picea sitchensis* (Bong.) Carr.)
	3	Lodgepole pine, south coastal provenance (*Pinus contorta* var. *contorta*). At Kilworth only
Sub-sub treatments:	A	0 kg P/ha
	B	30 kg P/ha
	C	60 kg P/ha
	D	90 kg P/ha

Results after three growing seasons are presented below (Table 5). Height increments have been used because of the differing heights of the species at planting. For Avonmore both Sitka spruce and Douglas fir columns are included because of a significant species x cultivation x level of P interaction. While the results show a trend for the superiority of Clark tine ploughing over both control and ripping the magnitude of the difference between ripping and ploughing is small. This difference reaches statistical significance at only one site, Kilworth, which is the poorest of the three in terms of nutrient availability and where ploughing would be likely to have a short-term beneficial effect. Indeed the long term beneficial effects of intensive cultivation have often been called into question (van Goor 1977).

Table 5 — Mean height increment (cm) three growing seasons after establishment

AVONMORE

	Control		Clark tine ploughing		Ripping	
kg P/ha	†S	*D	S	D	S	D
0	23	25	52	25	40	36
30	28	25	36	28	51	33
60	19	29	45	24	37	26
90	20	24	45	31	31	35

Standard error of difference between two means = 5.4cm
Least significant difference at 5% level = 11cm

KILWORTH

	Control	Clark tine ploughing	Ripping
0	36	53	46
30	62	72	53
60	54	73	56
90	66	75	52

Standard error of difference between two means = 5.4cm
Least significant difference at 5% level = 11cm

SHILLELAGH

0	35	34	37
30	34	51	37
60	38	50	47
90	38	48	40

Standard error of difference between two means = 4.3cm
Least significant difference at 5% level = 9cm

†S = Sitka spruce
*D = Douglas fir

At this early stage it appears that P applications of up to 30 kg P/ha are justified on some Old Red Sandstone reforestation sites. This is to be expected since O.R.S. soils are generally low in 'available' P. At the other two sites there is little evidence so far of a response to P. It is hoped that soil chemical analysis will help to explain further the reason for positive responses at some of these sites and not at others.

Finally to return to the choice of species. Table 6 shows that at least as far as early growth is concerned significant differences have emerged between species and if these trends hold for volume growth then the suppositions about replacing lodgepole pine, for instance, with either Sitka spruce or Douglas fir will have to be re-examined.

Table 6 — Mean height increment (cm) three growing seasons after establishment

	Sitka spruce	Douglas fir	lodgepole pine
KILWORTH	55	45	72
SHILLELAGH	33	47*	—

KILWORTH: Standard error of difference between two means = 9.7cm
Least significant difference at 5% level = 27cm

*Difference between means significant at 99.9% level

ACKNOWLEDGEMENT

Thanks are due to the Research Foresters who were involved with the laying-down and assessment of the reforestation experiment referred to.

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Treatment of Lop and Top

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INTRODUCTION

The forest manager faced with the problem of reforestation has a number of options open to him in relation to lop and top. These options are as follows:

1 Leave the lop and top undisturbed and plant through it.
2 Burn the lop and top *in situ* and pit plant.
3 Windrow the lop and top and cultivate the soil by ripping with a ripper or ploughing with a tine plough. Ploughing with Cuthbertson single or double mould board does not seem to have been practised.
4 Place mounds on top of the lop and top and plant in these mounds.
5 Where the first rotation is unthrifty and has no trees of marketable size the crop can be pushed over by bulldozer and ripped by ripper in one operation.

ASSESSMENT OF OPTIONS

1 *Leave lop and top undisturbed and plant through it.*
I do not propose to discuss whether this method is biologically sound or silviculturally advantageous but I can say that it is generally less costly than other methods. From the point of view of cost reduction, timing of the planting operation is of paramount importance. Ideally it should be undertaken one year after clearance of the previous crop. This seems to allow the second rotation time to beat the inevitable weed invasion of the site and at the same time leave a sufficient interval to enable the lop and top to die back to a point where planting through it can be undertaken without expensive preparation (see Table 1). There are situations however where planting through the lop and top without some preparatory work is not possible. I have seen two examples of this and I am quite sure there are several others.

(i) At Coolgreaney forest in an area where there had been a gradual removal of first rotation Douglas fir *(Pseudotsuga menziesii* (Mirb) Franco) there was a simultaneous invasion of the site by weeds, particularly bramble (*Rubus sppx*) with the result that now when all the crop is cleared and the site available for reforestation, the bramble has reached problem proportions. It is proposed, I understand, to use an excavator to create planting strips through the vegetation.

(ii) At Anner forest, Co. Tipperary, a situation similar to the one at Coolgreaney obtained. The gradual invasion of the site by a dense growth of bramble coincided with the gradual removal of transmission poles. Here the forester introduced a rather novel ground preparation system. He had a heavy log dragged by wheeled tractor through the vegetation at 2 metre spacing. This created adequate planting strips. In this connection, it is interesting to note that one of the first attempts at mechanical scarification in Canada was the dragging of a granite boulder rigged to a bulldozer over the ground. This provided a crude drag-type scarifying unit.

The reason for my visit to Coolgreaney forest initially was to see an area at Raheenleigh property which I first saw in 1975, after a crop of unthrifty lodgepole pine age 26 years had been felled. The lop and top here was extremely heavy and I did not think it would have been possible to establish the second rotation without first windrowing the lop and top.To my surprise I found that the area had been reforested in 1976 with little difficulty. Sitka Spruce (*Picea Sitchensis* (Bong.) Carr) was pit planted through the lop and top at a cost of 67 standard man hours per ha. The lop and top has now disappeared almost completely and the second rotation is very promising indeed. Damage by hares has not occurred and sheep trespass is also non-existent. Both animals evidently dislike having their movements impeded by lop and top.

2 *Burn lop and top in situ and pit plant*

This is a method which appears to have been practised on a very limited scale only. The best example of it I have seen is at Kilcash property of Slievenamon forest. Here the lop and top was forked in manually from the perimeter of the area as a safety precaution. The material was then successfully burned, the ground was ripped by ripper and the area planted with Sitka Spruce which is now growing vigorously through *Ulex gallii.*

As very few reforestation areas are isolated from existing plantations there is for them a serious fire risk associated with this method. Burning may also be conducive to the spread in the second rotation of the group dying disease, *Rhizima undulata.*

metre centres and place large mounds of spoil from the drains on the lop and top. Each mound was 0.5 to 0.75 m^3 in volume. The cost of this method was only 38% of the cost of the original proposal. Today it would probably be as low as 16% of the original method because machine costs have risen at a much slower rate in recent years than manual costs.

Planting was done into the mounds and the second rotation is quite vigorous today. One wonders, however, if the method of

Table 1 — Cost of lop and top treatment options

Option	Method	Cost range per hectare (£)
1.	Slit Plant in old plough ribbon (gley soil)	78.00 — 96.00
	Notch Plant (gley soil)	102.00 — 115.00
	Pit Plant (dry mineral soil)	150.00 — 180.00
2.	Windrow	55.00 — 120.00
	Rip	40.00 — 150.00
	Plant	80.00 — 130.00
3.	Burn (includes manual forking of material in from perimeter)	36.00 — 125.00
	Rip	40.00 — 150.00
	Plant	80.00 — 130.00
4.	Mound	135.00
	Plant (figures from one forest only)	78.00
5.	Roll and Rip	90.00 — 143.00
	Plant	80.00 — 130.00

3 *Windrow lop and top with dozer and cultivate the soil by ripping or ploughing*

This has been the most widely practised ground preparation method for reforestation although doubts have recently been expressed about the silvicultural advantage and cost-benefit of the method.

Dozing of lop and top into windrows is, even if only temporarily so, quite unaesthetic. There is evidence also that microtopography can be permanently changed through the lifting of submerged boulders to the top of the soil by dozer blade. I would raise the question too as to whether the exposure of the humus layer to drying conditions is desirable.

If it is desirable to have humus and mineral soil mixed together then obviously cultivation is necessary, and if so then some form of soil scarification is necessary. While other countries have a highly mechanised approach to cultivation, and have developed sophisticated scarifiers, our cultivation machinery is limited to rippers and ploughs. To use these pieces of equipment, windrowing of lop and top is usually necessary.

Those who would argue for or against the windrowing of lop and top, and for or against ripping the ground would find much to interest them at Boherboy property of Anner forest, Co. Tipperary, where two adjoining compartments with the same conditions of soil and topography have recently been replanted. The first crop was Douglas fir. One compartment was reforested in 1973 by pit planting through the lop and top. In the second compartment the lop and top was windrowed by dozer, the ground ripped and planted in 1974. The second rotation species is again Douglas fir which is remarkably vigorous in both compartments, but the crop which was planted through the lop and top has I would say a definite edge in vigour on the other crop and it is still very obviously a year older.

In relation to windrowing of lop and top there is some disquieting evidence that damage to the young trees of the second rotation by hares is quite serious in some areas, and sheep trespass is also quite common. The inter-row freedom of movement seems to be quite attractive to both.

4 *Place mounds on lop and top and plant in the mounds*

This method has as far as I am aware been practised only at Tulla Forest, Co. Clare. Here in 1957, 18 ha of Sitka spruce, 25 years old, was blown, and in 1961 a further 33 ha of the same species. Following the disposal of saleable material, the reforestation of the area was undertaken in 1967. The soil is a peaty podzol and it was decided to burn the lop and top and distribute mounds on the area before planting. The cost per ha £154.00 (about £1000 in present-day money terms) was alarmingly high and an alternative method was employed involving the use of an excavator to open drains at 20 reforestation employed has made the second crop more or less stable than the first crop. In complete contrast is the method which has been used in the saturated gleys of Co. Leitrim. Here lop and top from stands which were blown at age 20 to 23 years has been left untouched and planting of the second rotation has been done by slit planting into the plough ribbon which has remained intact during the shortened life span of the first rotation. This method has been practised at Manorhamilton and Drumkeeran forests. At Glenfarne forest where the first crop (Sitka spruce) had reached a more mature stage (38 years) before removal, the lop and top was also left untouched and the second crop was notch planted between the original planting lines.In all those cases the second rotation is showing exceptional promise.

5 *Establishing the second rotation in areas carrying unthrifty crops*
The indications are that where the pioneer crop has been unthrifty due perhaps to the presence of iron pan, or lack of drainage, or to unsuitable species, intensive mechanical preparation has been practised to good effect. The levelling or rolling of the pioneer crop with a dozer simultaneous with ripping of the ground has proved very effective and quite cheap.

GETTING RID OF LOP AND TOP IN OTHER COUNTRIES

Cultivation of the soil prior to establishing a new rotation is general practice in the Nordic countries. However, only in Denmark is it customary to remove logging residue before cultivation. The residue is removed in strips 2.5m. apart which would seem to correspond to our windrows. Cultivation of the cleared strips is done by various implements such as disc plough, disc harrow, wing plough, and disc plough plus harrow. The last method at £170.00 per ha. was three times more costly than using the disc plough only. Site preparation costs in Denmark are considered to be very high compared with the other Nordic countries. Mechanical site preparation without removal of lop and top has been widely practised and is increasing in scale annually (Table 2). This type of mechanical preparation has been made possible by the development of spot scarifiers and the disc ploughs, wing ploughs and harrows to ahich I have already referred. Spot scarifiers are set so as to provide 2000 to 2500 prepared planting spots per ha.

In Canada, too, the emphasis is on mechanical cultivation prior to artificial regeneration of the next rotation. In 1957 the area cultivated was 27,000ha. In 1968 it was 30,600 and this is expected to rise to 120,000ha in 1982-83. Scarification accounts for 80% of this area while chemical treatment and burning account for 20%.

Table 2 — Mechanical site preparation (ha) 1973 and projected 1980.

	1973	1980
Sweden	101,000	161,000
Finland	78,000	110,000
Denmark	1,600	5,000

CONCLUSION

My impression of the results of the various second rotation site preparation methods that I have seen here, compels me to make the following observation — where a site has produced a good commercial crop of timber and where drainage is unlikely to be a problem following the removal of this crop, excellent results at low cost seem to be possible by pit or notch planting through the lop and top. However, where the pioneer crop has been unthrifty, site cultivation is necessary and until we have some of the sophisticated machines of other countries windrowing of lop and top will be necessary before such site cultivation.

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The Challenge to the Forest Manager

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INTRODUCTION

As well as constituting a challenge the Second Rotation constitutes a time of great opportunity for the forest manager. By his appraisal of the performance of first rotation crops through an entire cycle of production from establishment to harvesting, he is in a unique position to contribute a wealth of experience and knowledge to the creation of a new generation of forest crops.

He has available to him the results of investigative research, the records of management information, the expertise developed in the ancillary activities of the wildlife and amenity interests. These enable him to chart a course of development which hopefully will avoid the necessity for speculative advances into the unknown, which perhaps were his lot during the first rotation.

However, the process of timber production is always a complex and sometimes a tortuous undertaking. The interaction of relevant factors can be influenced by events and contingencies completely outside the control of the forest manager. He must therefore continue to anticipate and foresee possible developments. Herein lies the challenge. The opportunity is presented in that he can make decisions in the light of known and relevant experience. He must ensure that these decisions contribute to balanced resource management so that the productivity of the resource is assured for future generations.

In relation to the silvicultural practices in vogue during the first rotation the forest manager must ask, has an ecosystem been created which will ensure for future generations the continued maintenance of the forest as a renewable natural resource providing a sustained yield? Is an ecological balance being maintained in, for example, the intake of nutrients by the tree crop and the return of litter and dead plant material to the soil. Is the biological activity of the humus layer such that its break-down is in balance with its accumulation and a satisfactory N-cycle and nutrient intake are being established which will continue in perpetuity.

Short-term rewards are not a measure of the success of silvicultural practice. Nor is a low-cost technique because it is deemed economically desirable necessarily that which will contribute most to the ecological balance which is so vital to forest renewal. Is the criterion then of the short-term reward or the low-cost technique disturbing the existing site relationships to the detriment of the ecosystem. The answers are not easy or straightforward. The constraints of economic timber-production cannot be ignored.

The problems predicated in the previous paragraphs are invariably associated with proper selection of species. The choice of tree species should accord with the properties of the site. A species going into check on a particular site after perhaps satisfactory establishment indicates that the selection is not ecologically appropriate. Some imbalance exists or has been created (a common experience with first rotation crops). Experience gained during the first rotation, having covered the entire production cycle, is invaluable in determining future species selection.

As far as our major species are concerned, I think we can now say with confidence the type of site suitable for Sitka spruce (*Picea sitchensis* (Bong.) Carr.) Norway spruce (*P. abies* L.), Lodgepole pine (*Pinus contorta* Dougl.), Douglas fir (*Pseudotsuga menziesii* (mirb.) Franco), Japanese larch (*Larix kaempferi* (Lambert) Carr.) and the other species in common use.

This is a time therefore when site mapping of the forest estate can provide an invaluable basis for the maintenance of the production capability of the forest in perpetuity. Species suitability can be matched to site category and the dangers of ecological imbalance in future generations can be dimished.

Preservation of the Ecosystem

The importance of the maintenance of the proper ecological profile has been stressed and the importance of species selection in this context. Matching of species to site, however, is not in itself a guarantee of protection to the ecosystem. The maintenance of growth can be and is influenced by fertilisation regimes, by drainage systems, by the application of herbicides and insecticides. Misuse of any of these can have side-effects which could be damaging to the ecosystem. The forest manager therefore must always be on the alert to the inherent dangers and guard against them by judicious practice.

One major source of difficulty is that of *site cultivation* and this perhaps merits some very sèrious study by the forest manager at the outset of the second rotation. Many of our first rotation crops have been established on sites which lacked all the requirements of a forest ecosystem. The physical condition of their soils was extremely poor. Their nutrient status was extremely low. Development of tree growth was virtually impossible without intensive cultivation and application of phosphate. Guidelines for species selection were speculative. Nevertheless relatively satisfactory crops have been produced on them. These sites therefore having successfully adapted themselves to forest conditions under the influence of a pioneer crop have now created a forest ecosystem which bears all the hallmarks of developing a desirable ecological progression. The key factor in this progression is the biological layer which has been created by the pioneer crop. Humus in the soil is the heart of soil fertility. The maintenance of a balance between its accumulation and its decomposition or mineralisation is a vital silvicultural requirement, and is therefore vital to the preservation of the ecosystem.

How best to treat humus at the initiation of a second rotation is a matter on which opinions vary considerably. The Germans will argue in favour of intensive cultivation and incorporation of the humus in a very intimate way with the mineral soil matrix. This will ensure early and even mineralisation and rapid absorption of the humus in the early years after establishment when it is most required. They will argue that once the crop is established it will recreate a new humus layer and growth will continue without recession.

The Dutch will argue that the too rapid mineralisation of the humus following cultivation is conducive to 'check' developing in the new forest crop when the humus reserves are exhausted. They tend in practice to disturb the humus layer as little as possible and to employ planting methods involving direct planting into an uncultivated site. Soil-type will, of course, have a distinct bearing on the actual practice in specific cases. On light sandy soils no cultivation will be practised whereas on heavy loams or podsolised gleys a case for cultivation can be made.

As far as Irish practice is concerned, speaking for the mineral soils of the East, South-east (mainly Silurian and Old Red Sandstone podsols, with acid brown-earths on the better sites, and some lithosols on the worst) the general tendency would now be to avoid cultivation for most situations. The importance of the humus layer to second rotation establishment has been amply demonstrated. No cultivation is required on acid brown earths which invariably have carried a highly-yielding crop of Douglas fir or Sitka spruce. Neither is cultivation required on the better podsols where cultivation was included in ground preparation for the first rotation. Where cultivation was not practised at the start of the first rotation and where poor crop development could be attributed to poor physical condition of the soil, cultivation may be deemed necessary. If so, it should be accomplished by ripping rather than ploughing. In this manner while the cultivation effect will accelerate the breakdown of humus, sufficient will be left undisturbed in situ to maintain a balance in the forest ecosystem.

Preservation of Crop Structure

The importance of preservation of the ecosystem has been stressed because of its significance in the management of a renewable resource. A second major consideration for the forest manager in the context of the second rotation is that he must ensure that his silvicultural code of practice will enable him to preserve the structure of the forest crop in accordance with the production objectives that have been set. Here the most difficult problem is the maintenance of crop stability throughout the rotation. While no code of practice will prevent windblow absolutely (there will always be catastrophic gale, about which nothing can be done) experience of the first rotation has shown that certain well defined site types are prone to wind-damage in mid-rotation. Gleys and peaty gleys are particularly vulnerable in this respect.

The causes of windblow on such sites can be attributed to a combination of the following.

(1) Delayed thinnings.

(2) The practice of line-thinning.
(Other factors have an inter-play here *viz.* the delayed thinning and the timing of the thinning relative to the incidence of the storm).

(3) The practice of planting on ribbons.
(Again other factors have an inter-play here. e.g. basal sweep and degree of imperviousness of the soil).

The forest manager must therefore modify his silvicultural practice to endeavour to overcome these sources of instability. It is suggested that this can be achieved by application of the following options, or a combination of them.

(1) *Wider spacing at establishment*
(Planting at 2½m to 3m spacing).
This can be done without appreciable loss of volume increment. An appropriate pruning regime would have to be adopted to maintain timber quality. Furthermore should a delay in thinning ensue the effects would not be so critical. In fact a no-thinning option would be a possibility, should marketing fluctuations indicate that such would be desireable.

(2) *Incorporation of extraction lanes into the planting pattern*
Extraction lanes created at time of first thinning create lines of weakness. Instead extraction racks are laid out at time of planting and left unplanted. Stability on the edge of extraction lane is thus assured. It is probable that selection thinning would be preferable to line thinning is exposed areas.

(3) *Use of tunnel plough for ground preparation in exposed areas, followed by pit planting*
This would eliminate the tendency for tree-roots to develop within and along the ribbon, without significant penetration into the soil matrix.

(4) *Where standard spacings have been used at planting thinning regimes should start early*
Thinning to waste is an option in exposed areas. Root development must be encouraged early to ensure continuing stability.

APPRAISAL OF OTHER RELEVANT FACTORS

The experience gained in the first rotation on other factors which contribute to the successful completion of a rotation of timber production must also be applied to the planning for the second rotation.

(1) Ensure eradication of pernicious weed growth e.g. *Rhododendron ponticum.* (Use of 2.4.5.T or Round-up).

(2) Improve planting standards and plant production standards to eliminate 'beating-up', and keep grass-cleaning to a minimum.

(3) Initiate thinning regime at appropriate time and ensure that access and extraction roading is adequate to deal with the utilisation of produce.

(4) Practice standard anti-disease and anti-pest infestation procedures at appropriate times. Neglect can lead to widespread proliferation of the problem.

(5) Harvest in accordance with best known methods in order to produce raw-material at a rate which will maintain the competitiveness of wood as a commodity.

(6) Revise fire-protection plans to take cognisance of the new situation in the context of internal protection. A crop that was in a 'low-risk' category is about to be classified (or will be in the foreseeable future) as a 'high-risk'.

(7) Examine age-class distribution with a view to adjusting same by perhaps delayed planting if deemed necessary or desireable.

CONCLUSION

A forest is no longer just a wood-producing enterprise. Incorporated within its basic role we now must integrate other activities which have an undoubted importance in their own right. For example, the wildlife of the forest constitute a resource. Deer and game-birds if managed in a proper manner can be very remunerative assets. The flora of the forest may be significant in a conservation context. The location of the forest may render it unsuitable for public recreation purposes. The forest as a constituent of the landscape is having an impact on the aesthetic appearance of the countryside. All these elements were evolved during the first rotation. Their integration as appropriate into the milieu of the forest may have been on an *ad hoc* basis. The start of the second rotation is an appropriate time to review their roles and to redevelop them in a more harmonious fashion with the overall forest management regime.

The second rotation then is a time when the knowledge and experience gained during the first rotation is applied in such a manner as to produce a viable and wealth-producing enterprise. To create a viable enterprise in any field is always a challenge to management. To do so in the forest enterprise is an even greater challenge. One can I feel express the view with confidence that Irish forest managers will not be found wanting.

Productivity of Scandinavian Forests in relation to changes in Management and Environment

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INTRODUCTION

The concept of limiting factors goes back to the work of Liebig in the 1840s, where he stated that plant growth was limited by the nutrient element in minimum, that is the element in least supply as compared with the demand of the plant. Liebig's way of looking upon plant growth relations was a very simplified one, and it has later been found that very often more than one factor limits plant growth and that the various limiting factors may interact in different ways. Often the interaction between growth factors can be expressed as multiplicative effects with positive interactions between factors. However, there are also cases described where one factor may act as a substitute for another factor to a larger or smaller extent.

In forestry we often find rather well established empirical relations between forest growth and some factor, although the relationship may be a very indirect one. A few cases of this type will be discussed in the present paper, because indirect relationships present difficulties in interpretation, when we apply the principle of limiting factors.

It is characteristic of the boreal forest that it shows distinct successional patterns (Fig. 1). A common cause of the start of a new succession in a natural forest is a forest fire, but extensive wind felling or insect attacks may sometimes replace the fire. In the succession there are gradual changes both in the forest stand and in the soil, and the factors limiting forest tree growth are not necessarily the same in different phases of the succession. At the

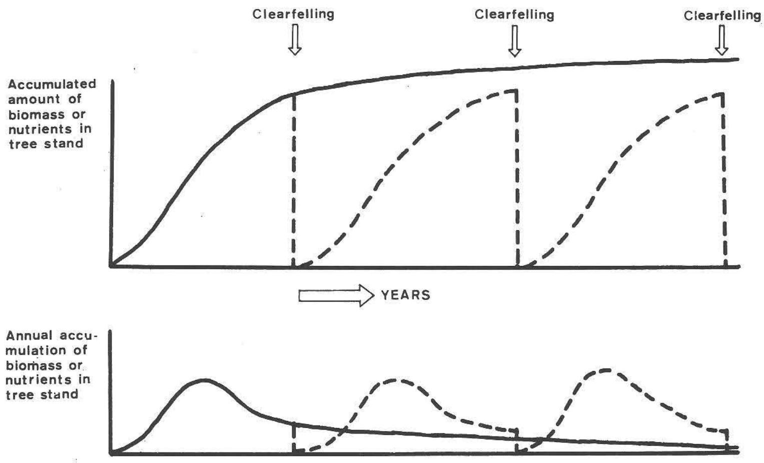

Fig. 1 — Schematic picture of how biomass accumulation changes with time in a boreal forest ecosystem. The assumption that subsequent tree crops show identical development is hypothetic.

start of a new succession, irrespective of its causes (natural or man-made), there is an intensive decomposition of most of the organic forest floor material (the A_O horizon) and also of slash remaining on the ground. For a few years there is a good supply of nutrients on the cleared area, better on good sites than on poor sites. In any case there are higher concentrations of available plant nutrients in the soil than at any time beneath a closed canopy. Pioneer vegetation takes advantage of this, as do tree seedlings, if seed sources are available or plants are put in by man. The rapid decomposition is a transient stage, and when the new saplings are 5, 10 or 15 years old (depending on site quality) most of the nutrients in the humus layer are gone. They have been leached from the site or washed into the mineral soil where some of them are bound in a form not easily available to plant roots. However, with the growth of the young trees, the soil beneath the trees is again supplied with litter, and a new humus layer starts to build up. Competition between trees and between the tree stand and lesser vegetation is severe, and most of the litter is decomposed already in the organic horizon (A_O) on top of the mineral soil, which is interwoven with fine roots and their mycorrhiza. Fungal hyphae, both of decomposing fungi and of mycorrhizal species, form a considerable part of the humus layer and there is some evidence that mycorrhizal roots may decrease the rate of litter decomposition (Gadgil and Gadgil 1974). The "Gadgil effect" has so far been conclusively shown only for Pinus radiata plantations in New Zealand, but ongoing research in Sweden has given preliminary results qualitatively in agreement with the hypothesis (B. Berg, personal com). The physiological background for the assumed antagonism between mycorrhizal and decomposing fungi may be complex, but it is clear that mycorrhizal fungi are better off with regard to energy supply than are decomposers compelled to extract their metabolic energy from cellulose, lignin and other resistant materials. Ecologically, the delayed decomposition might give a certain degree of stability to the undisturbed ecosystem, where litter supply often changes by a factor of 1.5 or more from one year to the next. On the other hand, after a disturbance, such as clear-felling or thinning, the Gadgil effect would result in a more enhanced decomposition and faster nutrient mineralisation than accounted for only by the decrease in competition. Such an increase in nutrient availability after disturbance has long been observed, the "assart effect" (cf. Romell 1935, 1967). Of course the "assart effect" does occur also in other types of forests, but it is particularly striking in an environment characterised by a generally low availability of nutrients.

THE RÔLE OF NITROGEN

Numerous experiments have shown that a supply of nitrogen fertiliser increases growth in typical boreal forests (Table 1). Effects

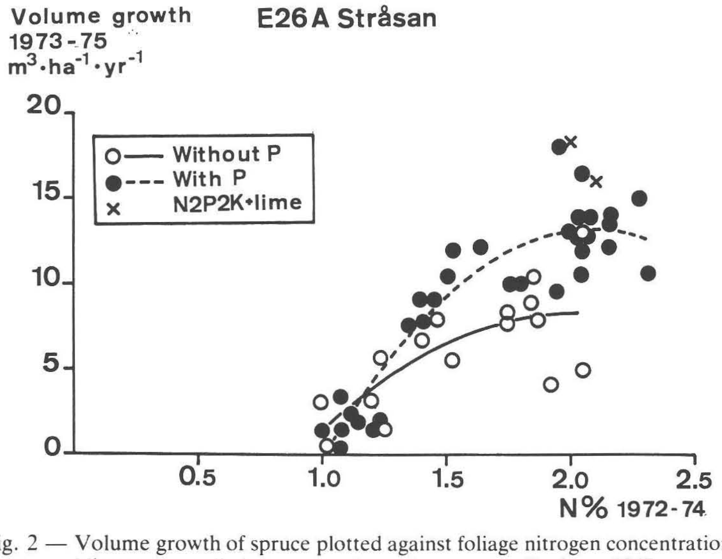

Fig. 2 — Volume growth of spruce plotted against foliage nitrogen concentrations. Nitrogen supplied as ammonium nitrate annually from 1967 onwards, phosphorus 1967, 1969 and 1970. Open dots represent plots without P, filled dots with P. Stand planted in 1958.

(From Albrektson, Aronsson and Tamm 1977)

Table 1 — Summary of more than ten-year-old fertiliser experiments including comparisons between nitrogen only and nitrogen + PK. The first six sites represent typical boreal forests in middle and north Sweden, while Experiment P 883 represents a highly productive spruce stand planted on former arable land in southwestern Sweden (the "beech region").

Experiment Designation	*Tree Species*	*Observation Period — Years*	*Current stem volume growth m^3 ha^{-1} yr^{-1}*		
			No N	*With N*	*With NPK*
S 84, Siljansfors	Pine	15	1.3	3.2	3.3
P 731, Lövnäs	Pine	15	1.7	4.3	4.5
P 728, Själlarimsheden	Pine	15	2.3	5.0	4.4
S 85, Siljansfors	Pine	15	2.3	3.7	3.8
P 777, Rotnäset	Spruce	10	2.4	4.3	4.2
P 725, Ljusbergskilen	Spruce, pine (birch)	15	5.9	9.3	9.2
P 883, Frodeparken	Spruce	14	15.2	15.8	17.0
No. of plots measured			14	12	9

of other nutrients (phosphorus, potassium etc.) are rare on mineral forest soils on the young glacial material prevalent in Scandinavia, although an additional effect of phosphorus has been obtained in young spruce forests fertilised with large amounts of nitrogen (Fig. 2), sometimes even in fast growing stands. (cf. Table 1). It can thus be considered a fact that nitrogen supply is a factor limiting tree growth in the boreal forest, and that this deficiency of nitrogen directly affects tree growth. The physiological mechanism may be either more intensive photosynthesis of needles well supplied with nitrogen or an increased amount of needles which can be formed if the nitrogen supply is good. Very probably both of these mechanisms operate simultaneously, but an experiment in young spruce forest in central Sweden has shown that the tree crowns and the amount of needles rapidly increase following nitrogen

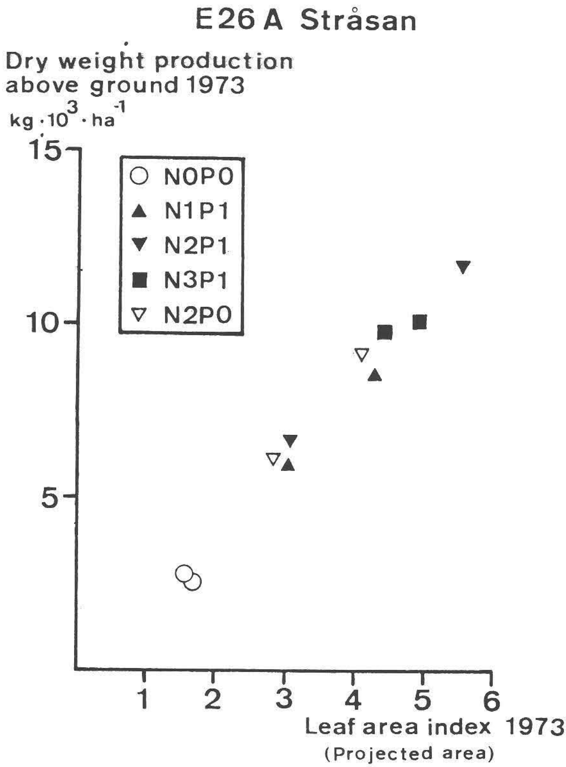

Fig. 3 — Dry weight production above ground as a function of leaf area index in the spruce experiment in Fig. 2. Each symbol represents one plot.
(From Albrektson, Aronsson and Tamm 1977)

fertilisation, and that this increase explains most of the subsequent growth increase (Fig. 3, Tamm 1974). Similar studies in a young pine stand (Albrektsson et al. 1977) also show an increase in needle biomass after fertilisation and a close relationship between stand growth and leaf area index (Figs. 4, 5). This does not exclude a fertiliser response due to increased photosynthetic efficiency (cf. Brix and Ebell 1969, Miller 1976, Linder and Ingestad 1977), which may occur also in dense stands, where an increased needle biomass would result in increased self-shading. However, the typical boreal forest is not very dense and the dominating control mechanism for the primary production appears to be the amount of photosynthetic tissue.

Manipulations such as thinning affect leaf biomass directly, but the decrease in competition for nitrogen allows the remaining trees to increase their crowns. A leaf area index similar to that before the thinning may be attained within a few years, always supposing that no major soil changes occur. It is a general belief that during the life-time of a stand, more and more of the site's nitrogen store is immobilised in the tree biomass and in an "inactive" mor layer. On poor sites and where decomposition is slow, due to a cold climate, this may eventually hamper tree growth. There is not much firm evidence for this theory, even if it is in agreement with what we know at present (Tamm 1977). Yet in parts of Scandinavia and Finland there are environmental influences which may complicate

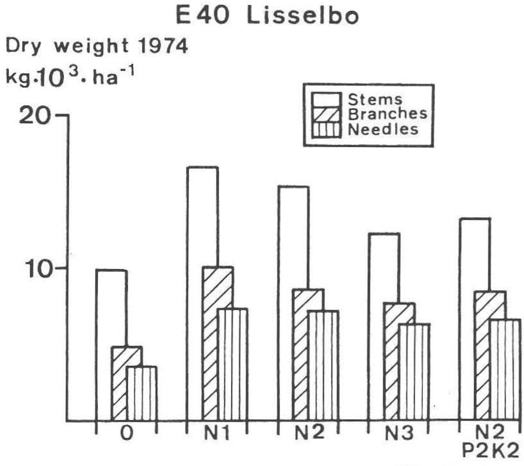

Fig. 4 — Dry weight above ground of a young pine stand fertilised with ammonium nitrate annually from 1969 onwards (see Tamm, Nilsson and Wiklander 1974). Each value mean for four plots. Stand established after wind-fellings in 1954.

(From Albrektson and Aronsson, in prep.)

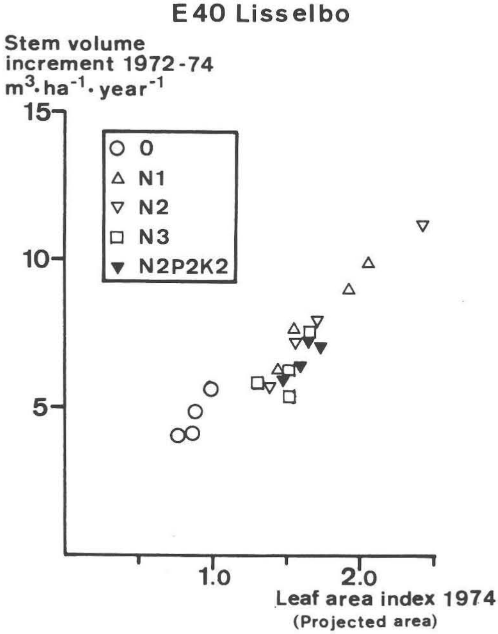

Fig. 5 — Stem growth 1972-74 plotted against leaf area index in the experiment in Fig 4. Each symbol represents one plot.
(From Albrektson, Aronsson and Tamm 1977)

the picture. Nitrogen immobilisation in old forest stands may be compensated for by increasing atmospheric deposition of ammonia and nitrate (at present estimated at 2-20 kg N ha^{-1} yr^{-1}). The increasing acidity of the rain, caused by both sulfur and nitrogen compounds might work in the opposite direction by slowing down decomposition.

Primary and Secondary Factors

Even if it is proven beyond doubt that nitrogen is the most directly growth-limiting factor among the plant nutrients in most Scandinavian forests, it is somewhat difficult to consider nitrogen as a primary factor. All nitrogen present in the Scandinavian forest soils has been added to the soil during the 8000 — 12000 years since the Pleistocene glaciation, which left Sweden covered with virtually nitrogen-free mineral soil (glacial till and various sediments). There must be some mechanism accounting for the large differences occurring in nitrogen supply (amounts and concentrations).

Dahl et al. (1967) have observed that there is a close relationship between the amount of nitrogen in the humus layer and the base saturation in this layer and also that the poorer forest types are low in both nitrogen concentration and base saturation, while more fertile forest types are high in both properties (Fig. 6). A similar relationship holds true on Swedish peatlands (Holmen 1964, Dahl et al., l.c.), There are several mechanisms possible to explain this relationship. One is the preference of nitrogen-fixing organisms for higher pH and better base saturation conditions. Another one is the possibility that more stable humus, rich in nitrogen, is formed, if the base saturation is higher. Also the water regime interacts with this relationship between nitrogen and base saturation. Slopes with more or less regular supply of surface or subsurface water trickling down them are usually good sites (cf. Hägglund and Lundmark 1977) and apparently higher than the surroundings in both nitrogen and base saturation.

Practical Implications

There are many problems still to be solved with respect to the

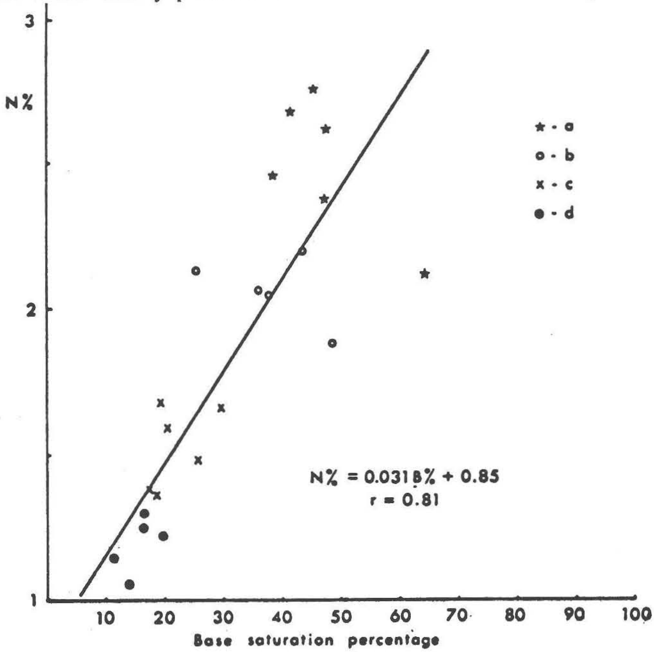

Fig. 6 — Nitrogen concentration in humus (A_O) samples (% of loss on ignition) plotted against base saturation in the same samples. The symbols stand for forest vegetation types with their productivity decreasing in the series a »b »c »d. Southern Norway.

(From Dahl, Gjems and Kielland-Lund 1967) relationship between forest growth and site properties. The evaluation of site quality is also complicated by the fact that only a small part of the nitrogen in the forest soil is available for trees at a given time. We have no commonly accepted method for assessing the active fraction of the soil nitrogen supply, even if a method suggested by Nömmik (1976) offers some promise. A better insight into these relations is urgently needed, and particularly into how man's operations affect soil nitrogen availability. Man-made forest is now rapidly replacing the old, natural or at least self-sown forest in North Sweden. In this man-made forest there is often a change of tree species. Widely spaced pine is replacing old-growth spruce or a mixed hardwood-coniferous forest. Wide spacing between trees (2 x 2m and wider have been used extensively on poor sites) in the earlier phase of the succession prolongs the time during which there is no regular circulation of nutrients between soil and tree stand. Fertilisation is used as a silvicultural tool to improve yield. Changes in the negative direction are due to increased attacks of insects on the forest and to the acid rain, mentioned already, which has increased considerably in Europe during the past decade, due to combustion and processing in Europe's industrial and urbanised areas.

Some of the factors affecting forest production in a long-term perspective are listed below:

Positive Factors

Replacement of self-sown stands, often unmanaged in earlier days, with new stands planted in regular spacing with proper site treatment and genetically better material (genotypes or even species).

Space regulation and brush control in young forest, thinning in middle-age stands.

Fertilisation.

Increase in atmospheric supply of ammonia and nitrate nitrogen.

Growth improvement and increase in forest area by draining peatlands.

Negative Factors

Too wide spacing in planting.

Too little attention to local site conditions because of increased mechanisation.

Increasing number of injurious insects (partly inadvertent side-effects of management operations).

Extended intervals between thinnings (as compared with conditions 2-3 decades ago).

Increase in rain acidity and in absorption of acid substances from the air.

Forest fires, especially on dry sites.

Factors with Slow or Uncertain Effects

Climatic changes, mineral weathering, increased carbine dioxide concentration in air, increased proportion of coniferous monocultures.

It is difficult to forecast the combined effects of all these changes, but it has caused alarm that the last reports from the Forest Survey of Sweden indicate a decrease in forest growth, at the same time as wood consumption continues to increase. We must use all scientific information available in order to optimise forest growth, with due attention to economic considerations and possible environmental restrictions. Some of the proposed forest programmes have been criticised for the last reason (intensive fertilisation, extensive drainage operations, herbicide use, etc.).

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TAMM, C. O. 1977. Factors limiting primary production in the boreal forest — long-term and short-term considerations — Bicentenary celebration of C. P. Thunberg's visit to Japan. Tokyo, Kyoto and Nagasaki, 17-25th May 1976. pp. 53-59.

TAMM, C. O., ARONSSON, A. and BURGTORF, H. 1974. The optimum nutrition experiment Strasan. A brief description of an experiment in a young stand of Norway spruce (*Picea abies* Karst.) — Research Notes, Department of Forest Ecology and Forest Soils, Royal College of Forestry No. 17. Stockholm.

TAMM, C. O. NILSSON, A. and WIKLANDER, G. 1974. The optimum nutrition experiment Lisselbo. A brief description of an experiment in a young stand of Scots pine (*Pinus silvestris* L.) — Research Notes, Department of Forest Ecology and Forest Soils, Royal College of Forestry No. 18. Stockholm.

Notes and News

Ceremony at Ballykelly Forest

The birth of State Forestry in Northern Ireland took place at Ballykelly on December 1, 1910. A commemorative stone, on the site of the first planting in State hands, was unveiled at Ballykelly Forest on Wednesday, July 25, 1979. Mr. Mick Farren who for many years worked as foreman at Ballykelly Forest, performed the ceremony.

On the same day, Mary Peters, MBE, opened a new jogging trail in the forest. Following an approach from Limavady District Sports Advisory Council for facilities for jogging, the Forest Service waymarked two jogging trails, one of 1.20km and another of 2.00km. In addition an explanatory information point has been provided to illustrate to joggers the trails through the Forest. The trail, the first of its kind in Northern Ireland, follows forest roads and trails through the Forest. It passes close to a Heritage Stand of Sitka spruce planted in 1919. This grove of trees will be retained as some of the oldest planted trees in State Forests in Northern Ireland.

Ballykelly Forest, Walworth Wood or Caman Wood as it is locally known, was originally owned by the Fishmongers' Company of London. The wood consisted of oak, beech, birch and holly of which some was almost certainly primeval forest. It is said that some oak from Ballykelly was used in the construction of the Houses of Parliament at Westminster.

In 1886 the company sold their estates to occupying tenants and the wood was due to be sold to timber merchants for felling. However a Limavady corn miller, Mr. S. M. Macrory, "... thinking the absolute abolition of the wood would be not only an eye sore but a loss to the country ..." together with 5 others formed a syndicate and bought the wood from the company. They subsequently felled portions of it in 1893 and replanted with larch. In 1907 on hearing that the government were considering purchasing land for forestry purposes Mr. Macrory wrote to Dublin and offered the wood for sale. The Department of Agriculture and Technical Instruction for Ireland finally acquired the Wood in 1910.

European Vegetation Map

In the "Nature and Environment Series", the European Committee for the Conservation of Nature and Natural Resources has recently published the "Vegetation Map of the Council of Europe Member States". This map provides a comprehensive, homogeneous picture of European vegetation. The scale selected — 1:3,000,000 — makes it possible to chart potential vegetation, i.e. climax communities, which are identified by the use of different colours and shading patterns on the map. In all, 96 vegetation units are represented: the map indicates the name of the principal community and the accomanying text identifies the following features for each unit, insofar as they are known:

— the environmental conditions;
— the type of primary vegetation (natural and semi-natural), when this has been studied;
— the geographical or ecological subdivisions;
— the main type of land-use (forestry or agriculture);
— the "locus typicus", i.e. one or more typical examples of European interest, for each unit; plus an indication of any conservation measures that have been, or ought soon to be, adopted.

Every description is followed by a list of the most comprehensive or most recent publications. A general bibliography is appended, together with a six-language glossary of the tree-names most frequently cited. (On sale from the Publications Service, Council of Europe, B.P. 431, F67006 Strasbourg Cedex). (Council of Europe Newsletter).

Finland, increased efficiency through computerisation

A country of forests and lakes, Finland has relied on computers for some years in managing its environment. The use of appropriate data-processing techniques makes it possible to manage woodland effectively and to rationalise forestry operations, since information is instantly available on suitable machinery, working methods, costs, the needs of young trees and the various uses of fertilisers. Once processed, this information also makes it possible to implement felling schemes more rapidly. As for water, paper-pulp factories are the main source of pollution, since cellulose reduces the oxygen content of the water. A simultation-model is now being devised. This is a mathematical model which can be used to analyse all the reactions possible to a certain number of polluting substances. It will be fully operational within a year. (Le Matin de Paris).

Co-ordination of Forestry Policies

There have been proposals for a *Standing Consultative Forestry Committee* to be set up by the Commission of the European

Communities to achieve better co-ordination of national forestry policies. The Commission bases its proposals on the following facts:

— one fifth of the Community is covered by forest, and one third of world trade involves wood and wood products;
— the Community's balance of payments deficit in wood products is second only to its oil deficit.

Besides the fact that there are economic reasons for developing the sector, forests play an important role from the social, regional and ecological points of view (soil, water, flora, fauna and landscape conservation, as well as recreation for urban populations). (Council of Europe Newsletter).

Forestry Commission Census

The Forestry Commission has started work on a census of all trees and woodlands in Great Britain. This is the first national assessment since 1965. The operation, which involves aerial photography and surveying techniques, started in mid-April and will continue until 1982. The aim is twofold: to produce a clear picture of the distribution of Britain's woodlands and to estimate the potential timber production of the existing forests.

Destruction of the World's Forests — Forests for People

These were the central themes of the 8th World Forestry Congress held in Djakarta, Indonesia, on 16-18 October, 1978. The Director of FAO warned the 2,500 experts from 100 countries attending, of the growing seriousness of the problems of drought or flooding and over-exploitation of forests (1% of the world's tropical forest disappears each year!). Apart from regulating the climate, however, forests also represent the "poor man's energy" — especially in Asia and Africa, where the shortage of wood is so great that peasants are reduced to burning 400 million tons of straw and dung every year. Yet these natural fertilisers are essential for soil regeneration.

Annual Study Tour — Handouts

On behalf of the Society, Councillor Eric Joyce is presently making a collection of handouts for all previous study tours for which they were available. If you can help fill some of the following gaps in his collection, please contact him directly at Glenealy, Co. Wicklow (0404-5701) or send what you have to any members of the Council of the Society. 1960 Ballina; 1961 Glengarriff; 1962 Ballinasloe; 1963 South of Ireland; 1964 Britanny; 1965 Cavan; 1966 North Derry, Antrim; 1967 Cahir; 1968 Donegal; 1974 Mayo; 1975 Cavan.

OBITUARY

Patrick Hackett

It was with great regret that we learned of the recent death of our esteemed member and colleague Pat Hackett. It seemed only a very short time since he had, as was his custom over the years, attended the Annual Study Tour — on this occasion in Co. Donegal in September last. Pat was one of our 'emigrant' foresters who although spending his entire professional career on the other side of the 'Channel' always maintained an interest and a contact with his colleagues on the Irish scene.

A native of Tullamore, Co. Offaly, he qualified from U.C.D. in 1944. In the difficult times then obtaining in forestry in this country he perforce went abroad and took up an appointment with T. W. Dalgleish & Son, Forestry Consultants, Kilmarnock, Scotland.

I had the privilege of working under him with that firm during the late '40s. I am indebted to him for all that I learned from him of the art of forest management. He was a hard task-master, but a fair one. His greatest quality in those immediate post-war days of restriction and hardship was a strongly developed sense of humanity and justice in his dealings with his sub-ordinates. He earned the well merited respect of both his superiors and his fellow-workers. The esteem in which he was held by his employers was reflected in his appointment as a partner in the firm, with responsibility for operations in South Scotland based in Dumfries.

Pat's association with Dalgleish & Son continued for many years. His impact on forestry in the private sector of South Scotland is generously and unambiguously acknowledged by those who knew him and worked with him. In latter years he moved to the then newly emerging force in the private sector in Great Britain, Economic Forestry Group. This involved a move from Scotland which he loved (and where he had wooed and wed his charming wife Betty) to the Welsh Valleys in Llandovery in Dyfed. Here his duties happily enabled him to strengthen his contacts with his colleagues in Ireland. Many will recall his visits to this country as purchasing agent for Economic Forestry.

His positive contribution to commercial forestry development will live after him and will be an ever renewable memorial to his work. Forestry in Scotland and Wales will be the poorer for his demise, but will have been enriched by his endeavours. We in Ireland will miss his visits and his stimulating contributions to discussions and debates on his favourite subject — forestry. To his wife Betty and to his family, we extend our sincere sympathy. "Ar dheis Dé go raibh a anam". L.C.

Society Activities

ANNUAL GENERAL MEETING 1979

COUNCIL REPORT FOR 1978

Council Meetings:
Six council meetings were held during the year. Attendance of Councillors was as follows: F. Mulloy, L. Furlong, J. Dillon, J. Gillespie (6); M. L. Carey, E. Joyce, J. Prior (5); J. Mackin, L. P. O'Flanagan, C. Tottenham (4); M. O'Brien (3); W. J. Wright (2); E. P. Farrell (1); P. J. Morrissey (0).

Society Meetings:
A successful Symposium on the theme "Wood for Industry in Ireland" was held at Belfield, U.C.D. The day study tours to Lisnaskea and Scotstown in May, and to John F. Kennedy Park in June were well attended. The proceedings of the symposium and the day study tours are printed in "Irish Forestry", Vol. 35, No. 2. A Lecture entitled "Forestry in New Zealand" was delivered by Mr. T. McEvoy at the R.D.S. The Society expresses its thanks to those who acted as field leaders and speakers.

Guided Forest Walks:
Despite poor weather approximately 3,000 people participated in the walks which were held at 32 centres throughout the country. The Society wishes to thank Mr. J. Connelly, who undertook the organisation of this event, and those members who acted as walk leaders at the various centres. The assistance and co-operation of the Forest and Wildlife Service, Dublin, and the Forest Service, Belfast, is also acknowledged.

Annual Study Tour:
The Annual Study Tour, held in September, was based in Ballybofey. Our thanks are due to Mr. Phillips and Mr. Johnson, tour leaders and staff who assisted with the organisation in conjunction with the Meetings Sub-Committee.

Annual General Meeting:
The 36th Annual General Meeting was held in the R.D.S. on the 10th March, 1978. The minutes are available in Irish Forestry, Vol. 35, No. 2.

Society Publications:
Irish Forestry, Vol. 35, Nos. 1 and 2 were published. A revised "Why Forests" was again issued with other literature in conjunction with the guided "Forest Walks" publicity drive. Work on the second and revised edition of "Forests of Ireland" continues.

SOCIETY OF IRISH FORESTERS — STATEMENT OF ACCOUNTS FOR YEAR ENDED 31st DECEMBER, 1978

1977	*RECEIPTS*		*1978*
3,563.05	*Balance from Last Account*		4,353.52
	Subscriptions Received		
	Technical 1978	1,878.45	
	Technical 1977	129.57	
	Associate 1978	432.00	
	Associate 1977	38.50	
	Student 1978	34.50	
	Student 1977	5.50	
	Other Arrears	9.00	
	Advance Payments	130.50	
2,258.00			2,658.02
	Interest on Investments		
	Dublin Corporation Stock 9¾%	20.11	
	Savings Account	11.84	
	Educational Building Society	302.34	
368.70			334.29
	Journal		
	Sales	257.98	
969.59	Advertising	1,313.82	1,571.80
369.58	*Forest Walks*		549.96
40.00	*Examination Fees*		
52.00	Donations		
8.75	Tax Refund		
7,629.67			**9,467.59**

1977	*PAYMENTS*		*1978*
85.11	*Stationery and Printing*		
1,509.68	*Printing of Journals*		1,499.81
353.02	*Postage*		520.35
	Expenses re Meetings: A.G.M.		
	Annual Dinner		
256.09	Other	69.00	69.00
33.03	*Bank Charges*		33.25
310.00	*Secretarial Expenses*		522.19
62.00	*Value Added Tax*		104.43
114.18	*Examination Expenses*		70.91
	Honoraria: Secretary	30.00	
	Treasurer	30.00	
	Editor	30.00	
	Business Editor	30.00	
80.00			120.00
325.04	*Forest Walks*		549.96
48.00	*Typewriter*		
100.00	*Transfer to Prize Bonds*		
	Balance: Current	1,065.10	
	Savings	274.91	
	Educational Building Society	4,637.68	
4,353.52			5,977.69
7,629.67			**9,467.59**

I have examined the above accounts, have compared it with vouchers, and certify same to be correct, the balance to credit being £5,977.69 which is held in current and savings accounts at the Ulster Bank, and in the Educational Building Society, less £70.00 in uncashed cheques. There is also a holding of £206.19, in the Dublin Corporation 9¾% Stock and £100.00 in Prize Bonds.

Dated: March 1st, 1979

Signed: W. H. Jack, Hon. Auditor

Examinations:

The result of the 1977/1978 examinations were not available for inclusion in the Council's Report of last year. We are pleased to announce that two condidates were successful at the Foresters Certificate Examination. Three candidates presented themselves for the Foresters Certificate Examination 1978/1979 which was held in February, 1979. The Minister for Fisheries and Forestry has informed council that he will refund fees and travelling expenses to employees of his Department who sit for the Society's examinations. The Society thanks the Minister for his action in this matter.

Elections:

Three positions of Councillor Technical and one of Councillor Associate for the period 1979-1980 were filled by election.

New Members:

A total of 68 new members were enrolled in the following categories: Technical 28; Associate 22; Student 18.

MINUTES OF THE 37th ANNUAL GENERAL MEETING

Thursday, 5th April, 1979, Thomas Prior House, R.D.S., Dublin

Attendance:

The President Mr. F. Mulloy in the chair, present were: L. Furlong, B. Morrissey and J. Tottenham, Messrs J. Gardiner, N. O'Carroll, E. P. Farrell, E. Hendrick, C. Tottenham, J. Dillon, J. Brosnan, J. J. Maher, M. J. Sheridan, O. V. Mooney, M. O'Brien, J. Prior, D. A. Dickson, P. Savill, F. J. Shekleton, L. O'Flanagan, A. W. Simpson, K. Ellis, J. M. Sanderson, T. Wilson, J. A. McEwen, J. Durand, C. S. Kilpatrick, M. Carey, J. Gillespie, R. Tottenham, S. Milner and R. F. Mackenzie. Apologies were received from Messrs T. McEvoy, P. M. Joyce and J. O'Driscoll.

A minutes silence was observed as a mark of respect to Mr. P. Hackett and Mr. J. K. McGerty, two past members of the Society who had died during the year.

Secretarys Business:

The minutes of the 36th Annual General Meeting were read and signed. The adoption of the council report for 1978 was proposed by J. Maher and seconded by M. Sheridan. Dr. O'Carroll, in commenting on the report mentioned that that a commercial firm had expressed an interest in publishing the new edition of "Forests of Ireland". It was felt that such a development could result in substantial savings for the Society. Mr. Carey, in reply to a question from Mr. Mooney stated that there were 611 members who had paid their full subscription and 21 who had paid part of the subscription. It was intended, in future years, to remove from the address list all members who were not fully paid up by the 1st of March each year.

Abstract of Accounts:

In presenting the statement of accounts the treasurer attributed much of the healthy balance to increased revenue from journal advertisements. It was pointed out that honoraria had been increased from £20 to £30. Some discussion on the possible means of utilising the large credit balance ensued. The editor pointed out that problems with both the quality of printing and date of publication of the journal had been evident in the past. Overcoming these problems might result in some extra outlay on the journal in the coming years. In answer to a question from Mr. Gardiner the treasurer stated that where excess payment of subscription had been made in error, usually due to bankers mistakes, the overpayment was refunded. The meeting was informed that a substantial reduction in costs asociated with meetings held in the R.D.S. was being negotiated. The president thanked Miss Furlong for the role she had played in these negotiations. On the proposal of Mr. Mooney, seconded by Mr. Kilpatrick the accounts were formally adopted.

Elections:

The 1979 Council elections were confirmed as follows: President F. Mulloy; Vice-President J. O'Driscoll; Secretary E. Hendrick; Treasurer J. Brosnan; Editor E. Farrell; Business Editor M. O'Brien. Technical Councillors J. Kilbride, J. Gardiner and P. McArdle. Associate Councillor C. Tottenham. Northern Regional Group Representative K. Ellis.

Presidential Address:

The president thanked the outgoing members of council for their support during the year and welcomed the incoming vice-president, treasurer, secretary and councillors. He congratulated Mr. J. Prior on his appointment as chairman designate of the Central Forestry Examination Board and thanked both him and the examiners for their work on the Society Examinations. On behalf of the Society he thanked Mr. McEvoy who acted as registrar for the Societies Examinations, Mr. W. Jack the honorary auditor, Mr. J. Connelly who had organised the 1978 Forest Walks, the Northern Ireland Forest Service and the Forest and Wildlife Service who facilitated the work of the Society in many ways.

Other Business:

Mr. Dillon gave details of the 1979 Annual Study Tour to be held in Scotland. Preparations for the Symposium were moving ahead satisfactorily despite the distruption caused by the post and telephone situation. The question of seeking sponsorship for some of the societies activities was raised. The general opinion seemed in favour of the Society maintaining strict independence though the question of sponsorship in future years should the necessity arise was not ruled out. The meeting concluded at 9.50 p.m.

PUBLICATIONS RECEIVED

The Forester, Vol. 16, No. 2, 1978. Forest Service, Department of Agriculture, Northern Ireland.

National Board of Science and Technology. Annual report, 1978.

FOREST WALKS

This year, the annual guided forest walks were held on Sunday September 9th. Walks were organised in the following forests.

Forest	*Points of Interest*	*Leader*
Ardnageeha, Cong, Co. Mayo	Scenic walk by Lough Corrib through mixed woodland.	P. Cambpell B. Lambe M. J. Maye
Ards Forest Park, Co. Donegal	Forest Park. Conservation of native woodlands. Wildfowl sanctuary.	D. Connolly
Avondale, Co. Wicklow	Home of Charles Stuart Parnell. Birthplace of Irish Forestry. Arboretum; tree species from many lands.	J. Brosnan D. McAree O. V. Mooney
Ballinamore Wood, Kiltimagh, Co. Mayo	Pleasant walk through mixed woodland area. Amenity development.	T. De Gruineil P. Doolin R. O'Cinnéide
Ballinascorney, Brittas, Co. Dublin	Mixed conifer woods. Scenic views of city and suburbs.	J. Callaghan J. J. Crowley P. Cunningham
Ballinastoe Wood, Roundwood, Co. Wicklow	Pleasant walk through diverse conifer plantations, at various stages of development. Scenic views.	J. F. Fee A. P. Higgins G. J. Patterson
Ballybrittas, Co. Laois	Wide variety of tree species and their management. Pleasant lakeside walk.	G. T. Hipwell J. Prior
Ballydowling Wood, Co. Wicklow	Treatment of old Oak/Beech wood. Management of Douglas fir plantation towards production of ESB poles.	H. M. FitzPatrick
Ballygar, Co. Galway	Forest at various development stages. Wildlife interests.	P. McArdle T. McGuinness
Bishopswood, Dundrum, Co. Tipperary	Mature conifer and broadleaf plantations, wildlife and amenity interests.	M. Grace J. Hanly
Breen Forest, Co. Antrim	Remnant of natural oak woodland. Mixed conifer plantations.	W. J. Crawford
Broadford, Co. Clare	Scenic walk through mixed broadleaf and conifer woodland.	E. Larkin J. Madden
Castlecaldwell, Co. Fermanagh	Mixed conifer plantation on shores of Lough Erne. Wildlife exhibit, lakeside trails.	G. J. Cunningham
Jenkinstown, Co. Kilkenny	Amenity development. Mixed broadleaf and conifer woodland. Wildlife sanctuary.	G. McCarthy K. Ryan

Forest	*Points of Interest*	*Leader*
Castlefreke, Rosscarbery, Co. Cork	Pleasant walk through mixed conifer and broadleaf woodland.	T. Galvin W. Shine
Castleshane, Co. Monaghan	Mixed broadleaf and conifer woodland. Waterfall and castle ruins.	M. Dooley J. Finlay
Clonegal, Co. Wexford	Forest nursery with ten million trees. Poplar cultivation and wildlife interests.	P. J. Cotter G. Murphy J. J. O'Reilly
Donadea, Co. Kildare	Mixed broadleaf and conifer woodland. Lakeside walk.	S. Carew P. Crowe E. Fitzpatrick
Dromore, Ennis, Co. Clare	Conifer and broadleaf woodland. Lakeside amenity. Wildlife interest.	M. Barry L. Cawley P. J. O'Sullivan
Drumkeeragh Forest, Co. Down	Mixed conifer plantation on slope of Slieve Croob Mountain, overlooking East Down and Dundrum Bay.	R. T. Sherwood
Forth Mountain, Co. Wexford	Scenic valley walk. Management of various broadleaf and conifer species.	J. I. Kilbride J. J. Shorten
Foynes Forest, Co. Limerick	Pleasant riverside walk through mixed woodland.	T. O'Halloran M. O'Sullivan
Glendalligan, Comeragh, Co. Waterford	Scenic walk through mixed conifer woodland at various stages of development.	J. M. Doyle N. Kavanagh
Killakee, Co. Dublin	Wide variety of broadleaf and conifer trees overlooking Dublin. Panoramic views.	J. Fennessy M. O'Brien
Kilworth, Co. Cork	Forest management of mature conifer woodland.	J. C. Crowley J. McCarthy
Lisgoold Forest, Co. Cork	Forest at various stages of development.	E. Flanagan W. Leahy
Lough Eske, Co. Donegal	Amenity walk through broadleaf and conifer plantation. Historical interest.	A. Connolly
Moydamlaght, Co. Londonderry	Conifer plantation on eastern slopes of Sperrin Mountains. Riverside walks.	G. B. Jones
Mullaghmeen Wood, Castlepollard, Co. W/Meath	Mixed broadleaf and conifer forest. Panoramic views.	P. J. Morrissey J. Quinlavin
Newport, Co. Tipperary	Management and harvesting of productive conifer woodlands.	J. F. Cahill T. P. Earle
Oughaval Wood, Stradbally, Co. Laois	Scenic walk through mixed broadleaf and conifer woodlands.	F. Dineen S. P. White
Rathcarrick Wood, Collooney Forest, Co. Sligo	Scenic walk through conifer and broadleaf forest with panoramic view over Sligo Bay.	P. Finnerty J. Murray P. O'Malley
Ravensdale, Dundalk, Co. Louth	Commercial and scenic aspects of established conifer and broadleaf trees.	T. J. McCarthy
Tomies Wood, Killarney, Co. Kerry	Remnants of old oak woodland. Scenic view of Lakes of Killarney. Sika deer.	P. J. Bruton D. Walsh
Tower Hill, Curraghmore, Co. Waterford	Commercial and scenic aspects of mature broadleaf and conifer woodland.	D. Magner J. O'Riordan

SYMPOSIUM ATTENDANCE

List of members who attended Symposium "The Challenge of the Second Rotation" on 6th April, 1979, U.C.D.

*Lord Ardee

Barrett, J.
Beasley, J.
Berkery, W.
Booth, I.
Brassil, D.
deBrit, G.
Brosnan, J.
Butler, P.

Callaghan, J.
Carey, Dr. M.
Carlin, P.
Carmody, J.
Carney, S.
Carroll, P.
Clear, Professor, T.
Clinch, P.
Collins, F.
Condon, L.
Connelly, J.
Conway, M.
Corbett, P.
Cosgrave, M.
Cremin, K.
Crowe, P.
Crowley, J.

Deasy, J.
Dennehy, N.
Dickson, Dr. D.
Diffley, L.
Dillon, J.
Dodd, P.
Donoghue, T.
Doolan, P.
Doyle, J.
Doyle, M.
Drea, F.
Duane, J.
Duggan, M.
Durand, Dr. J.

Ellis, K.
Emery, L.
Enright, J.

Fahy, C.
Farmer, C.
Farrell, Dr. E.
Fee, F.
Fennessy, J.
Fenton, P.
Finnerty, T.
Fitzgerald, P.
Fitzpatrick, E.
Fitzsimons, B.
Flanagan, E.
Fleming, G.
Flynn, P.
Fogarty, M.
Friel, M.
Freeman, J.
*Furlong, Miss L.

Gallagher, D.
Gallagher, Dr. G.
Gallagher, L.
Gardiner, Dr. J.
Gatins, J.
Griffin, E.

Harney, G.
Hayes, S.
Healy, J.
Hendrick, E.
Hennessy, M.
Higgins, A.
Howell, P.
Hunt, T.
Hutchinson, K.

Johnson, E.
Joyce, E.
Joyce, Dr. P.

Kavanagh, N.
Kavanagh, T.
Keane, D.
Keane, M.
Kelleher, P.
Kelly, M.
Kilbride, J.
Kilpatrick, C.

Larkin, E.
Lawler, B.
Layton, T.
Lee, E.
Lynch, T.

Macken, J.
*Madden, Major, J.
Magner, D.
Maher, J.
Mannion, T.
Milner, S.
Moloney, B.
Moloney, F.
Moloney, T.
Mooney, O.
Moore, J.
Moran, M.
Morrissey, P. J.
Mulloy, F.
Murphy, G.

McArdle, P.
McAree, D.
McCarthy, D.
McCarthy, Dr. R.
McCarthy, T.
McCormack, C.
McElroy, P.
McEvoy, T.
McEwen, J.
McGlynn, D.
McGuinness, E.
McGuire, D.

McKenzie, R.
McLoughlin, J.
McLoughlin, J.
McNamara, S.
MacOscair, P.

Neilan, J.
Nyhan, C.

O'Brien, D.
O'Brien, M.
O'Brien, P.
O'Brien, T.
O'Carroll, Dr. N.
O'Connor, J.
O'Dea, J.
O'Donoghue, P.
O'Donovan, C.
O'Donovan, M.
O'Dowd, J.
O'Driscoll, Jim
O'Driscoll, John
O'Dwyer, B.
O'Dwyer, P.
O'Flanagan, L.
O'Grady, P.

O'Halloran, M.
O'Halloran, P.
O'Kelly, P.
O'Neachtain, M.
O'Regan, T.
O'Reilly, J.
O'Sullivan, J.
O'Sullivan, M.
O'Sullivan, P.

Patterson, G.
Pfeifer, A.
Phillips, H.
Phillips, J.
Prior, J.
Purcell, T.

Quinlivan, J.
Quinn, E.
Quinn, L.
Quinn, S.

Raftery, P.
Robinson, D.
Rouine, M.
Ryan, J.
Ryan, M.

Sanderson, J.
Savill, Dr. P.
Shekleton, F.
Sheridan, M.
Shorten, J.
Simpson, A.
Swan, M.
Sweeney, M.

Teigue, N.
*Tottenham, C.
*Tottenham, Mrs. J.
*Tottenham, R.
Treacy, J.
*Tucker, C.
Twomey, J.

Walsh, D.
Ward, D.
Watson, F.
*White, D.
White, P.
White, S.
Wilson, T.
Wright, W.

*Associate Members

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