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IRISH FORESTRY

JOURNAL OF THE SOCIETY OF IRISH FORESTERS

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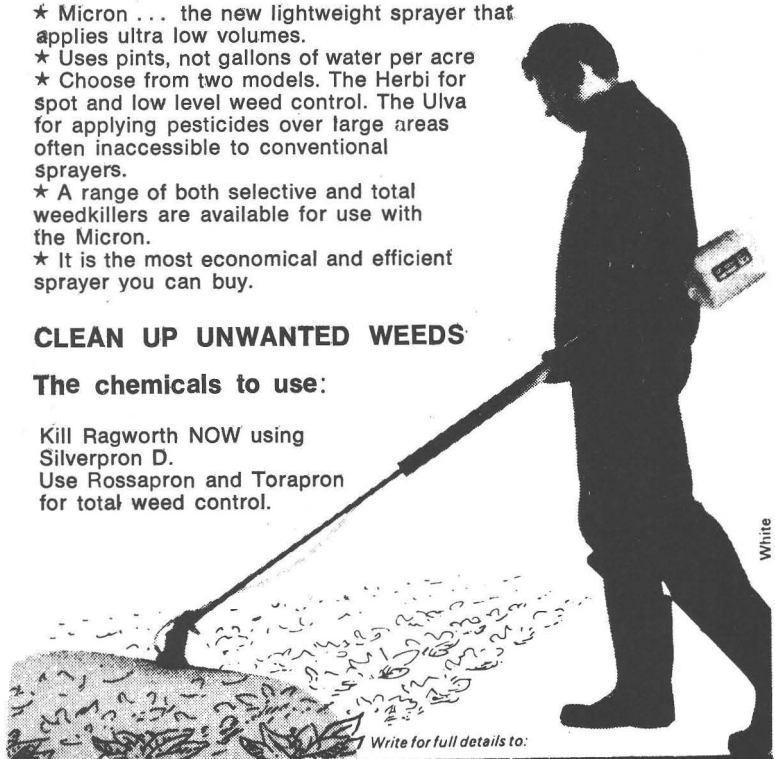

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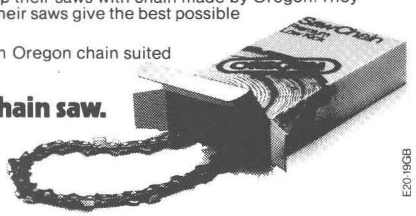

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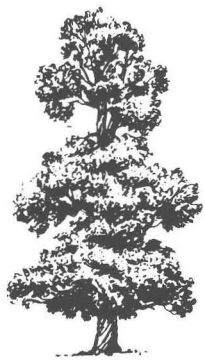

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Notes for the

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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.

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

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

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EDITORIAL

Promoting Private Forestry

Economic analysis have shown that forestry is a good investment. However, not all of our forests are equally rewarding in financial terms. Even though it costs more to buy good forest land it is a much better investment than poorer, cheaper sites where productivity is lower and, critically, rotation is longer. There are many reasons why state forestry cannot confine itself to the best sites in the most productive tree-growing areas of the country. Nevertheless, the relationship between site type and financial return should be borne in mind by all who are concerned to see the money invested in forestry well spent.

Private forest estates represent one source of good forest land which is not realising its full potential at present. The area of privately owned forest in the Republic is 82,000 ha, in Northern Ireland 14,000 ha.[1] This land is for the most part of good quality yet productivity is very low. The proportion of hardwood crops is high and much of the standing crop is well beyond the age of maximum M.A.I. A large proportion of the forest area in private ownership is totally unproductive. Over 40% is scrub land in the Republic, 12%[1] in the North. The forest services promote private forestry by means of planting and scrub clearance (in the Republic) grants and technical advisory service. However, with the lapse of the free scrub clearance scheme in Northern Ireland, private planting has fallen to a very low level. In the south, the response to the scrub clearance scheme has never been good and nowhere is there a scheme to encourage the utilisation of overmature stands.

What is required is a vigorous promotion campaign involving a revised system of grants and a comprehensive advisory service for private forestry. The reasons for the reluctance of private owners to fell their mature stands are social and historical rather than economic. They often feel they do not have the expertise even to approach the problem nor the incentive to look for advice. Ideally there should be a forestry advisor to whom they can turn and who himself is dedicated to promoting the development of private woodlands. It may be questioned as to whether this should be the responsibility of the forest services. it might be better to have a forestry advisor appointed to ACOT (in the Republic) in each county, thereby making the service an integral part of the local agricultural and horticultural advisory service. The advisor would thus become known as such and identified with an established advisory service.

1 Personal communication, Mr. Cecil Fitzpatrick, Chief Forest Officer, Northern Ireland Forest Service.

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Tree Ring-Series — A Valuable Source of Ecological and Environmental Information

A. McNALLY[1] and G. J. DOYLE

Botany Department,
University College Dublin.

INTRODUCTION

Uniform tree ring patterns are observed in particular sites or regions where tree growth is limited by a single factor or factors. The most obvious and readily measureable feature of such ring patterns is variable radial width. Such measures are used in the science of dendrochronology or tree ring analysis. The fundamental object of this approach is to place a time sequence on the ring-series, enabling us to place a calendar date on any particular ring.

If it is possible to correlate wide or narrow rings with some limiting factor, by experiment or by statistical analysis of measured environmental parameters, the tree ring-series becomes a valuable source of environmental and ecological information.

RING MEASUREMENT

The timber samples used can be cross sections or cores. Both are thoroughly dried before measurement. Dry cores are glued to grooved lathes for support during the final preparation which is essentially the same for cores and sections and involves abrasion with a variety of sand papers, until the annual rings are sufficiently obvious to view under a binocular microscope.

The ring widths are measured by passing the core or section on a graduated moving stage under a microscope fitted with cross hairs.

1 Present Address: Department of Biology, McGill University, 1205 Avenue Docteur Penfield, Montreal, PQ, Canada H3A 1B1.

The distance traversed by the stage (the ring width) is displayed on an electronic counting device in units of 0.01mm.

Normally, three radii per tree are measured. This allows a check against any inaccuracies which might arise if a single radius were measured, e.g. false or missing rings in part of the tree.

TREATMENT OF RESULTS

The ring width data may be plotted against a time scale. The ring width series in Fig. 1 is based on measurement of cores from living oak (*Quercus petraea*) from Killarney, in County Kerry. The long term trend in ring width with tree age has been removed by a

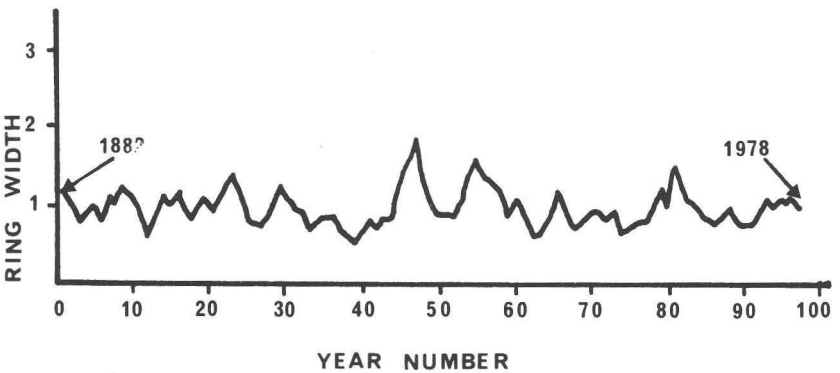

Fig. 1 A tree ring series from live oak (*Q. petraea*) at Killarney. The ring width scale is not given in absolute terms but is based on transformed data varying about a mean of one.

standardising procedure. Each ring width is expressed as a percentage of five ring widths: the current, two previous and two following. As a result each ring width is reduced to an index varying about a mean of 1. Since the formation year of the outer ring is known, it is possible to give a precise calendar date to any ring in the series. The particular tree in question is seen to have survived from 1882 until 1978 when the sample was taken.

The living tree-series may be used to date tree stumps in the area. If both have been subject to the same environmental influences for part of their lives, there will be an overlapping series with a similar pattern of wide and narrow rings. Fig. 2 shows a plot of the living oak ring-series mentioned above, and a series obtained from an adjacent oak stump. There is an obvious overlap in pattern during

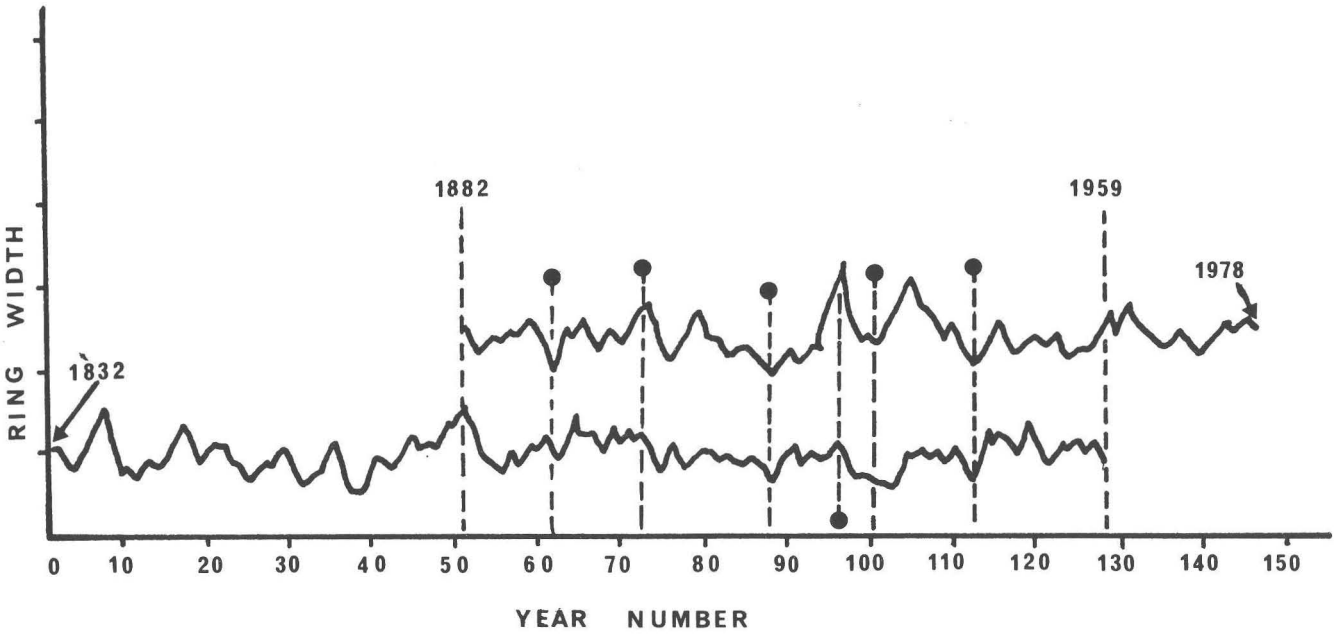

Fig. 2 Cross matching of ring series from a live (upper plot) and a dead oak stump (lower plot) from Killarney. The very obvious points of comparison are indicated by the dashed lines and solid spheres.

the period 1882 to 1959. As a result, it is now possible to put calendar dates on any ring of the undated stump. For example, it commenced growth in 1832 and was felled in 1959.

Overlap between tree ring series may be visually assessed, or may be statistically proven. The statistical comparison involves the calculation of a correlation coefficient for every possible overlap. A Student's t-test is used to indicate the most likely position of correspondance. When the live and dead ring-series above were compared in this way, a t-value of 6.4 was obtained with the 77 degrees of freedom involved. This indicates a very highly significant match.

The authors have computer programmes which will test for overlap in such series and will carry out the statistical procedures outlined below. These are written in FORTRAN 20 and designed to run on the DEC computer at University College Dublin. Copies will be made available on request.

Such techniques allow matching of a large number of ring-series from a particular area and subsequent computation of 'mean master series'. This involves averaging ring widths for each calendar year, based on the overlapping series. By combining information from living and dead timbers in this way long tree-ring-series can be obtained. Baillie (1973, 1977 a & b) has constructed long oak chronologies from Northern Ireland, spanning the period from 1001 A.D. to the present, and from Dublin for the Medieval periods, 885-1306 and 1357-1556 A.D. Pilcher et al. (1977) have set up a 2990 year floating chronology for bog oaks in Northern Ireland. If such series are absolutely dated, i.e. cross matched with present day series, they may be used in dating wooden archaeological materials made of oak. Medieval ships (Baillie 1978, McGrail 1978) and oak panel paintings (Bauch 1978, Fletcher 1978) have been dated in this way.

Oak is particularly suited to this type of analysis as it produces annual rings so consistently. Some species are less suitable as they produce false rings or have missing rings on occasional years. Coniferous species such as the Scots pine (*Pinus sylvestris*) are included in the latter category, but may be utilised if sufficiently rigorous cross checks are made. We have successfully matched pine chronologies from The Scalp and Glencullen in County Dublin, with others from Knocksink in Wicklow, and from a number of sites in Offaly and Kildare. The master chronologies from The Scalp and Glencullen are shown in Fig. 3 and show obvious crossmatching.

In some geographical areas, including the tropics, trees may not produce rings on an annual basis and are not suitable. Despite these

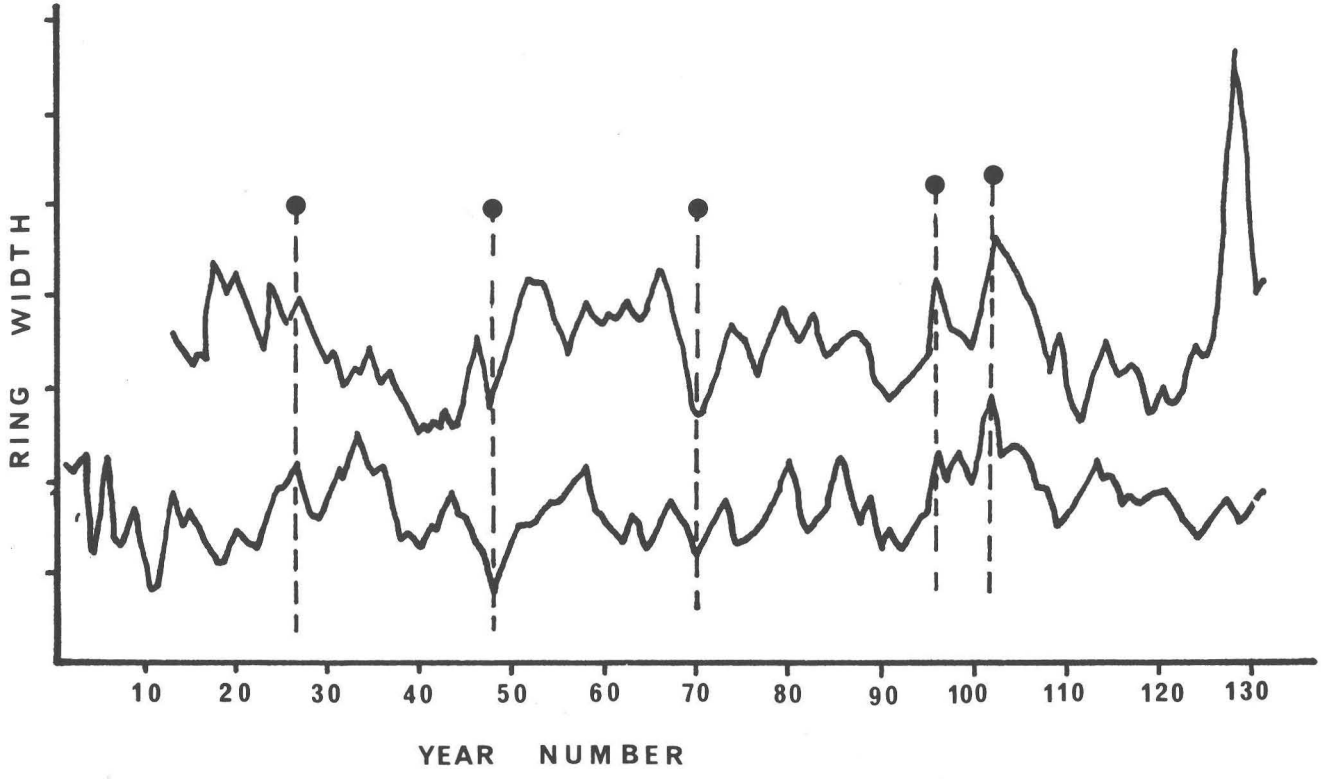

Fig. 3 Master chronologies for pine (*P. sylvestris*) at Glencullen (upper plot) and The Scalp (lower plot). Points of obvious comparison are indicated by dashed lines and solid spheres.

problems, quite a number of species from different geographical areas have been used in tree ring studies. A list of genera used is presented in Table 1.

Table 1 Genera utilised in tree ring studies.

Abies	*Cupressus*	*Picea*	*Sequoia*
Alnus	*Fagus*	*Pinus*	*Sequoiadendron*
Araucaria	*Fraxinus*	*Populus*	*Thuja*
Betula	*Juniperus*	*Pseudotsuga*	*Tsuga*
Cedrus	*Larix*	*Quercus*	*Ulmus*

Crossmatching between trees in any one site, or between sites, indicates the relationship between tree growth, or ring width extension, and some common influencing environmental parameter or parameters. When empirical environmental records are available for part of the period spanned by a tree ring-series, statistical techniques may be used to elucidate the relationship between ring width and particular factors.

The most basic of these techniques is simple regression analysis. Such analysis allows ring width to be regressed against a series of environmental paramenters such as temperature, precipitation etc. The analysis may be based on annual, seasonal or monthy measures depending on the type of environmental records available. The influence of these parameters in current or previous time periods may also be investigated by including parameters for previous years, seasons etc. in the analysis.

Fig 4 shows a plot of coefficients based on a regression of mean monthly temperatures recorded at the Phoenix Park, against the Scalp Pine chronology. The graph clearly indicates that pines at this site are positively affected by temperature for most months of the current year as well as the previous year. The relationship with temperature is particularly strong in the early part of the growing season — in February, March and April. These statistical conclusions make ecological sense, as the Scalp pines are located on a steep slope (45 degrees) and grow on a very poor thin soil in between large granite boulders. As a result, the majority of the tree roots are at, or near the surface and would be immediately affected by changing air temperatures.

Simple regression with other meteorological parameters does not show such a convincing relationship with ring width at the Scalp, so one must conclude that temperature is one of the most important limiting factors.

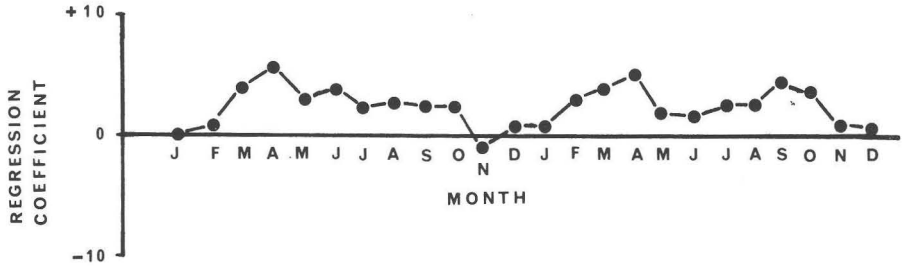

Fig 4 Regression coefficients of ring width from the Scalp pine master chronology against mean monthly temperatures recorded at the Phoenix Park. The monthly values for the previous and current year are included (data for the previous year to the left and for the current year to the right).

Once a relationship with temperature has been established one may wish to investigate the relationship between ring width and long term climatic trends in air temperature. To do this it is necessary to reduce the high frequency variation in the ring width series. This may be accomplished by a digital filtering technique (c.f. Fritts 1976) which involves multipying the original series with numerical weights that emphasise variation at selected wavelenghts (in years). We have applied this technique to the Scalp and Glencullen chronologies (Fig. 5), and have emphasised variations occurring at wave lenghts greater than eight years. These plots show remarkable correspondence, and indicate that there have been periods of above and below average ring growth over the past one hundred years. Superimposed on the graph are the mean surface temperatures based on 5-year averages from 1875-1970 (Chandler and Gregory 1976). The agreement with the Scalp master is immediately noticeable as the peaks and troughs coincide in almost every case. The correspondence with the Glencullen master is again striking but does not correspond to the temperature curve at all times. This difference might be explained on ecological grounds, as during particular warm periods above average precipitation was recorded. This would have affected trees at the two sites in different ways. As already indicated the Scalp trees are confined to very freely draining, shallow soil while at Glencullen the trees grow on relatively deep peat (0.5m) which becomes waterlogged in wet periods. As a result one would expect lower growth in a wet period at Glencullen, despite warmer temperatures.

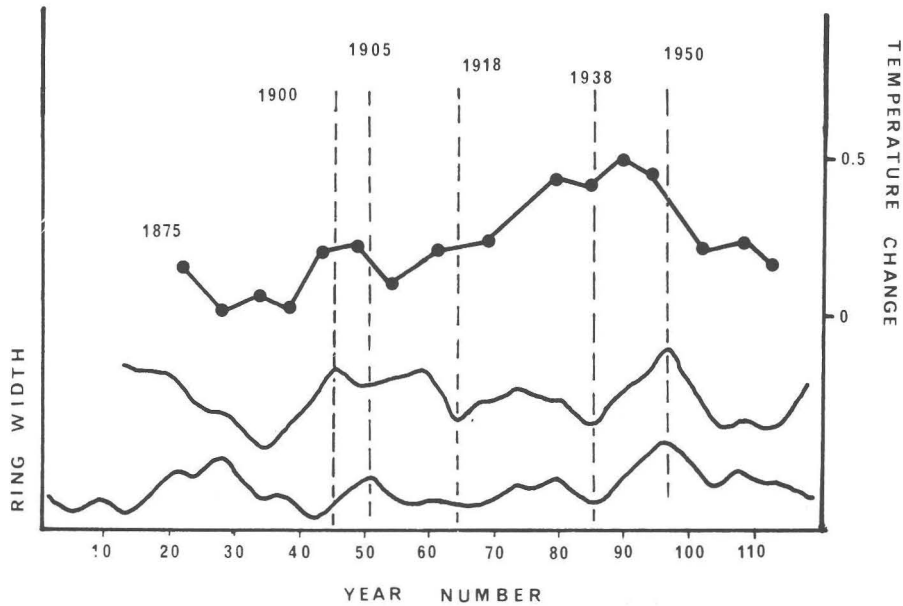

Fig 5 Pine chronologies from the Scalp (lower plot) and Glencullen (middle plot) treated with a digital filter to emphasise wavelengths greater than eight years. The upper plot shows changes in global mean surface temperatures (in degrees centigrade) since 1875 (based on Chandler and Gregory 1976).

Multiple regression analysis may also be used to elucidate the relationship between ring width and a combination of environmental factors. In this way one may account for a considerable proportion of ring width variation (80 percent) and may take into account such factors as autocorrelation, the influence of previous year's growth on the current ring.

Principal components analysis may be combined with multiple regression in a procedure called 'response function analysis' developed by Fritts et al. (1971) and described in detail in Fritts (1976). This technique has become widely used in specifying tree growth and climatic relationships. A set of parameters, measured over the period believed to encompass the greatest climatic influence on tree growth are chosen as predictor variables. Mean monthly temperatures and monthly precipitation for the fourteen month period from June of the previous year to July of the current

year are usually used when dealing with conifers. This set of twenty eight variables with the ring-series are subjected to principal components analysis which extracts eigenvectors (principal components) which are each independent of each other. The procedure identifies the components responsible for the major portion of the variation in ring width, and allows selection of a smaller set of the most important variables. Multiple regression analysis is carried out on the selected components. This results in a set of coefficients related to the principal components, which are then transformed in terms of the climatic parameters. These transformed coefficients are plotted with their associated ninety five percent confidence limits and this represents a response function. Fig. 6 is a response function based on the Scalp pine chronology. The parameters investigated were the fourteen month's temperature and precipitation mentioned above. The significance of each monthly precipitation or temperature in affecting ring width

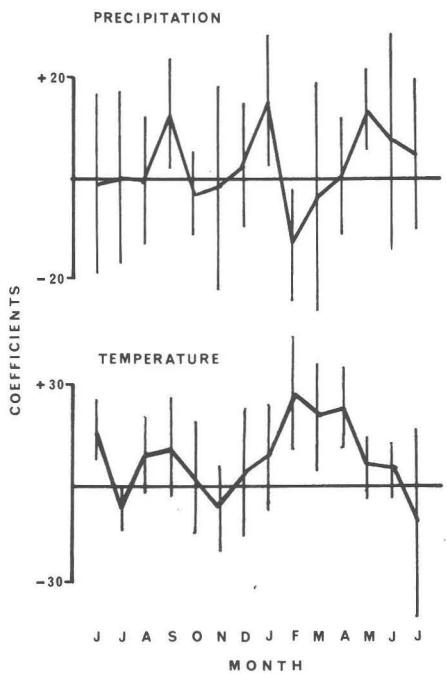

Fig 6 Response functions based on the Scalp Pine chronology. The climatic parameters used were monthly precipitation and temperature data for the fourteen month period from June of the previous year to July of the current year. The vertical bars are the 95% confidence limits.

may be either positive or negative and is significant only if the confidence bars do not intersect the zero axis. The response function indicates that monthly precipitation has little effect on ring width at this site. However, temperature has positive effects which are significant. These effects occur in June of the previous year, and February, March and April of the year the ring was laid down. In this way, the temperature effects on ring width may be broken down into monthly values, and ecological and physiological inferences may be more justifiably made. For instance, there is a marked negative effect of temperature in November, which would indicate that the tree was adversely affected by higher November temperatures. This may be explained in physiological terms as pines usually go through a hardening off process at this time, which is not properly accomplished in warmer weather.

The main advantages of this response function analysis are (1) a large number of climatic variables are included in the analysis, (2) interrelationships between these variables are eliminated, (3) the important variables are recognised, (4) the less important, or random variables which are unlikely to have an effect on tree growth are removed from the analysis and (5) the response function, in the form of plots with associated confidence limits are readily interpreted.

Uses of Dendrochronology

We have used these dendrochronological techniques in a study of subfossil forests preserved under Irish peat deposits. The majority of subfossil stumps and trunks are pine (*P. sylvestris*) but we also find oak (*Q. petraea*), yew (*Taxus baccata*) and birch (*Betula pubescens*).

The midland bogs developed by Bord na Mona are of particular interest as large numbers of stumps and trunks are excavated and piled up at the bog edges. These have provided us with most of our material. We have established a floating pine chronology of over six hundred years from bogs in Kildare and Offaly (this work will be fully described in a series of papers in preparation). Our chronology allows us to comment on (1) the rate of invasion of the peat surface, (2) the age-structure of the pine wood over the duration of the forest period, (3) the longevity of individual trees, (4) the length of time taken for the pine forest to die off and (5) the length of the whole forest period.

^{14}C dating has allowed us to place the forest period in time (circa 4000 B.P.) and has verified our cross-dating techniques. The date suggests that the pine period in the Irish raised bogs is equivalent to

the Late Atlantic Pine Forest described from Europe (Munaut 1966, Munaut and Casparie 1971) and corresponds to the upper pine layer seen in western blanket bog (Malmer pers. comm.).

We have applied the climatological analyses to extant pines at various sites within a forty mile radius of Dublin City. The sites were chosen to present a spectrum of soil types, from the shallow Scalp soils to the relatively deep peat deposits at the edge of raised bogs near Edenderry. The sites had a variety of slopes, aspect etc. The results obtained in this way will allow us to reconstruct the environmental conditions prevailing before, during and after the pine period of four thousand years ago. In addition we have investigated vegetational changes associated with the forest period by pollen analysis.

These dendrochronological techniques have been applied in a wide range of other studies and have demonstrated correlations between ring patterns and regional environmental conditions as well as more local site factors. Ring-series from *Pinus longaeva*, *P. cembra* and *P. sylvestris* have been correlated with regional temperature and indirectly with glacial advances in the United States, the Alps and in Norway (La Marche and Fritts 1971, La Marche 1974, Matthews 1977). Many species have been shown to be influenced by precipitation and have been used to indicate pressure anomalies over the north Pacific and north America in historical times (Fritts 1976). At a more local level the techniques have been used to reconstruct streamflows (Stockton 1975) and water levels in deltaic wetlands (Stockton and Fritts 1973). In both of these cases the results obtained have proved particularly useful, as they showed much greater variability over an extended time period than was indicated in the recent records available. The reconstructed records were used as a basis for subsequent environmental planning. The techniques have also been used in pollution studies (Havas and Huttunen 1972, Taylor 1973) and have demonstrated the adverse effects of nitrogen dust and gaseous air pollutants on ring width.

As time progresses further applications of the techniques are being tested. They may be relevant to forestry studies as they can provide a clearer explanation of tree performance at particular sites, where the influence of regional climatic and local site factors such as soil type, nutrient status etc. on tree growth may be assessed in a realistic way.

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Henry — The Tree Breeder[1]

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Dr. Augustine Henry joined the Chinese Imperial Maritime Custom Service in 1881 and spent two tours of duty in China between 1881 and 1900. (Morley 1979). His interest in forestry, which had commenced during his years in China finally blossomed in the winter of 1901/02 following a meeting he had with Prof. Schlick, the well-known German forestry expert. His desire to follow a forestry course stemmed from his wish to do something worthwhile for Ireland. At this stage of his life he was 45 years of age. Undeterred by the diversity of the subject he plunged straight into it with all the enthusiasm he had shown during his years collecting botanical specimens in China. He soon found the study difficult mainly on account of the language problem as most of the lectures were in French. However it was the field work which really excited him. He saw, how, with modern cultivation techniques, the potential of forestry could be developed. He became aware of the importance of choosing the correct species for the site conditions and not the haphazard planting of species which had been carried out at Knockboy in the late 19th century. The value of trees other than as a source of lumber was also clearly demonstrated in the Alps where they were used as soil stabilizers and as preventors of avalanches and landslides. He took particular note of species which grew on bogs as he felt that such areas would have the greatest potential for afforestation in Ireland (Pimm 1966). As a positive move in this direction he forwarded seed of American larch (*L. occidentalis*) to his brother for growing on peats in Ireland. This early awareness of the importance of ecology was to permeate all his writings in later years.

His work on "Trees of Great Britain and Ireland" demonstrated clearly that it was a mistake to base both Irish and English forestry on purely European species. He found that European summers

1 Paper presented at a symposium marking the fiftieth anniversary of the death of Professor Henry, organised jointly by the Society for the Bibliography of Natural History, and the Society of Irish Foresters, 7th November, 1980.

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were hot and dry while winters were hard. In contrast western north America, with its vast reservoir of species, had climate conditions similar to those found along the western seaboard of the British Isles. His expedition to North America in 1905 brought these facts home forcibly to him. He was instrumental in obtaining seed of Western Larch (*L. occidentalis*) during this trip but was disappointed in the quality of stems from which it was collected. In 1906 he was able to put his expertise at the disposal of the Government when he made his deposition to the Departmental Committee on Forestry (Anon. 1908). Henry's main interest was in the species that should be planted. Many of the experts preferred hardwoods but he came out strongly in favour of conifers, as broadleaved species were a long term investment. He urged them to try out species from countries with mild damp climates such as Douglas fir, Sitka spruce, Scots pine and Sequoia. At all times during his presentation he stressed that the trees must be appropriate to the climate. Subsequent events in Irish forestry have shown how right he was in his choice.

The preparation of the "Trees" had a constant stimulating effect on him. In the course of the preparation of the section on elms (*Ulmus*) he was puzzled how best to classify the numerous varieties of the species. With his usual enthusiasm he investigated the ancestry of as many varieties as possible of the species. In 1909 he sowed ninety different seed lots collected in various locations in the south of England. His first conclusion was that there were only two pure species *U. montana* and *U. glabra.* This conclusion was based on his observations of the growth habit of the seedlings raised in boxes. All seedlings of both *U. montana* and *U. glabra* were uniform in size and in other characteristics. Every other kind of elm when sown produced seedlings which were different in size and arrangement of leaves. When he sowed the seed of the Huntingdon elm, first recorded as a seedling in 1746/56, he found that the progeny segregated out in the Mendelian ratio of 3:1 when leaf arrangement was examined, — 732 seedlings with opposite leaves and 239 with alternate leaves. When a second characteristic was entered into classification the seedlings segregated out into a 9:3:3:1 ratio (small opposite leaves : large opposite : small alternate : large alternate). He came to the conclusion as a result of this study that the Huntingdon elm was a hybrid between *U. montana* and *U. glabra.* He also pointed out that like most first crosses the Huntingdon elm lent more to one parent than the other. When he examined the seed boxes of the "English elm" he found that none had germinated. On further examination of the parents many were found to have malformed flowers. He had no doubt that were it not for its ability to produce suckers the English Elm would have long since

disappeared. A further conclusion he drew from this study was that varieties were often simple Mendelian combinations of two existing species. Where only one species occurred no varieties of the kind so common to elms were present. He instanced beech (*F. sylvatica*) where all varieties can be classified as sports arising from some malformation or misdirection of growth in the individual plant e.g. copper beech, variegated beech. A similar situation exists for ash. (Henry 1910).

Henry was of the opinion that the variation within oaks was similar to that in the elm. where the number of species was large there was a correspondent increase in the number of varieties. This was particularly so in southern Europe where no less than 35 varieties of *Q. Ilex* occur. The position within the oaks was typified by the Lucombe oak which originated as a result of crossing Turkey oak (*Q. cerris*) by Cork oak (*Q. suber*) in 1768. The hybrid was found to be intermediate between both parents, being subevergreen. When seedlings of the Lucombe oak were raised a variety of forms developed, bearing a strong resemblence to what Henry had discovered with elms.

These investigations indicated to him the value of hybrids. He saw that the only hope for forestry was in the growing of timber rapidly. This could be achieved not only by the introduction of fast growing species but also by hybridisation for non-coniferous species. His awareness of the value of tree improvement can be guaged from the statement in his paper to the Linnean Society in 1910 when he advocated the use of tree breeding methods for the improvement of forest trees similar to that used by farmers and gardiners for centuries (Henry 1910).

While at Cambridge he continued to work on the "Trees" and by 1913, with the publication of the last volume, this mammoth task had been completed (Elwes and Henry 1913). In the same year he resigned his post at Cambridge and took up the first Chair of Forestry at Dublin. This appointment re-awakened his keen interest in Irish forestry. In a lecture to the Irish Forestry Society in October 1913 he again stressed the need for the correct choice of species. When he said "On the wise choice of trees for planting depends the continued success of the afforestation movement". However choice of correct species alone was not sufficient for success. Both Douglas fir and Sitka spruce have large distributions and on account of such require special study. His was the first pronouncement on the importance of correct provenance choice for Irish forestry. In relation to Douglas fir he stated that the coastal origins were superior in vigour to those growing in the mountains far inland. Furthermore, individuals of northern stations are not

so vigorous as those of southern stations. He proposed that "it might be worthwhile to establish, with the aid of the Governments of British Columbia and Washington State, seed collection stations under the supervision of a trained forester. The localities where vigour and good form of the different trees exist with considerable exposure to wind would serve as collection grounds for the seed to be used in raising plants for similar stations in Ireland. Of Sitka spruce he said that "with such a history no tree seems better adapted to the worst sites in our afforestation areas" (Henry 1913).

Hybridisation of species as a means of increasing production was always of great interest to Dr. Henry. Not satisfied with advocating their use he also took an active part in the production of new hybrids. His main object in this work was to show that novel and valuable trees could be artificially made, particularly with hardwood species. He recognised that the growth of pure species was so slow as to require long periods for their maturity and without vigorous crosses the most valuable classes of timber can only be grown in limited quantities. There was also the hope that immunity to disease might be increased by first crosses. As his work with elms had shown that "first crosses do not come true from seed" it was important that they could be reproduced vegetatively. This could be achieved by cuttings in the case of poplars and elms or by grafting where rooting was a problem. He attempted to ascertain the cause of hybrid vigour with the aid of Miss Marshall of T.C.D. She examined the growing points hybrid poplars and their parent species but could find no difference in size or chromosome number. He postulated the theory that it may be due to some enzyme and proposed that the enzymes of hyrids be injected into growing points of parent species to see if this would stimulate growth. Another possibility was the closeness of the relationship between the parent species. He discounted this latter theory as the hybrid *x P. generosa* was derived from two unrelated parents. The problem of creating hybrids was brought home forcibly to him in 1914 when flowers of *Juglans regia* which he had pollinated with pollen of *Juglans nigra* were killed by late spring frost. He also saw difficulty in obtaining pollen of suitable exotic species and it was for this reason that he proposed that much of this work should be carried out in more southerly stations. Nevertheless he pressed on with his own work in this field. In 1912 he pollinated *P. angulata (P. deltoides)* from Carolina with pollen of *P. trichocarpa* which produced four seedlings of excellent vigour. By the end of 1913 they had reached 1.1m in height growth and at age 7 years 11.3m tall. The hybrid was intermediate between parents with regard to width and colour of leaves. He named the hybrid *x P. generosa.* Though it was

remarkably rapid in growth it was not a commercial success because of its susceptibility to disease. Its main value today lies in its historical value as it was the first cross between a black and a balsam poplar (Henry 1914a).

On the same day he crossed *P. angulata (P. deltoides)* x *P. nigra betuifolia*, which yielded 7 seedlings. These were not as vigorous as the previous cross. Though it is not named, the hybrid is probably x *P. vernirubens*. He favoured working with poplars because they yielded seed within one year which allowed rapid evaluation of their merit. The genus Fraxinus was another genus which he felt could yield valuable hybrids. In 1912 he crossed *F. oregona* with *F. lanceolata*. This cross yielded twelve seedlings all of which were considered to be vigorous. The cross *F. oregona* x *F. excelsior* yielded no seed. *F. excelsior* x *F. americana* yielded five seedlings two of which were vigorous and three were weak. Unfortunately no record is available of their further development. All of the ash crosses were carried out at Kew.

A third genus with which Henry worked was that of *Alnus*. This was undertaken at Cambridge Botanic Gardens in 1911. In all four species were used in this work (1) *A. cordata* (2) *A. glutinosa var japonica* (3) *A. incana* and (4) *A. glutinosa europaea*. The yield of viable seedlings and their subsequent vigour depended on the parents. Of the crosses attempted only *A. cordata* x *A. incana* yielded progeny of interest. It was the first occasion on which this hybrid had been produced naturally or artifically as the five species do not grow together. In all instances yield of seedlings was low due either to late bagging or selfing. In the same year crosses were attempted within the genera *Ulmus* and *Larix*. With both genera, yield of seedlings was poor and no hybrid vigour was recorded. The *Fraxinus* crosses were repeated in 1913 at Kew but no record is available of their success. His work on hybridisation did not end when he moved to Dublin. In 1914 he was instrumental in having a number of crosses carried out at Avondale within a number of genera these being *Larix, Cupressus, Fraxinus, Fagus* and *Quercus*. Fruits were set but unfortunately no records exist to state if these crosses yielded viable seed (Henry 1914b).

Many natural hybrids have occurred in gardens and aboreta, when geographically distinct species are planted side by side. In the early part of the present century many such hybrids among broadleaves were recognised. Among conifers they were less frequent. Henry was one of the first to recognise that they could also occur in the coniferae when he wrote on the origins of *Larix pendula* (Henry 1916a). Delving into the history of planting at Peckham, where it was first recognised, Henry came to the conclusion that

it was a hybrid between *L. decidua* and *L. americana (L. laricina)* Bean 1950). The latter species had been introduced by Peter Collinson in the late 18th century. This particular hybrid was of no commercial value because of its lack of vigour. Seeds raised in Russia from *L. pendula* exhibited bizare, prostrate and pendulous forms. Henry was of the opinion that these were the results of mutation as a result of hybridity. In the course of his work with *L. pendula* he came to the conclusion that *L. Marschlinsi* was also a hybrid. The tree was first seen in the forest of Igis, Switzerland having been raised from seed collected from a *L. leptolepis*. Though not proven conclusively Dr. Henry was of the opinion that the male parent was *L. sibirica* (Henry 1915b).

His interest in hybrids was rewarded in 1919 when he positively identified the Dunkeld larch as being a hybrid between *L. leptolepis* and *L. decidua*. He used material supplied by Mr. Murray at Murthly and by Mr. Kerr at Dunkeld. His examination included both the macroscopic and microscope features of the possible hybrid. He saw a great future for this particular hybrid as "all known hybrids were remarkable for their great vigour and good health". In recognition of his work in the identification of this hybrid it bears his name *L. eurolepis, A Henry*. (Henry and Flood 1919b).

Throughout the "Trees of Great Britain and Ireland" there is constant reference to hybrids within each of the genera. Henry was not able to investigate all of these or to examine their history. One species, however, received his full attention, the species being *Plantanus acerifolia,* the London Plane. He was, originally of the opinion that it was not of hybrid origin. This opinion was to be changed in his paper on the history of the London plane. The occidental plane *(P. occidentalis)* was introduced to England in 1636 approximately a century after the oriental plane *(P. orientalis)*. This first record of a hybrid between the two species was made in 1700 by Plukenet at Oxford Botanic Gardens. As a result of these historical delvings he came to the conclusion that the species *P. acerifolia* was in fact a hybrid (Henry and Flood 1919a).

When speaking of commercial foresty Dr. Henry was always aware of the importance of the choice of the correct species and of the correct seed origin. This is clearly demonstrated in his submission to the 1908 Interdepartmental Commission on Forestry. He returned to the same theme in his paper on Douglas fir published in 1920 when he stated that the importance of a comparative study of *Pseudotsuga menziesii* and *Pseudotsuga glauca* is unquestionable. To prove his point he quoted Schlich as stating that Oregon Douglas fir at 12 years produce 1176 cubic ft/acre compared

with 206 cu.ft/acre for Colorado Douglas fir. Reference is also made to the susceptibility of the various species in this genus to frost exposure and unsuitable soil types (Henry and Flood 1920). A further genus in which he had taken a keen interest was that of *Larix*. In 1908 he advocated the use of *L. occidentalis* for peat sites and stated that he had carried out a collection in Montana and Idaho of seed of this species. The results of this collection and a further one in 1908 are reported in his paper on cultivation of Western larch. Growth was generally poor on a wide variety of site types and in addition mortality was high (Henry 1922).

His foresight and knowledge in tree breeding have long since been widely recognised. It is to be regretted that his pronouncement on choice of correct seed source for exotic species was not heeded more widely. If they had, many of the problems associated with incorrect choice would not have occurred, both in Ireland and world wide. Ernst J. Schreiner the famous American geneticist most aptly summed up his work when he stated "Augustine Henry was the first forester to realise the possibility of creating better forest trees by scientific breeding and he was the first forester to do something about it" (Schreiner 1949).

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The Tunnel Plough in Peatland Afforestation

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INTRODUCTION

Because of its cool moist climate, much of Ireland is covered by deposits of peat. These are known in Ireland as bogs or peatlands, and internationally as mires. There are two main classes of bog: raised bogs and blanket bogs. These have recently been mapped and described by Hammond (1979).

Raised bogs occur in undulating midland areas. Initiated as post-glacial lakes, they are now composed mainly of sphagnum and reach a thickness of 9m or more. These areas have been extensively developed for fuel production and pressure in that direction is increasing.

Blanket bogs occur on flat or undulating areas in the wetter parts of the country, down to sea-level along the west coast. Depth is variable, generally 2-3m but can be up to 6m. The main body of the peat is composed predominantly of the remains of *Molinia* grass and *Eriophorum* species with *Calluna vulgaris* and *Myrica gale* occurring locally (Hammond 1979).

The low level Atlantic type of blanket bog, occurring below 152m elevation and mainly in counties Galway, Mayo, Donegal, Kerry and Cork and the area of this type considered unmodified has been mapped by Hammond as covering 243,610ha.

The principal limitations in the use of peatlands for crop production have been waterlogging and infertility. The waterlogging is due to the gelatinous nature of the peat substance and its very low permeability, with hydraulic conductivity estimated by Galvin (1976) at about 10mm per day. Other data published by Galvin (1976) indicate that the air content of typical undrained blanket bog is less than 6%, whereas earlier work summarised by

Russell (1961) suggests that this should be at least 10% for the growth of various crops including trees.

A major attempt at peatland afforestation was made by the Government during the decade 1890-1900 on an area of about 400ha near the west coast at Knockboy in Co. Galway. This failed (O'Carroll 1962), but since drains in the deeper peat areas were 9m apart and from 0.9 to 1.8m deep (Schlich 1908) the failure was probably caused more by lack of fertiliser treatment than by water-logging.

An interesting plantation was established in 1952 in Cloosh Valley Forest, Co. Galway on a deep blanket bog which had previously been reclaimed for agriculture, but not intensively cropped. One of the basic elements of the reclamation technique was a system of drains of a traditional design, formed by excavating to a depth of 75cm, then constructing at the bottom an open channel of inverted sods, and refilling (O'Carroll 1962). The plantation outgrew contemporary plantations on adjacent virgin bog, but because of additions of gravel and fertilisers other than phosphorus on the reclaimed area its success cannot be simply ascribed to the deep drainage system. (The area was burned in 1976).

PLOUGHING

A comprehensive account of the development of ploughing techniques for pre-establishment drainage is given by Neustein (1976). First attempts in Wales and Scotland in the 1920s led to the development in the 1940s of a number of models built by Cuthbertson of Lanarkshire in Scotland. Two of these, the F (forestry) and the P (planting) were used in Ireland from 1951. The F model was a single mouldboard (SMB) plough designed to give drains 45-60cm deep and 50-90cm wide, while the P model, a double mouldboard (DMB) plough and that most widely used in preparation for planting in Ireland gave drains 20-30cm deep and 70-80cm wide. Similar ploughs were later manufactured by Clark of Parkgate, Drumfriesshire, Scotland.

Both these ploughs provided a drain to remove surface water and an elevated "ribbon" on which the young trees are normally planted. The ribbon is the continuous ridge of peat and its original vegetation, usually inverted, or sometimes turned on its side, which is removed by the plough and placed alongside the furrow drain at a distance determined by the design of the plough.

A new plough for peatland, later to be known as the tunnel plough[1] was designed and built at Glenamoy, Co. Mayo in the late

1 So named at the suggestion of Mr. H. M. Fitzpatrick of the Society of Irish Foresters, made during a demonstration of the plough to the Society at Glenamoy State Forest on 31st May 1960.

1950s (Armstrong *et al* 1960). This provided a closed drain similar in effect to the traditional sod drain already described, at a depth of about 75cm to the bottom of the drain. The first model gave a drain channel 38cm high and 20cm wide. The method of operation of this plough is shown is Figs. 1 and 2.

In 1960 the tunnel plough was incorporated into a formal experiment at Glenamoy Forest which forms the main basis of this paper. A further experiment with the tunnel plough was begun at Glenturk, part of Glenamoy forest, in 1967, and will also be reported briefly.

Fig. 1 Tunnel plough in operation at Glenamoy, Co. Mayo.

THE EXPERIMENT

GLENAMOY

This experiment was designed to achieve two objectives: first, to provide a direct comparison of the relative effects on tree growth of the Cuthbertson F (SMB) and P (DMB) ploughs, which were both then in widespread use; second, to compare the tunnel plough at various drain spacings with the standard open-furrow ploughs. The

two main tree species in use in peatlend afforestation, Sitka spruce(*Picea sitchensis* Bong., Carr) and lodgepole pine (*Pinus contorta* Douglas ex Loud.) were used in the experiment. The experimental treatments are summarised in Table 1.

Table 1 Glenamoy Experimental treatments

Plough	Furrow/Drain spacing*	Furrow depth
Cuthbertson P (DMB)	3.05m	28cm
Cuthbertson F (SMB)	1.52m	31cm
Tunnel	1.52m	n.m.
Tunnel	3.05m	n.m.
Tunnel	4.47m	n.m.

* Originally specified in feet. n.m. not measured.

The experiment is located in Glenamoy State Forest, Co. Mayo (Grid Ref. F8732) on peat 2.4m deep at an elevation of about 20m. The site has a slope of 2° and a north-east aspect. Vegetation before ploughing consisted predominantly of *Molinia caerulea* Moench., *Calluna vulgaris* Hull., *Erica tetralix* L., *Schoenus nigricans* L., *Eriophorum angustifolium* Honck., with occasional *Myrica gale* L. and *Scirpus caespitosus* L.

The site had been ploughed at 30m intervals in 1954 using a Cuthbertson B (bog) plough, DMB, producing furrows 1m deep. These had almost closed through horizontal subsidence of the peat when the experiment was established in October, 1960. The five ploughing treatments were combined factorially with the two species and the 10 combinations were replicated four times in randomised blocks. The plots were 27m squares (.073ha) located between the earlier 30m furrows.

The tunnel plough model used in this experiment had an intake orifice 37cm high and 28cm wide. The Cuthbertson ploughs were the standard models supplied at that time. The furrow depths given in Table 1 are the mean depths achieved in the experiment measured immediately after ploughing.

Planting took place in November, 1960 and was carried out either on the ribbons, or in the case of the wider tunnel treatments, on the ribbons and on mounds cut from the ribbons and spaced at 1.52m.

The Sitka spruce was raised from seed collected in Mountrath Forest, the lodgepole pine seed was from La Pine, Oregon, an inland source which would not now be acceptable in Ireland.

In the spring of 1961 each tree was given a spot application of ground rock phosphate, 57g to Sitka spruce and 43g to lodgepole pine, supplying 36 and 27kg P per ha respectively. In 1968, following a marked reduction in annual leader growth of the spruce, all plots were given a broadcast dressing of 90kg P and 125kg K per ha.

In 1973 observation of the soil water table was begun. Measurements were made in a series of boreholes lined with 70mm diameter slotted PVC drainage pipes. Six holes were bored in each Sitka spruce plot of two of the replicates.

In 1976 a number of root systems in each of the ploughing treatments were excavated and recorded by the method described by Carey and Barry (1975).

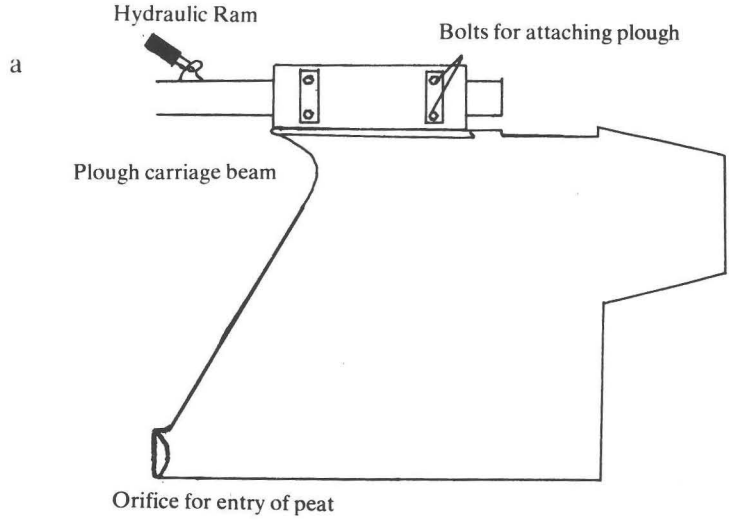
GLENTURK

The Glenturk experiment was begun in 1966 in order to gain further information on tunnel ploughing, which was by now showing promise in Glenamoy and had the obvious advantage of providing an unbroken forest floor, in comparison with the standard open-furrow techniques. A trial with lodgepole pine of coastal origin was also desired.

Glenturk is situated in Glenamoy State forest (Grid Ref. F8629). The site has an elevation of 15m and a slope of 1°. Vegetation was similar to that at Glenamoy but without the *Eriophorum* and *Scirpus*. Ploughing details are in Table 2. Plants were 1.52m along ribbons in the Cuthbertson plots and 1.82m along the ribbons and along the lines of mounds mid-way between each drain in the tunnel plots.

The ploughing treatments were replicated in four randomised blocks, with two plots of tunnel ploughing in each, so that the tunnel plough was replicated eight times and the Cuthbertson ploughs four times each. The ploughing plots, each 27.4 x 18.3m (0.05ha) were split equally for the two species. The seed origin for the Sitka spruce was Masset, Queen Charlotte Islands, British Columbia. The lodgepole pine derived from seed collected in a stand in Cloosh Valley Forest, Co. Galway which was from seed of unknown origin but believed to be from coastal Oregon or Washington.

Initial fertiliser treatment in the spring of 1967 was a spot application of ground rock phosphate supplying 36 and 18kg P per ha to the spruce and pine respectively. This was followed in



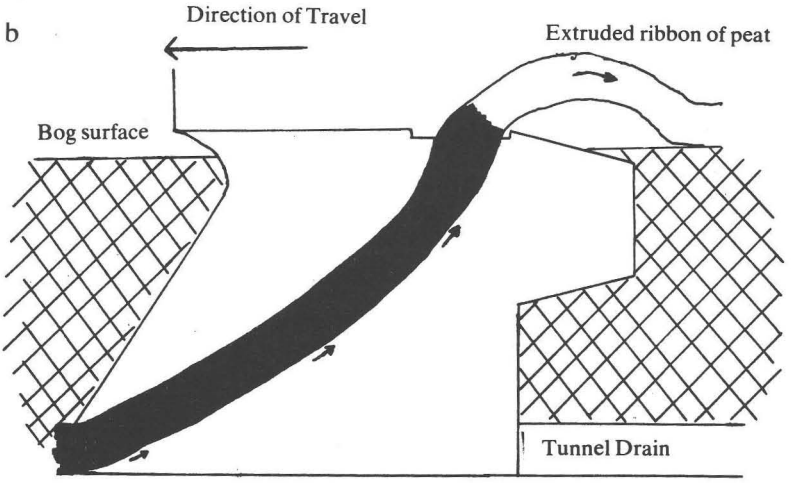


Fig. 2. a. Principal components of tunnel plough and b. Method of operation.

Table 2 Glenturk Experimental treatments

Plough	Furrow/Drain spacing	Depth
Cuthbertson P (DMB)	3.66m	30cm
Cutherbertson F (SMB)	1.82m	34cm
Tunnel	3.05m	n.m.

October, 1972 with a broadcast dressing which supplied 90kg P, 150kg K and 4kg Cu per ha.

A number of root systems in this experiment were excavated in 1978.

RESULTS

GROWTH: 1 GLENAMOY

Mean height of both species was assessed at three year intervals up to age 12. At age 15 mean height and breast height diameter of the Sitka spruce were measured, and these results are shown in Table 3. Results from the earlier assessments follow a very similar pattern to those shown in the table. In the variance analysis of the data at age 15 the following components of the treatments sum of squares were examined (cf Cochran & Cox, 1957):

1. Average Cuthbertson (SMB and DMB) *compared with* average of tunnel at 3 spacings.
2. Cuthbertson SMB *compared with* Cuthbertson DMB.
3. Linear effect of tunnel plough spacings.

There were no significant interactions between any of the ploughing components and species, so that the effects of the ploughing treatments are best estimated by the species means. The significant levels of the separate effects of the ploughing components are shown in Table 4.

2 GLENTURK

Mean heights of both species at age 12 are shown in Table 5. Because of the different replication of Cuthbertson and tunnel

Table 3 Glenamoy Mean height (m) of both species and diameter (cm) at breast height of Sitka spruce at age 15.

Ploughing	Mean height	DBH
DMB	6.1	9.3
SMB	5.7	8.2
Tunnel 1.5	5.7	9.0
Tunnel 3.0	5.2	8.7
Tunnel 4.6	4.4	6.2
S.E.	.40	.95
L.S.E. at 5%	1.2	2.9

ploughs separate standard errors must be calculated for their means, and it is not feasible to calculate simple least significant differences for comparison of the treatment means. The variation among ploughing treatments was significant. Use of the standard errors will show that the following significant differences occurred.

Sitka spruce: No significant difference.

Lodgepole pine: Cuthbertson ploughs not significantly different.

Tunnel significantly better than both.

Table 4 Glenamoy, F values of individual components of the ploughing effects in the assessment results shown in Table 3.

Component	Ht	DBH
Cuthbertson v tunnel (means)	4.72	1
SMB v DMB	1	1
Linear effect of tunnel spacing	5.38	4.34
Significant value 5%	4.75	

Any value in the body of table 5 greater than the corresponding significant value in the bottom line indicates that the component is significant at the 95% probability level.

Table 5 Glenturk, Mean height (m) at age 12.

Species	SS	LP
Ploughing		
DMB	2.46	5.12
SMB	2.48	5.05
Tunnel	2.44	5.54
S.E. (DMB SMB)	.110	
S.E. (Tunnel)	.078	

WATER TABLE LEVELS

Water level readings in the pipes at Glenamoy at fortnightly intervals since 1973 have shown those in the tunnel ploughing treatments to be consistently lower than in either of the Cuthbertson ploughing treatments (Fig. 3). The fluctuations in the water table level follow a seasonal pattern, with the lowest levels in July. the increased evapotranspiration by the crop during this period undoubtedly contributes to a further lowering of the water table. The overall means for the water table levels by treatment for the 1980 (Table 6) show conclusively the effect of tunnel ploughing on reducing the water-table depth. Rainfall data from the nearby Agricultural Institute field station for the same period also show a seasonal pattern with the minimum rainfall during the period April-May.

ROOTING STUDIES

Root excavations involved the digging of pits 3m long by 2m wide beside randomly selected trees so that one side of the pit approximately bisected the root system. At the Glenamoy experiment the Sitka spruce in the tunnel plots had a uniform radial distribution of root and the depth of rooting was greater than in either of the Cuthbertson ploughing treatments. Most of the larger roots in the latter treatments were confined to the ribbon. Occasional fine roots crossed the furrow bottom (Figs 4a and 4b). In the tunnel ploughing treatments prolific rooting to 60-65cms was common. At Glenturk the rooting pattern of the lodgepole pine was also affected by the ploughing treatment. In the Cuthbertson ploughing treatments most of the large roots (over 1cm diameter) were confined to the top 20cm of the ribbon. There were few

roots in the furrow bottoms. The tunnel ploughing treatments had roots growing to the bottom of the tunnel at 80cm depth and radial spread of surface roots was symmetrical. During both excavations the tunnel drains were located and though they had shrunk considerably (45cm^2 at Glenturk, compared with the original tunnel plough orifice of 1036cm^2) they are still discharging water to the cut-off drains.

Table 6 Mean water-table depth for 1980 (cm) at Glenamoy 16/61

		Treatment		
DMB	SMB	T1.5	T3.0	T4.5
38	43	80	78	55

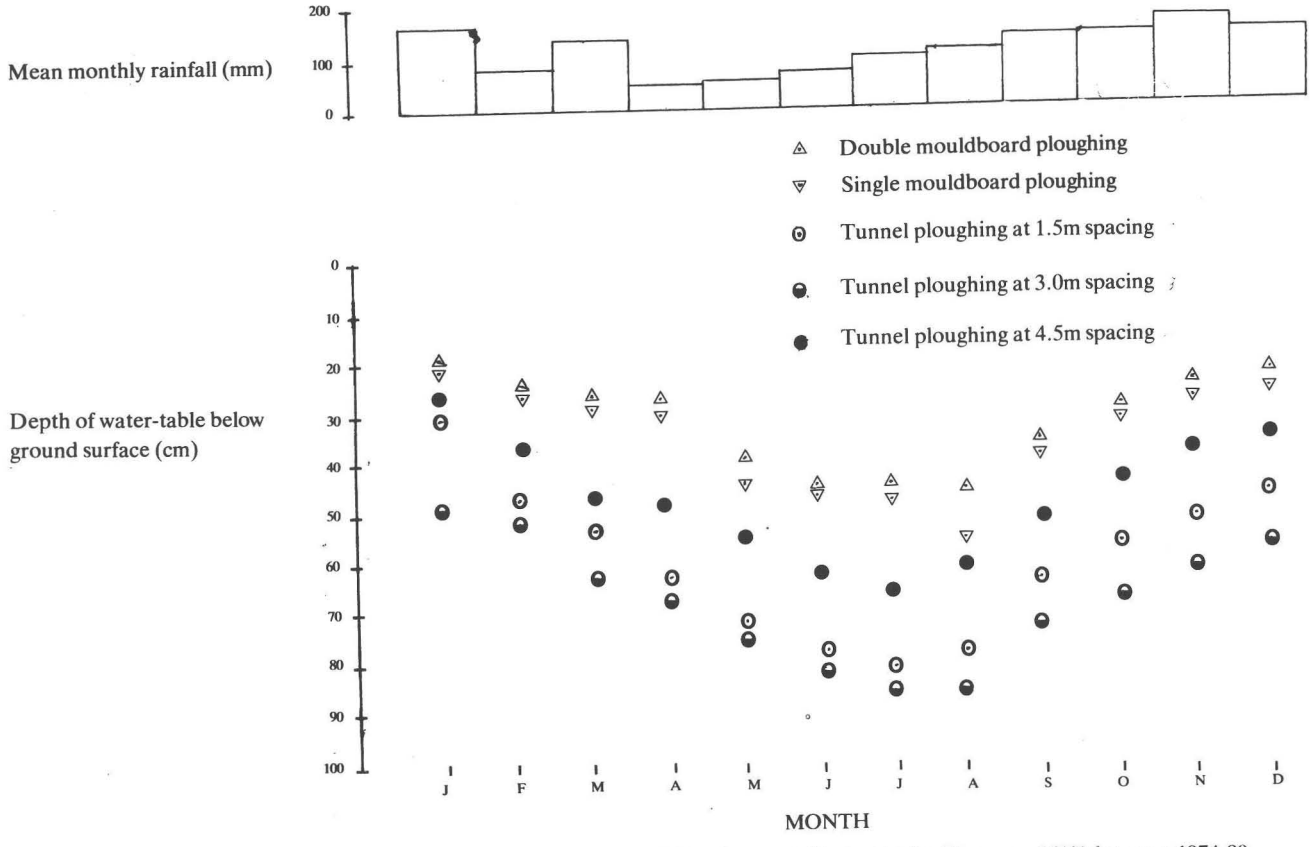
Standard error=3cm L.S.D. at 5%=6cm.

Effects on Peat

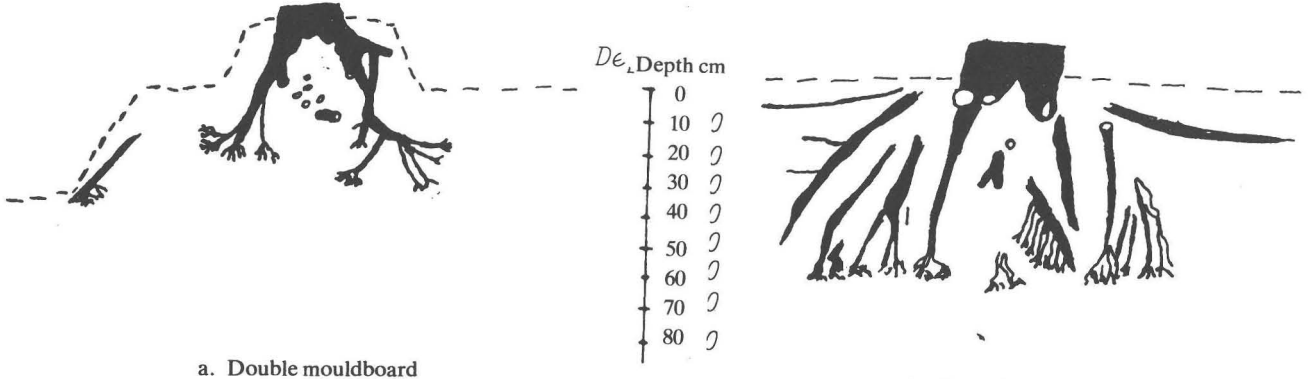
Samples for the measurement of peat physical properties reflecting the effects of two of the drainage treatments were collected in the Glenamoy experiment in late summer of 1977 by W. Burke, who has published the results in detail elsewhere (Burke 1978). Samples were taken at a range of depths in plots of SMB Cuthbertson and of tunnel at 1.52m Burke's data on air content and water content at the time of sampling are given in Table 7.

Table 7 Glenamoy. Air content and water content of peat in SMB and tunnel plots (both as % volume) as sampled in late summer 1977. Data from Burke (1978).

Sampling	water %		air %	
Depth (m)	SMB	Tunnel	SMB	Tunnel
.15	79.9	36.7	12.6	55.6
.30	89.6	54.0	4.3	36.5
.45	89.7	56.8	3.8	35.1
.60	91.5	75.1	2.5	17.1
.90	—	88.9	—	3.0



Average rainfall and water-table depths for Glenamoy 16/61 for years 1974-80



a. Double mouldboard

b. Tunnels at 1.5m.

Fig 4a & b. Typical root profiles of 15 year old Sitka spruce at Glenamoy 16/61.

Discussions and Conclusions

The present standard technique for forest establishment on peat is double mouldboard open furrow ploughing. This has proved to be satisfactory for early establishment and growth. Disadvantages of this technique now becoming apparent are the restriction of both horizontal and vertical root development which may give rise to relatively unstable crops and impedance of harvesting operations both by the elevated ribbons and the open furrows.

The experiments reported here show that the tunnel ploughing technique results in tree growth which is as good as or better than that following the present standard method, but it has the advantage that the lower water table (Fig. 3 and Table 6) and the better aeration (Table 7) encourage deeper root development. This, together with the more symmetrical habit permitted by the absence of open furrows and large ribbons is likely to result in more wind firm crops.

The absence of those furrows and ribbons also results in a more even forest floor leading to greater ease in harvesting operations. This is further enhanced by the uniform root spread, giving a greater load-bearing capacity to the peat surface.

The Glenamoy experiment suggests that tunnel drains spaced at 4.5m may be too far apart for optimum tree growth, and this question is now being investigated further.

Three tunnel ploughs are being used by the Forest and Wildlife Service at present. Large blocks have been successfully ploughed in counties Donegal, Mayo, Galway, Kerry, Cork and Offaly and it appears that the technique has widespread application on blanket bog peats deeper than about 1.5m provided that there is adequate slope to drain the water from the tunnels. It may also have some applicability in the preparation of road sites. There are some doubts at present as to its applicability on raised bog peats. It is intended to modify the plough design to make it suitable for shallower peats and two experiments examining tunnel plough spacing and planting position have been established in recent years.

Acknowledgements

Acknowledgement is due to Mr. P. J. O'Hare, formerly Officer-in-Charge at the Agricultural Institute's Peatland Experiment Station at Glenamoy, who provided the tunnel plough used in both experiments, and to the following who were involved as Research Foresters in various aspects of the fieldwork; W. F. Collins, M. Fordė, J. Freeman, M. P. G. Harbourne, T. Hunt and P. J. Lyons.

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COCHRAN, W. G. and COX, G. M. 1957. Experimental Designs. Second Edition John Wiley and Sons Inc. New York.

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Letter

Dear Sir,

In his excellent article on Lodgepole pine in Vol. 37 (1) of this journal, John O'Driscoll quotes Veitch's Manual of Coniferae (1881) for the origin of the botanical name *Pinus contorta* Douglas, suggesting that he got the specific name from the curious branch form of dead trees of this species near Klamath Lake, Oregon. We have Douglas's own view of the tree in his journal (Douglas, 1914). This publication is not easily available, but the description of the tree has been quoted again by John Davies (1980) in his recent book on David Douglas. From this it is quite clear that he had a very poor opinion of the coastal form of the tree, which grows on sand dunes and rocky bluffs near the mouth of the Columbia River. The form is certainly contorted there, partly due to exposure to coastal storms. It would seem more likely that this is the origin of the specific name.

What we cannot now discover is whether David Douglas recognised the inland forms, now known as var *latifolia* and var *murrayana*, as being even the same species. He was quite familiar with Jack pine, *P banksiana* Lambert, from his earlier travels in eastern Canada and perhaps thought that the straight-growing inland varieties of Lodgepole pine were of this species.

As far as I can ascertain, David Douglas never visited the Klamath Lake region, as his travels in Oregon never took him so far south east and when he later based himself in California he travelled mainly in the coastal region.

Another point of interest in J. O'Driscoll's paper concerns his estimate of the loss in value from the bowed stems of the southern coastal origins. It is useful to have this properly quantified and my only reservation is that in addition to the loss in marketable timber value, trees with swept butts are more liable to later damage from wind and snow. Studies or basal sweep in British provenance trials show that there is a good positive correlation between tree height and incidence of basal sweep across a wide range of seed origins.

The task of the forest manager is to select origins which balance adequate vigour with an acceptable level of basal sweep, at the same time trying to reduce sweep by cultural practices.

Yours faithfully,

Roger Lines,

Silviculturist (North), Forestry Commission,
Roslin, Midlothian, Scotland.

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J. J. Deasy 1916-1980

Joe Deasy entered Avondale Forestry School in February 1936 to pursue a course of studies and practical training in forestry. From the outset he showed more than an average grasp of the scientific aspects of the course and as for the effective practice of the essential details of forest farming he was second to none. During those early years his social leanings were very evident. "He mixed with Kings — but didn't lose the common touch".

On conclusion of the training period at Avondale Joe was selected for a special course of study in Germany, where he spent about a year gleaning the "forest lore", German style. On his return to Ireland he went to Avondale as Housemaster and then as Forester-in Charge to Enniscorthy area — later to return again to Avondale as Forester-in-Charge and Housemaster. He was promoted Assistant Nursery Inspector in 1950 later to become Grade II and subsequently Grade I with complete responsibility for the organisation and management of all State nurseries. In addition he was responsible for directing the operation of the amenity section of the forestry service. It was during this period that he made his most significant contribution to forestry — while he always believed that he was still learning.

Joe was a prominent member of the Society of Irish Foresters filling many offices on Council. His contributions to the Journal were simple and informative.

His promotion to the post of Senior Inspector was the final step in a career dedicated to the advancement of forestry. Let us hope that he has left some rewards of his research — they should be worth preserving for future generations interested in forestry.

To his wife Maura and the children we offer our deepest sympathy. As a family man Joe, as in all his work, was a perfectionist.

Ar Dheis Dé go raibh a Anam.

A Colleague.

A. W. Duggan 1918-1980

His many friends in the Department of Fisheries and Forestry and elsewhere were deeply shocked at the sudden death of Billy Duggan in November last. Billy had retired as Secretary of the Department in July having spent most of his official career in what is now Forest and Wildlife Service.

He came to the Forestry Division of the then Department of Lands as an Executive Officer in 1942 after a short period of service with the Office of Public Works. His distinguished career was to carry him to the rank of Assistant Secretary with responsibility for Forestry and Wildlife and ultimately to Secretary of the Department of Fisheries and Forestry. In the course of that career he was closely associated not only with the very important bread and butter aspects of State forestry but with the many innovations in the field of amenity and recreation, and with the extensions of the services functions to cover wildlife and game.

To his various assigments he brought a penetrating mind, backed by sound judgement. He had the ability to lead rather than push. He could disagree without rancour and debate without heat. I cannot recollect an occasion, in an association which spanned forty years, on which he lost his temper or found it necessary to raise his voice to make a point. His many fine qualities won him the respect of all his colleagues but it was a respect that extented to affection because Billy was above all a warm approachable and friendly man with a humane approach to the problems of others.

It came as no surprise to his colleagues that he was chosen as administrative head of the newly formed Department of Fisheries and Forestry or that he continued to full that post with distinction until his retirement in July 1980.

His many friends in the Society and the Department extend to his wife Mary and his children Eileen, Clodagh, Mary and John deepest sympathy at his passing.

Harry Sullivan.

Book Reviews

SOILS — Their formation, classification and distribution.

E. A. Fitzpatrick. Longman Group Ltd., London. 1980. £25 Stg.

This new book on SOILS has a subtitle "Their formation, classification and distribution" and the publisher's blurb claims that it is a completely rewritten new edition of "PEDOLOGY — a sysetmatic approach to Soil Science", published by Oliver & Boyd in 1971. Why Dr. Fitzpatrick's new publishers used a new (and somewhat misleading) title is not immediately apparent since this book contains very little on the edaphological aspects of soil science.

As a treatise on pedology this book is certainly very welcome and should grace the shelf of any professional who can afford the price. For his (her) outlay he (she) will get very well presented work with an enormous selection of line-drawings, maps and diagrams; a wide variety of monochrome photos of soilscapes, profiles and thin-sections (as well as some colour plates) and an up-date discourse on most aspects of pedology. It certainly fulfills its claim as a book prepared as an aid to teaching and will find appreciative users amongst graduates and undergraduates as well as teachers.

The first third of the book has a fairly standard presentation with chapters on the factors and processes of soil formation and on the properties of soils and their constituent horizons. Considerable attention is given to the micromorphological features of soils. The Fitzpatrick stamp is clearly seen in Chapter 5 on Nomenclature and Classification. He repeats and strengthens his 1971 rejection of the A/B/C system of horizon designation and hierarchical classification systems. He expands his own concept of soil designation formulae, introduces the concept of reference soil segments and provides a key to his own list of horizon names. Rather than hierarchical systems he still contends that the soil continuum is best divided into arbitrary segments and that the use of segment symbols to produce formulae for soils achieves almost unlimited versatility in designating soils and in producing an *an hoc* system of classification.

Chapter 6 (100 pages) gives a brief discussion of the major soil classes of the world including their subdivisions. The principal nomenclature is that of the F.A.O. and is augmented by U.S.D.A. and Fitzpatrick terms. Tables of approximate equivalents for various national systems (e.g. Australia, Brazil, Canada, France) are included and the general characteristics, field morphpology, analytical data, genesis, distribution and use of some of the major subclasses are given.

In his final chapter on soil relationships Dr. Fitzpatrick discusses relationships between soils and various factors of soil formation and the spatial variability of soils with the aid of maps, aerial photographs and schematic cross-sections. The book closes with appendices on soil minerals, soil horizons *a la* Fitzpatrick, a glossary of soil science terms, and a concise list of references.

This is a very well presented book, with good reproduction on high quality paper and should find favour with most readers. Whether those who already possess "PEDOLOGY" will regard the new material in "SOILS" worth the price is a debatable point; it should however be of great assistance to those who do not possess or have access to a modern treatise on Soil Science. Foresters whose main concept

of soils is that of "the natural medium for plant growth" will quickly realise, on reading this book, that the concept of soils as "a 3-D natural organised body" is equally tenable. Being written by a scientist who is as well acquainted with the natural habitat of many of our imported exotics as well as with soil-forming conditions on the Atlantic fringe of Europe, this book may be more appealing and applicable than others on the same topic.

J. F. Collins.

OTHER PUBLICATIONS RECEIVED

Institute of Terrestrial Ecology.

The Ecology of Even-Aged Plantations
(held over for review in next issue).

Annual Report 1979.

Forestry Commission, London.
Report on Forest Research, 1980.
Occasional Paper No. 7. *Establishment of Trees on Regraded Colliery Spoil Heaps.* 1980. Price (in U.K.) £1.00.
Research and Development Papers No. 129.
Chemically mediated behaviour in the Large Elm Beetle. 1979. Price (in U.K.) £1.50.

Stobart and Son Ltd., London.
Simmonds, Arthur. 1980. *Wide Bandsaws.* 224 pp. Price (in U.K.) £13.95.

Missing Issues of Journal.
The following issues of the Irish Forestry are needed to complete the Society's Collection: Volume 31, Nos. 1 and 2 and Volume 32, No. 2. If you have a copy of any of these which you do not wish to keep yourself, please contact the secretary. Your help will be very much apprecited.

Errata.
Growing space in Coniferous Crops, Supplement to Irish Forestry, Volume 37, No. 2.
Page 14, Paragraph 4 — "there is little effect of respacing" to read "there is lettle effect of spacing".
Page 29 — "Bartoli, m. 1971." To "Technique et Forêt." add "Rev. for. franç, 6: 605-608."
Page 32 — "Oswald and Pardé 1976." To Technique et Forêt." add "Rev. for. franç, 3: 185-192."
Page 95, Paragraph 4 — "can be expected to lower the optimum crop density" to read "can be expected to raise the optimum crop density."
Page 87, Figure 2 — x axis (spacing) should contain scale running from 0.9 to 3.6.
Page 86, Figure 1 — Broken lines should be labelled "1.2, 2.4, 3.6 in ascending order. Solid lines should be labelled with spacings given in Table 6, Page 85.

Society Activities

ANNUAL GENERAL MEETING 1981

COUNCIL REPORT FOR 1980

Council Meetings:

Six Council meetings were held during the year. Attendance of Councillors was as follows: J. O'Driscoll, J. Brosnan, E. Furlong, J. Prior, E. Hendrick (6); J. Dillon, E. P. Farrell, E. Joyce (5); J. J. Gardiner, P. McArdle (4); J. C. L. Phillips, C. Tottenham (3); J. K. Ellis, M. O'Brien (2); J. Kilbride (1).

Society Meetings:

A highly successful symposium on "Growing Space In Coniferous Crops" was held at Belfield, U.C.D. in March. Most of the papers presented were published as a supplement to Irish Forestry Vol. 37 No. 2. In September, Florence Court forest was the venue for a well attended field-day. To mark the fiftieth anniversary of the death of Augustine Henry a joint meeting arranged by the Society, the Society for the Bibliography of Natural History and the Forestry Group of the Agricultural Science Association was held at Belfield in November. Among those who read papers were Society members Dr. Jack Durand, H. M. Fitzpatrick and the President, John O'Driscoll. At the R.D.S. in December Dr. Michael Carey read a paper entitled "The Wonder Wood" — a critical look at plantation forestry in New Zealand, following a year spent with the Forest Research Institute there.

The Society expresses its thanks to those who acted as speakers and field leaders.

Annual Study Tour:

Over 80 members attended the Annual Study Tour held in the Midlands in June. Thanks for the success of the tour are due to Mr. Liam O'Flanagan, Tour leader, and all those who assisted with the organisation in conjunction with the Meetings Committee.

Guided Forest Walks:

Walks were held at 36 centres throughout the country on Sunday 14th September. Despite he petrol shortage and inclement weather over 4,000 people took part. The society wishes to thank Mr. John Fennessy who organised the walks 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 General Meeting:

The 38th Annual General Meeting was held at the R.D.S. on 27th March, 1980. The minutes are available in Irish Forestry Vol. 37, No. 1.

Society Publications:

Irish Forestry Vol. 37, Nos. 1 and 2 were published. A supplement to Vol. 37 (2) "Growing Space in Coniferour Crops" was also published. "Guided Forest Walks" and "Why Forests" were issued in connection with the Forest Walks. Work on the second and revised edition of "The Forests of Ireland" continues and is nearing completion.

Examinations:

One candidate passed the 1980 Forester's Certificate Examination with distinction. There were no candidates for the Preliminary Certificate. For the 1981 examinations three candidates for the Forester's Certificate and Eighteen candidates for the Preliminary Certificate have been accepted.

Elections:

The position of Business Editor for the period 1981-82 and three positions of Technical Councillor for the period 1981-83 were filled by election. Each of the remaining positions had only one candidate and they were, therefore, filled without election.

Membership:

Membership at the end of 1980 was as follows: Technical 516; Associate 124; Student 28; Total 668.

New Members elected during 1980 were as follows: Technical 16; Associate 7; Student 17; Total 40.

Signed: E. HENDRICK,
Hon. Secretary.

MINUTES OF THE 39th ANNUAL GENERAL MEETING

Thursday, 9th April 1981, Thomas Prior House, R.D.S., Dublin.

Attendance:

The President Mr. J. O'Driscoll in the Chair, present were J. K. Ellis; S. Milner; O. V. Mooney; T. Donohue; M. Doyle; J. Fennessy; J. Prior; E. Joyce; B. Moloney; P. M. Joyce; E. P. Farrell; J. J. Maher; F. Convery; J. J. Gardiner; J. Dillon; J. McEwan; L. Collen; E. Collen; C. S. Kilpatrick; J. C. L. Phillips; B. Wright; C. F. Tanner; J. Mackin; M. O'Brien; I. Booth; F. Mulloy; T. McEvoy; V. O'Connor; P. Carlin; J. Brosnan; L. Furlong and E. Hendrick.

Apologies were received from N. O'Carroll.

Presentation of Foresters Certificate:

The Foresters Certificate was presented to Mr. Michael Doyle by the President, Mr. O'Driscoll, who congratulated him on his success at the certificate examination.

Secretary's Business:

The minutes of the 38th Annual General Meeting having been published in Irish Forestry 38 (1) were taken as read and signed. The Council Report for 1980 was read. In reply to Mr. Mooney, Dr. Farrell stated that some of the papers presented at the Henry anniversary meeting will be published in Irish Forestry. Mr. McEvoy suggested that the Council report could also deal with Council activities which do not appear in the report. The President thought this suggestion worthwhile and undertook to consider it during the drafting of the 1981 report. He went on to outline progress made in "The Forests of Ireland". Dr. O'Carroll had informed him that both Forest Services had given permission for publication of articles by their staff. Some minor editing remained and he hoped to have it with the publisher within a month. The adoption of the 1980 council Report was proposed by Mr. T. McEvoy and seconded by Mr. J. J. Maher.

Abstract of Accounts:

The treasurer discussed some points in the Abstract previously circulated. The large increase in V.A.T. for 1980 was because it was now being billed separately by the publisher. Postal charges had increased considerably in 1980 because the postal strike in 1979 had reduced postage. An account for members in the sterling area had been opened in Northern Ireland.

The question of alternative investments for Society monies was raised by Mr. O. V. Mooney. The President replied that the Council had investigated the matter thoroughly during the past year. On advice from the Treasurer they had decided to transfer most of the money in the E.B.S. account into the bank deposit account, which had a higher interest rate. The Treasurer had examined the possibility of opening an account with a commercial bank; because of the necessity of ready access to funds to pay outstanding bills this would have to be a notice account. Interest rates on this type of account would not be appreciably different from a deposit account. Adoption of the 1981 Abstract of Accounts was proposed by Mr. Mooney and seconded by Mr. F. Mulloy.

Confirmation of Elections:

The meeting confirmed the 1981 Council election as follows: President, J. O'Driscoll; Vice-President, J. C. L. Phillips; Hon. Secretary, E. Hendrick; Hon. Treasurer, J. Brosnan; Editor, E. P. Farrell; Business Editor, J. Fennessy; Hon. Auditor, W. H. Jack; Technical Councillors, J. P. Connelly, J. J. Gardiner and P. McArdle; Associate Councillors, P. Glennon; Northern Regional Group Representative, C. F. Farmer.

The President thanked the outgoing members of Council for their work on behalf of the Society.

Council Proposal for Membership Fee Increase:

The Treasurer circulated a submission in which he outlined a proposal for an increase in fees; from £4.00 to £10.00 for Technical members, from £3.50 to £9.00 for Associate members and from £2.00 to £5.00 for Student members. The submission outlined the reasons for seeking the increase as follows. The total publication costs for 1980 debited to the 1981 accounts were £3,984.20 including the cost of publishing the supplement to Vol. 37 (2). When the current amount of monies held by the Society was taken into account this left a balance of £853.00 to go towards an anticipated 1981 deficit. Payment of these bills removed the large surplus of money held by the Society. The cost of Society activities had risen almost two and a half times since the last subscription increase in 1977. Annual running costs were increasing relative to receipts and in 1979 and 1980 there was a combined deficit of more than £1,000.00 over receipts for the same period. The projected increase in costs for 1981 and 1982 would be met if the increase was agreed but there would be little to spare. The Treasurer emphasised that the increase was the minimum necessary to sustain the Society's activities at their present high standard. At this point the president opened the proposal to the floor. A full and lengthy discussion on the proposal took place. Most speakers agreed with the proposal and some asked for a greater increase considering the likely level of inflation in the years ahead. The Treasurer felt, however, that this increase would last for several years and was against a greater increase. Discussion on the cost of producing the journal took place. It was agreed that the Business Editor should examine the economics of printing advertisements in the journal, as there were suggestions that they were costing more to print than was received from the advertisers. The Editor, Dr. Farrell pointed out that the last issue of the Journal had 68 pages of text of which 20 pages were Society activities. He agreed that there should be a record of Society activities but thought they could be reduced in size. Mr. McEvoy agreed that the increase was

SOCIETY OF IRISH FORESTERS — STATEMENT OF ACCOUNTS FOR YEAR ENDED 31st DECEMBER, 1980

1979	RECEIPTS		1980
5,977.69	*To Balance from Last Account*		5,786.75
	Subscriptions Received		
	Technical 1980	1,849.30	
	Technical 1979	118.66	
	Associate 1980	384.25	
	Associate 1979	19.00	
	Student 1980	58.50	
	Student 1979	4.00	
	Other Arrears	4.00	
	Advance Payments	191.75	
2,465.07			2,629.46
	Interest on Investments		
	Dublin Corporation Stock 9¾%	20.11	
	Savings Account	231.04	
	Educational Building Society	293.86	
546.77			545.01
	Journal		
	Sales	135.31	
636.96	Advertising	1,361.23	1,496.54
2,439.70	*Forest Walks inc. donation*		2,235.00
45.00	*Examination Fees*		100.00
7.00	*Miscellaneous*		9.02
12,118.19			**12,801.78**

1979	PAYMENTS		1980
45.40	*Stationery and Printing*		35.28
2,467.10	*Printing of Journals*		3,244.60
496.18	*Postage*		767.22
109.14	*Expenses re Meetings:*		101.52
3.28	*Refund*		—
4.50	*Bank Charges*		61.00
484.45	*Secretarial Expenses*		822.96
106.69	*Value Added Tax*		504.48
50.00	*Examination Expenses*		71.80
	Honoraria:		
	Secretary	30.00	
	Treasurer	30.00	
	Editor	30.00	
	Business Editor	30.00	
120.00			120.00
2,444.70	*Forest Walks*		2,235.20
	Balance:		
	Current Accounts	83.86	
	Savings	1,150.88	
	Educational Building Society	3,602.98	
5,786.75			4,837.72
12,118.19			**12,801.78**

I have examined the above accounts, have compared it with vouchers, and certify same to be correct, the balance to credit being £4,837.72 which is held in current and savings accounts at the Ulster Bank, and in the Educational Building Society. There is also a holding of £206.19, in the Dublin Corporation 9¾% 1981-83 Stock and £100.00 in Prize Bonds.

Dated: February 17th, 1981

Signed: W. H. Jack, Hon. Auditor

necessary and thought the subscription rates for Technical and Associate members should be made the same. He felt that both categories had virtually the same rights apart from the latter not being able to hold officer posts on the Council. Mr. Collen agreed and felt that Associate members would not object to the increase. Mr. McEvoy then moved a formal proposal, amending the Council proposal as follows: "From 1982 onwards the Technical and Associate membership fee be increased to £10.00 and the Student membership fee to £5.00". This proposal was agreed unanimously.

Other Business:

Mr. McEvoy mentioned that there had been some overlapping of subjects required for Society's examinations. He suggested that a revision of the examination syllabus and recommended reading was needed. Mr. Dillon reminded the meeting that the Annual Study Tour was going ahead in late May. It would be based in Sligo and would have the silviculture of wet mineral soils as its theme. In concluding the meeting the President thanked all those who had attended, especially those who had travelled long distances. The meeting finished at 10 p.m.

39th ANNUAL STUDY TOUR 1981

SLIGO/FERMANAGH/LEITRIM

Tuesday, May 26th — Lough Gill Forest

Pat Finnerty, Divisional Inspector; Pat O'Malley, District Inspector; Tommy Gallen, Forester.

Carns Property. It is intended to replant a YC 22 Sitka spruce stand at present being clearfelled with ash, because it is considered aesthetically more desirable than spruce in this amenity area and because it meets a requirement for hurley ash. While it was agreed that on economic grounds Sitka spruce must be the first choice, the other considerations were felt by most to be overriding on this site.

The party travelled by lake cruiser on Lough Gill to the second stop, Killerry Property. The question faced here was the treatment of a P/61, YC 10 Lodgepole pine stand of inland provenance. The stand had not been thinned and the management decision was not to thin because of silvicultural (post thinning invasion of ground vegetation) and economic factors. Many took the view, however, that as crop form was very good and quality Lodgepole sawlog an attractive product, a strong argument could be made for selecting the main crop now and following a policy of thinning and high prunning.

Dromahair Forest

Michael O'Brien, Forester.

Tullinawannia Property. Thinning had been unavoidably delayed and was several years overdue in a P/60, YC 27 Sitka stand at present being thinned for the first time. The decision to thin now was a gamble particularly as the soil was a peaty gley. Extraction alternatives, cable and horse, were seen and discussed. While direct comparision of costs was not possible, horse extraction is attractive for small size material over 100-150mm. It causes more crop damage than skidding but less than cable. Cable extraction costs were discussed at length and the high cost of using obsolete equipment in this area of rapid technological advance stressed.

Lough Gill Forest

Diffreen Property. Thinning is at present in progress on a P/52, YC 26 Sitka spruce stand on a gleyed soil. This is considered a high-risk windblow area and the wisdom of thinning seven years before clearfelling was questioned both on silvicultural and economic grounds. The vulnerability of this fine textured gley to traffic damage was pointed out and the suggestion made that cable systems might have to be used on such sites in the future.

Wednesday, May 27th — Ballintempo Forest

Cecil Kilpatrick, Chief Forest Officer; John Phillips, Regional Officer West; Bill Wright, District Forest Officer; Pat Carlin, Head Forester; Dave Dickson, Chemical Research Division, Department of Agriculture; Stan Milner, Forest Research Officer.

Nutritional Requirements of Sitka Spruce. In addition to phosphate, Sitka spruce on high-level blanket peat, such as at Ballintempo has shown a requirement for nitrogen. In the experiment we visited, Yield Class of the P/63 crop was 12 without added nitrogen whereas with nitrogen it was 16. Two sources of P were compared, coarse rock phosphate which up to 10 years after planting was the more effective form and basic slag which in recent years has given superior growth even without nitrogen.

Respacing trial on Sitka spruce. Where a decision has been taken not to thin because of high windthrow risk, respacing is seen as an attractive alternative. The advantages of reducing stem density to 1500 to 2000 stems per ha are to give a larger mean tree attracting a higher price, to reduce felling and extraction costs and to offset the problem of dealing with dead trees, the result of self thinning at clearfelling. Pruning was not envisaged in respaced stands. The opinion was expressed that the respacing was not sufficiently drastic to increase mean tree size significantly. The possibility of following the respacing with a thinning to waste was suggested.

Lodgepole pine provenance trial. Nine provenances are being tested in this trial established in 1964. Performance measured in terms of mean height and basal sweep showed that the south coastal provenances had both the best growth and by far the highest incidence of basal sweep. The discussion was wide ranging covering the question of whether Lodgepole or Sitka was the best choice of species on such sites, the likelihood that the basal sweep problem could be lessened by better nursery and planting techniques and the possibility that a satisfactory main crop could be selected from the trees not affected by basal sweep.

Drainage/ploughing experiment: Drain depth, and spacing treatments were superimposed on SMB and DMB ploughing in this experiment. Deep SMB ploughing was almost as good as the most intensive drainage treatment. It was suggested in discussion that the effect of drainage was shortlived and that nitrogen application would probably be more cost effective.

Cultivation and liming experiment: This experiment while it was only established in 1977 generated a useful discussion. It represents an innovative approach to site preparation in an effort to find the best means of minimising two major problems on deep, oligotrophic peats, nitrogen deficiency and stability. DMB, SMB and tunnel ploughing are being tested in combination with liming and rotovation. Discussion covered the importance of lime incorporation, the merits of disc harrowing in place of rotovation and the long term value of liming for site improvement and nitrogen mineralisation.

Thursday, May 28th — Ballyfarnon Forest

D. M. O'sullivan, District Inspector; Tony Mannion, Assistant District Inspector;

Michael Donnelly, Forester in Charge; Eugene Hendrick, Research Inspector; Joe Freeman, Research Forester.

Cultivation of gley soils: This experiment was established in 1975 on an abandoned drumlin farm. The soil is a surfacewater gley with a stony subsoil which makes moling ineffective. Growth differences under a range of cultivation treatments are small, as yet. If it gives satisfactory growth, ripping would be the preferred treatment. It gives an unbroken ground surface which should increase stability and ease of extraction. However, grass cleaning, which is minimal under doublemouldboard ploughing assumes greater importance with the ripping treatment.

A brief lunchtime stop was made at Lough Key Forest Park where the group heard an account of the development of the park.

Drumhierny. Estate of Mr. A. O'Rahilly.

Professor Clear; Ted Lynch, Research Inspector.

The influence of wide spacing on volume producion and timber quality in a highly productive Sitka spruce stand was examined. The YC 26-30 stand was established in 1950 at an effective spacing of 2.6 x 2.6m. Standing volume is now 614m^3 of which 86% is sawlog material as compared with 439m^3 and 62% sawlog in the nearest equivalent stand (YC 24) in the Forestry Commission tables. Published Forestry Commission management tables are not appropriate for application to the spacing and thinning regimes practised in such stands nor is the range of yield classes quoted adequate. Grading rules and even the concept of stress grading were criticised also. The stability of this stand established on a gley soil without any mechanical site preparation was commented on and the suggestion made that it might be attributed to the initial wide spacing and the fact that thinnings when carried out were light.

Arigna Valley

Jerome Dufficy, John Duffy, Acquisition Officers.

A brief discussion was held on the problems of acquisition in the district.

The Society's Annual Dinner was held in the Sligo Park Hotel.

Ted Farrell.

STUDY TOUR PARTICIPANTS

*Lyal Collen, *Effie Collen, Donal Crowley, Jim Dillon, Jim Dooley, Joe Doyle, Michael Doyle, Declan Egan, Jim Fanning, Dr. Ted Farrell, John Fennessy, Mel Friel, Lily Furlong,Dr. Jack Gardiner, P. J. Lehane, John Madden, Jim Maguire, *Frank Moran, *Brid Morrissey, Thomas Murphy, Michael O'Brien, John O'Driscoll, Brendan O'Neill, Con O'Shea, Denis O'Sullivan, Tom Quinn, Brendan Riney, *Henry Sisk, *Jane Tottenham *Robert Tottenham, Cornelius Warren, George Beirne, Michael Burke, Charlie Crowley, Jim Crowley, Noel Cullinan, Gerry Cunningham, Tony Daly, Michael Donnelly, Pat Doolan, Frank Drea, John Duane, Jim Feenay, Tony Finnerty, Pat Finnerty, Noel Foley, Joe Freeman, John Hanley, John Harte, John Haughey, Pat Helbert, John Hogan, *Brian Hussey, Tim Hynes, Kevin Hutchinson, Richard Jack, Christy Jeffers, Barry Lambe, Eamonn Larkin, P. J. Lyons, Tony Mannion, G. Mawn, Geoffrey Michael, John Murren, Paddy McEneaney, Joe McEvey, John McLoughlin, Thady McTernan, James O'Connor, Seamus O'Domhnaill, Jim O'Dowd, Rory O'Driscoll, Tim O'Regan, John Phillips, John Regan, Martin Ruane, Frank Rushe, Nicholas Ryan, John Higgins, Michael Ward, Pat White, Sean White. — **Associate Member.*

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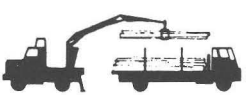
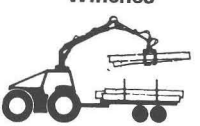


Loaders



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Roundup can be used pre-plant all species to control most broad-leaved grass and woody weeds. It may also be applied post-planting of some fir and spruce species offering a high level of tolerance when applied overall to young conifers after shoot elongation.

Pre-plant treatment

Roundup can be applied whenever growth and weather conditions allow. Woody weeds, heather and bracken are best treated in full leaf frond, usually between mid July-mid August.

Growing season

During spring and early summer apply with a well directed Knapsack Sprayer. A tree guard is essential to protect new tree growth.

Tree species tolerant to Roundup

Corsican Pine, Lodgepole Pine, Sitka spruce, Norway spruce.
Douglas fir may be treated in the late summer months but avoid early spring treatments when buds are swollen. Japanese larch may only be treated during the autumn and winter.

Post-plant Treatment: Dormant season

Overall application may be made to conifers tolerant to Roundup from August until the end of February.

Caution: Growing season and Lammas growth season

Roundup must not come into contact with trees during the growing and Lammas growth season. Treatment may commence when all extension growth has ceased.

Forestry in Lowland

	Rate	Water Volume	Timing
Grass weeds Broad-leaved weeds	1.5 l/ha	Rotary Atomiser 10-20 l/ha Mistblower 90-175 l/ha Knapsack Sprayer 200-300 l/ha	Grasses year round with 10-15cm leaf growth Broad-leaved weeds at full leaf or after flowering
Bracken Heather	3.0 l/ha	Rotary Atomiser 10- 0 l/ha Mistblower 90-175 l/ha Knapsack Sprayer 200-300 l/ha	Mid July to end of August

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