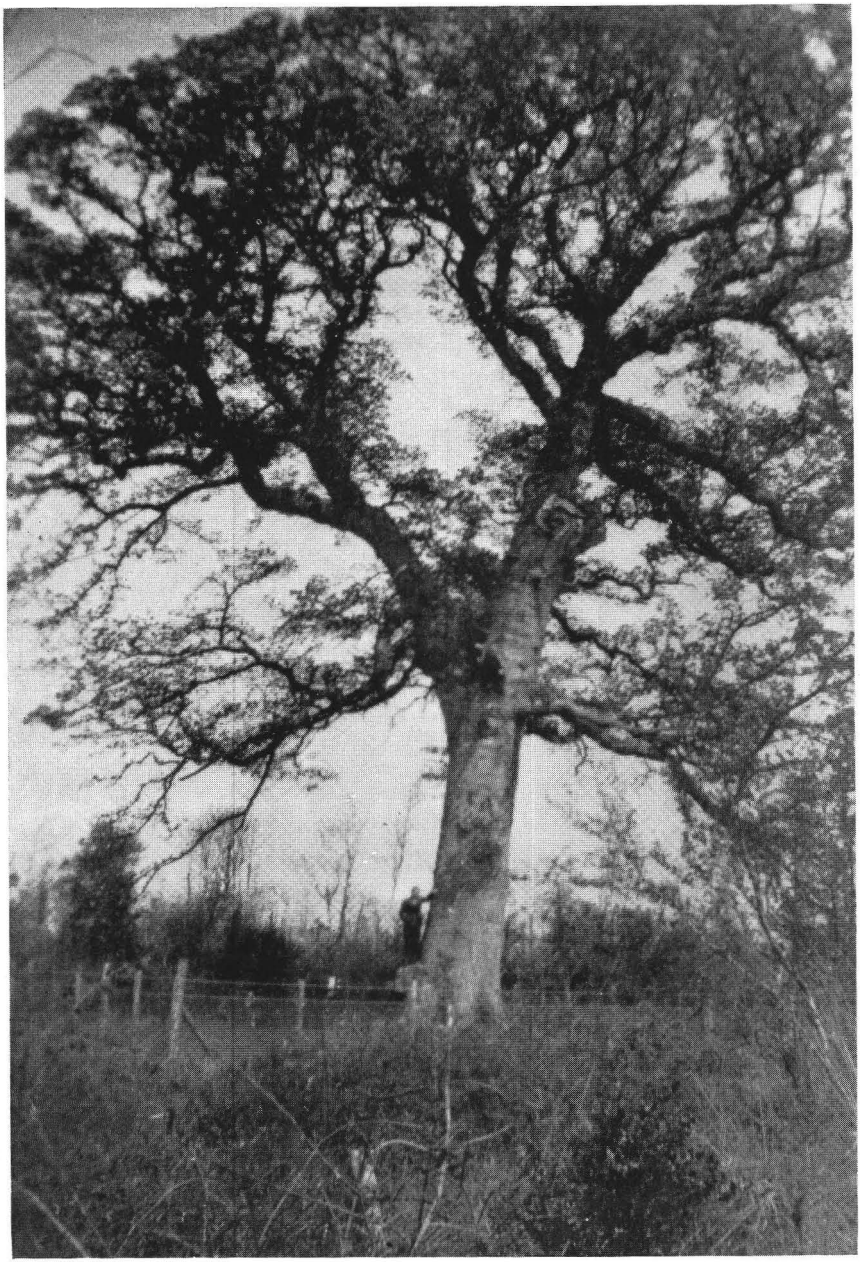
IRISH FORESTRY



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IRISH FORESTRY

VOLUME XI WINTER NUMBER 2

THE HEATHLAND NURSERY

By JAMES MACDONALD

DURING recent years a new kind of nursery for the production of forest planting stock has been developed in Great Britain. It is known as the " Heathland Nursery." It has obtained this name because the soils which are most suitable are characterized by the presence of a heathland vegetation. Heathland nurseries have two great advantages over nurseries of the traditional type. The first is that, given the right treatment, they can produce seedlings of conifers which are large enough to lift and handle at the end of the first year as against the two, and sometimes three, years which are usually required in normal nursery practice. This means a substantial saving. The second is that the heathland nursery, if properly sited and managed, remains remarkably free from weeds for a considerable time, thus saving the costs of weeding, which are often substantial. It must be admitted, however, that the development of modern methods of weed control with oils and spirit is making this advantage less weighty than it used to be.

The principal disadvantage of the heathland nursery is the relative scarcity of suitable sites, taking Great Britain as a whole. The other disadvantage is that, if for any reason, climate, late sowing, faulty technique, the seedlings are too small to lift at the end of the first season, and have to be left in the beds, then growth in the second year is usually so enormous that they cannot be used either for lining out or for planting. Fortunately, this is an event which very rarely occurs.

Generally speaking, the advantages of this type of nursery so greatly outweigh the disadvantages at the present time that it can be safely recommended for raising seedlings provided the conditions are suitable. Research into the nutritional requirements of young conifers has not yet progressed sufficiently far to offer any security that plants of equivalent size and quality can be produced wholesale in nurseries of the normal type; if this became possible the greater convenience of a more centralized nursery of the usual character could offset some of the advantages of the heathland nursery.

Although the most striking results in heathland nurseries are obtained with conifers these nurseries give excellent results with a wide range of broad-leaved species. They can also be used successfully for lining-out but the usual practice is to line the heathland seedlings out in normal nursery ground where they generally give good results, and confine the heathland nursery to the production of seedlings.

The technique of raising young forest trees in heathland nurseries was first worked out by the late Dr. M. C. Rayner at Wareham, in Dorset, where her new methods produced spectacular results on the dry, infertile heaths of that district. An essential feature of her practice was the siting of the nursery on land which had not previously been subjected to cultivation. The methods now in use in heathland nurseries all over the country follow closely those which were evolved by Dr. Rayner at Wareham, though in course of time various modifications have been introduced. The success of a heathland nursery depends in the main on careful choice of site and close attention to the details of technique.

Choice of Site

A site for a heathland nursery should be sought on uncultivated land on which vegetation is composed mainly of plants such as *Calluna vulgaris*, *Erica cinerea*, *Vaccinium myrtillus*. A moderate admixture in the vegetation of *Molinia caerulea* or of *Deschampsia flexuosa* would not rule out the site, but one must be careful about grasses, which are apt to seed themselves after the land has been prepared, and very grassy sites should be rejected. A thin distribution of bracken over the ground may be accepted but any sign of vigorous bracken growth is an indication of unsuitability.

Vegetation of this kind is usually associated with a layer of peaty raw-humus or peat on the surface of the mineral soil and, provided this layer is no more than four inches deep, there is every advantage in its presence. Soils under this covering may vary in texture but, for a heathland nursery, it is advisable to select a soil which is light and sandy and with a low silt content. It should be deep and well-drained. These soils are acid in reaction, which is an advantage for conifers, the upper layers are generally bleached and there is sometimes a hard iron pan beneath the bleached layer. When this is present it must be broken by subsoiling because it interferes with the natural drainage. Ground with a hard pan is frequently very wet in the winter when water accumulates and lies on the surface. It is important, therefore, to examine the site care-carefully during the winter before any work is done; one can be badly misled by the appearance of the ground in the height of summer.

If the upper layers of the soil have an appreciable content of humus matter so much the better; small stones and gravel do not normally cause inconvenience but large stones or flints in the upper layers of the soil are apt to be troublesome as they make it difficult to obtain a good tilth for sowing.

It is preferable to plan the heathland nursery on a slight slope which will assist drainage but level ground on a freely-draining subsoil has proved perfectly satisfactory. Steep slopes, on the other hand, should be avoided on account of the risk of surface wash when heavy rains occur. Sites which are obvious frost hollows should not

be selected; the topography of the land should allow cold air to drain away freely.

Although some heathland nurseries have been established in exposed situations there is no doubt that their performance is greatly improved by shelter. The best, and usually the most convenient, form of shelter is that provided by adjoining or surrounding plantations. Good heathland nurseries have often been made in forest rides but narrow rides should be used only if the plantations on either side are still small. Successful heathland nurseries have been made on woodland sites which carried crops of young trees up to a small pole stage. The roots of small trees can be extracted from the soil without too much disturbance or without bringing up the subsoil. A convenient way of doing this is to leave high stumps when cutting the trees and then to use a bulldozer with the blade set clear of the ground, to push the stumps out of the soil. Little soil disturbance results if the trees are small and the roots come out cleanly.

It is otherwise with large trees the stumps of which cannot be removed without considerable disturbance and experience has shown that nurseries formed on woodland sites on which large trees were present are always very patchy in performance. Seedling growth is usually poor on and round the sites of the old stumps. Woodland of this kind is not recommended for heathland nurseries.

The size of the nursery will depend on the quantities of plants which it is desired to raise but care must be taken lest pieces of unsuitable ground are included mainly to give the area required. It pays to confine the work to really suitable land and it is better to find the necessary area in two separate blocks than to attempt to form one nursery on land which is partly suitable and partly unsuitable.

The nursery should, if possible, be conveniently placed for labour and for supervision, and a supply of water is a great advantage.

The site selected should be reasonably close to a hard road but main roads, with fast-moving traffic, are apt to spread those weeds the seeds of which are airborne. Since one of the great advantages of the heathland nursery is freedom from weeds, the site chosen should not be liable to ready invasion from adjoining land.

Preparation of the Site

To prepare the land for use as a nursery it is necessary first to remove its existing plant cover and then to work the soil to a satisfactory tilth. In carrying out these operations certain important points must be kept in mind. Shallow cultivation is essential; the subsoil must not be brought to the surface; the humus content of the soil and the litter should be conserved as far as possible. These requirements rule out the use of deep-going cultivators while bulldozers or similar machines should not be employed to remove the vegetation (other than small tree-stumps) because they are apt to

remove the humus-bearing layers of the soil. Small areas can be prepared by hand-digging, but for areas of any size it is more convenient to use tractor-drawn implements.

If there is a dense growth of rank or strong heather this should either be burnt off or cut with a scythe or mowing machine and removed from the ground. If heather or other vegetation is short it is normally destroyed by the processes of cultivation.

The next step is to break the surface mat of heather, peat, etc. and for this the most suitable implement is a heavy rotary cultivator. This cultivation must be thoroughly done, preferably in dry weather, so that the peat and other matter can be broken up into fine fragments. The heavier, coarse root material and other debris which resists breaking up should be raked off by means of a tine harrow which drags it to one side. These two operations should completely destroy the surface vegetation, reducing part of it so that it is incorporated in the soil and removing the remainder which has proved intractable.

Subsoiling, if necessary to break a hard pan, should be done at this stage. The subsoiler should be run through the soil at two-foot intervals.

The ground should next be ploughed. Here care must be taken not to go too deep nor to bring up any subsoil. A depth of five inches is adequate. The land is then cross-ploughed and the fine tilth produced by a disc harrow.

By this cultivation the land should be brought into the same physical condition as one would expect to find in a nursery of the normal kind on a similar soil. It is important to leave ample time for the operations and in order to get a site ready for spring sowing the first cultivation should be started not later than the preceding December.

Manuring of Seed-beds

In Rayner's classical work at Wareham great use was made of composts which were applied to seed-beds at the rate of twenty tons per acre, a very heavy application indeed. Various materials were used in the manufacture of the composts but Rayner finally used, as her standard, a compost made from bracken and hop waste which was extremely effective in promoting the growth of large seedlings. When heathland nurseries, on the Wareham pattern began to be developed in other parts of Great Britain, the compost treatment was naturally followed but it was soon discovered that raw hop waste, uncomposted, gave equally good results when fortified by the addition of fertilisers, while it was found, experimentally, that fertilisers alone, if used in adequate quantities, could give most excellent results. It was thought, originally, that composts, in addition to providing nutrients, encouraged the development of mycorrhiza but recent research has shown that not all compost-grown seedlings are furnished with mycorrhiza, while plants grown

with chemical fertilisers alone have been found with complete mycorrhizal equipment. It appears, therefore, to be almost certain that the presence or absence of mycorrhiza makes no difference to the performance of a coniferous seedling in the nursery.

A practice which has now become common in heathland nurseries is that of combining chemical fertilisers with organic manures. For seed-beds raw hop waste or a bracken-hop waste compost is applied at the rate of ten tons per acre and this is supplemented by an application of potassic superphosphate (16 % P_2O_5, 16 % K_2O) at the rate of 14 lb. per hundred square yards of seed-bed. These are worked into the top five inches of the soil and are applied as early as possible in order to allow of early sowing which is essential if the best results are to be secured.

For Douglas Fir it is better to omit the organic manures and to apply the potassic superphosphate alone.

When a new heathland nursery is being established on a very acid soil with pH of below 4·5, a light dressing of lime is often beneficial. Ground limestone at the rate of 5 cwt. per acre is ample and this should be applied only at the start and again in five years' time. It must not be applied annually.

Preparation of Seed-beds

There is no essential difference between the practice followed in heathland nurseries and that commonly followed in nurseries of conventional type, but there are one or two points which should be kept in mind in the heathland nursery.

In the first place, if bulky organic manures such as compost or hop waste are used it is very necessary to make sure that the seed-beds are properly consolidated before sowing because the heavy applications to the superficial layers of such substantial quantities as are used is apt to leave the soil in an open condition with the result that there may be heavy losses from drought. In order to give the beds time to settle it is, therefore, advisable to apply organic materials early, at least two months before sowing. Further, to aid consolidation, the roller should be applied, and it may even be necessary to tread the seed-beds in order to secure the right conditions for sowing.

Since weed-growth should not be a problem the seed-beds may be made wider than is customary, thus leading to a saving of space and, since the heathland nurersy soils are not retentive of water, the beds need not be raised above the level of the alleys as much as is necessary in some ordinary nurseries.

Sowing of Seed

The heathland nursery produces large seedlings and this must be remembered when sowing densities are being considered; one must visualize, at the end of the first growing season, a crop of seedlings not unlike those in a two-year-old seed-bed in the normal

type of nursery. Sowing densities must, therefore, be calculated to give adequate space to those large seedlings in their first year. We find that with seed of average quality the following numbers of square yards per pound of seed, sown broadcast, for the following coniferous species, has given satisfactory results: Scots pine, 55; Corsican pine, 35; European larch, 45; Japanese larch, 60; Douglas fir, 45; Norway spruce, 45; Sitka spruce, 85. Broadcast sowing gives individual seedlings more room than drill sowing; since there is no weed problem there is little advantage in drill sowing.

Seed-beds, after sowing, should be covered with sand or grit. Where the site is exposed a coarse grit should be used, otherwise the covering and the seed may be displaced or removed by the wind. Any grit so used must be free from lime.

Top Dressing of Seedlings

To get the best results it is advisable to apply top dressings during the growing season. If the seedlings are of pine or spruce Nitrochalk should be applied twice, at the rate of 6 lb. per hundred square yards, in early July and again about the beginning of August. If larches are being grown the applications should be at half this rate (3 lb. per 100 square yards) while with Douglas fir no top dressing should be given as it promotes a late lush growth which lays the plants open to damage from early autumn frost. In a dry year it is safer to omit the second top dressing, but in a wet year a third dressing may sometimes be applied with advantage. Nitrochalk is best applied when rain is in prospect, but while the seedlings are still dry, so that any of the fertiliser which remains on the foliage can be brushed off without difficulty.

Lining-out

Heathland nurseries can be used for lining-out but it is arguable whether they are not better employed in raising large one-year seedlings which can be removed and transplanted in nurseries of the standard type. They can, however, produce most excellent crops of 1 + 1 transplants of a wide range of conifers.

For transplant lines manuring should be on the same basis as for seed-beds except that the organic matter should be cut down to five tons per acre. Top dressings should be carried out as for seedlings.

Size of Seedlings Produced

Coniferous seedlings, one year old, of the following species can be produced in a good heathland nursery in a normal year.

Scots pine	3½-7 ins.	Douglas fir	4½-10 ins.
Corsican pine	2-4 ins.	Norway spruce	2½-7 ins.
European larch	6-13 ins.	Sitka spruce	3½-8 ins.
Japanese larch	5-12 ins.		

Reference has already been made to risks of damage to Douglas fir by frost in the autumn, if full manuring is given, but apart from that and from a few isolated attacks by *Botrytis* in over-dense seed-beds of Sitka spruce, there have been no troubles and healthy stocks have been raised everywhere. There is no sign that the regime to which the young plants have been subjected in the nursery in any way impairs their strength or renders them unsuitable for use in the hard conditions of afforestation areas. For this purpose they have compared very well with plants grown in the normal nurseries.

MANAGEMENT

When we started heathland nurseries we had it in mind that they would be essentially temporary affairs, wearing out, or becoming infested with weeds after a brief number of years, but experience has taught us that their duration of life is likely to be much longer than we originally expected. With the manurial treatments prescribed it has been possible to continue already for six or seven years without loss in fertility or performance, and, so far as we can see, for a considerable time to come. This applies also to those nurseries which have been run on chemical fertilizers alone, although there are suggestions that there may be occasional slight disorders where the organic manures are not applied.

Similarly, the invasion of heathland nurseries by weeds has not occurred as rapidly as we expected, although, in one nursery at least, weeds were brought in with seedlings which had been introduced for lining out from a nursery on arable land. It appears, therefore, that if reasonable precautions are taken, that the freedom from weeds, which is one of the desirable features of the heathland nursery, may persist for at least a decade.

It is not easy to foresee the future of the heathland nurseries but, for some time to come, they are likely to play a very important part in the production of our seedling stocks. Any revolution in technique which would enable similar results to be achieved in centralized nurseries of the kind with which we are familiar, would lead, in all probability, to a movement away from the heathland type. But at the moment there are no immediate signs of this revolution.

SOME CONSIDERATIONS AFFECTING THE CLASSIFICATION OF THE BOGS OF IRELAND AND THEIR PEATS

By T. A. Barry

(*Paper presented to the International Peat Symposium Dublin, July, 1954*)

PART I

DESCRIPTION

Climate

THE island of Ireland, a small uplift of the Continental Shelf lying just off the land-mass of Europe, is flanked on the west by the Atlantic Ocean bearing the relatively warm waters of the Gulf Drift—that great ameliorant—past its shores; and has as its prevailing winds the South Westerly Anti-Trades, throughout the year. It has the temperate oceanic climate one would expect in such a situation and conditions.

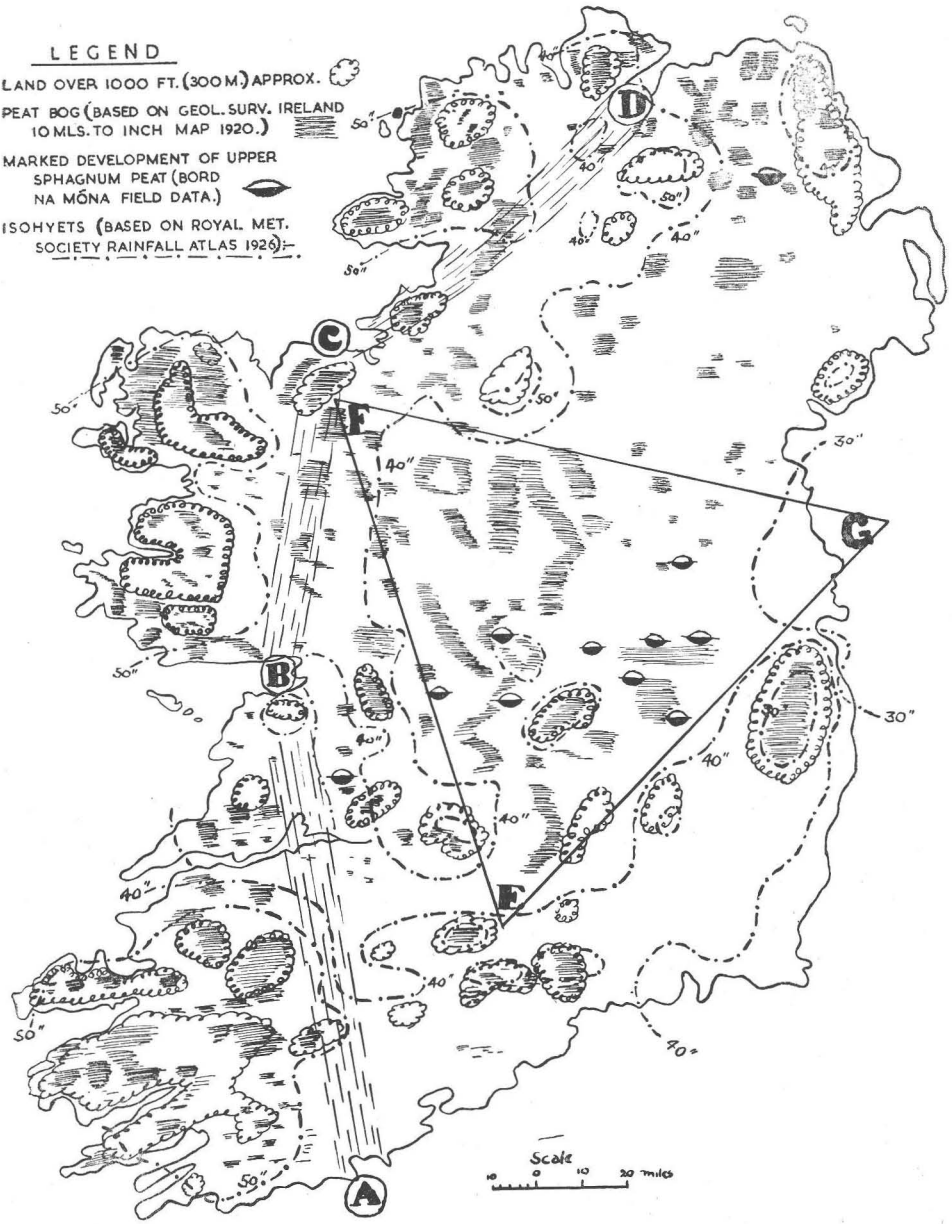
Table 1 shows the limits over Ireland of the means of some of the more important climatic variables.

TABLE 1

Approximate limits to-day over Ireland of some of the more important climatic variables ; data based on the isotherms, etc., shown on the Figures in Tansley (1939)

	Maximum	*Minimum*
Mean annual rainfall ..	150 in. (3,750 mm.)	30 in. (750 mm.)
„ rain-days per annum	250	175
„ duration of sunshine (hours per annum)	1,600	1,200
„ annual temperature	50°F. (10°C.)	42°F. (5·56°C.)
„ Minimal temperatures (Jan.)	41°F. (5 C.)	34°F. (1·1°C.)
„ Maximal temperature (July)	67°F. (19·4°C.)	63°F. (17·2°C.)

Hours of sunshine decrease from south-east to north-west ; total rainfall and rain-days decrease, generally from west to east



IRELAND

Showing high ground, certain isohyets, and the regional distribution of the main bog-types.

KEY TO THE MAIN BOG REGIONS

West of ABCD is the region of the blanket bog. Within the figure EFG are the main aggregates of raised-type bog. On high ground everywhere are the high-level (blanket) bogs.

Rainfall is rather evenly distributed over the whole year with a " peak " in December (early winter) and " valleys " in May and September. Actual mean annual temperatures are remarkably equable over the country as a whole, the annual range of mean temperatures for the warmest and coldest months (July and January, respectively) being only 20° F. (11·1° C.) in the Central Plain, and less than 16° F. (8·9° C.) on parts of the west and south-west littoral.

Thus, within the Atlantic island of Ireland there are, simply, the subregions of most marked and of rather less marked oceanic climate.

Topography. The land-forms are such that the more mountainous parts, reaching their greatest elevation at 3,414 ft. (1,024 m.) in the south-west, lie around the perimeter, that is, in the maritime counties, while the central part is more nearly flat. The Central Plain proper, however, lying at *circa* 200 ft. (60 m.) above sea-level, occupies not more than 10 % of the total area of Ireland. Uplands, often of rather rugged configuration and usually lying between 200 ft. (60 m.) and 800 ft. (240 m.) or more above the sea, cover much of the remainder. They are separated by numerous river-valleys that are seldom deep or narrow; so that the topography, by and large, is undulant rather than sharply outlined.

Rock-types and Drift. The solid geology comprises a great variety of rock-types. The mountains and major uplands present considerable areas of igneous material ranging from acidic granites and felsites to base-rich basalts and diorite. Metamorphic quartzites and mica-schists, Silurian and Cambrian grits and shales, Old Red Sandstone, and carboniferous limestone are common also.

But far more widespread and important is the glacial drift to which all of the foregoing rocks, and others, have contributed, and which covers up to 85 % by area of the whole country as may be estimated from the map in Kilroe (1897).

Climate versus Natural Succession, etc., as factors in bog formation. This, then, is the heterogeneous superstructure upon which the post-glacial peatlands of Ireland have been built; but there is a great body of evidence which appears to show that this is not the climate in which they have grown from the beginning. The common view, supported by data from the Continent of Europe and from other parts of the world, is that there have been a number of climatic changes, hence a succession of rather well-defined climatic phases, since the last retreat of the Ice about ten thousand years ago.

An opinion widely held is that the most recent major change, from a more dry and warm climate (the Sub-Boreal) to about that of to-day (the Sub-Atlantic) occurred *circa* 500 B.C.; but there is evidence that there have been a number of fluctuations of more or less significance since that time. Their relative importance remains to be worked out.

Another school of thought holds that such climatic changes as may have occurred since the retreat of the Ice have not been of

primary importance in fixing the stratigraphy of the peats, but that it was simply a matter of natural vegetational succession until the advent of Man. From which time, say three to four thousand years ago in these Islands, man, acting indirectly through the introduction of grazing animals, and directly through his tree-felling, burning, clearing and cropping operations has, as the principal biotic factor, interacted with the natural environmental factors, bringing about the minor gradations of the " Sub-Atlantic " and producing the bog-surface conditions of to-day.

The Common Factor in our Bog-profiles. Whatever be the true and complete explanation of it, there can be no doubt that the profiles of the bogs of Ireland exhibit a definite and regular sequence of strata. The curious thing is that this " common factor " appears to hold good whether the example chosen be a 5 ft. (1·5 m.) profile from a bog in Wicklow at 2,000 ft. (600 m.) elevation, an 18 ft. (5·5 m.) profile from a bog in the Shannon Basin at only 140 ft. (42 m.) above the sea; or, for that matter, a profile from one of the bogs whose remains now lie between the tide-levels along the West Coast. Highly simplified, the sequence is, from floor to surface, for every bog in Ireland:

(i) A peat or peats often highly humified, composed of the remains of eutrophic/mesotrophic plants and with high ash content. Sometimes with timber in situ.
(ii) A dividing layer of forest peat very frequently containing stumps of *Pinus sylvestris* or *Betula alba*, not uncommonly both together.
(iii) A peat or peats tending to be more fibrous than the peat or peats below the forest layer, usually less humified also, and composed of the remains of oligotrophic-mesotrophic plants. Such peat containing visibly increasing amounts of (*Sphagnum*) moss species near the surface.

While on the one hand it may be contended that this kind of vertical succession in peat-types is primarily the outcome of climatic changes down the centuries, and on the other that it is essentially a natural succession brought about by the " growing away " of surface plants from subsoil nutrients, it seems probable that, for long, all such factors have been inter-active.

It will be interesting to see how far the " common factor " succession of peats suggested above can be traced through the profiles of the general bog-types as given below.

Some Features of the Main Types of Bog in Ireland

The consensus of opinion is that the two great natural types of bog in Ireland are—the *raised-type* bog of the Central Plain and the *blanket-bog* of the West. To the latter may be added its montane sub-type, the *high-level blanket bog* (e.g., in the Wicklow mountains).

The Raised-Type Bog. The depth of the raised-type bog is said to be on average 25 ft. (7·5 m.) but much greater depths occur. For instance in 1949 soundings in a raised bog of 300 acres (120 ha.) commonly showed 40 ft. (12 m.) of peat. Such bogs in Ireland may or may not have basin bottoms (that is, concave floors). Clonsast and other bogs of the size-class 2,000-4,000 acres (800-1,600 ha.), present extent, in the Central Plain, rest partly on basins and partly on morainic sand-gravel ridges that may or may not reach the present-day surfaces. Blue clay, sand and gravel mixtures and (locally) shell marl constitute the subsoils. These are usually calcareous.

From bog-floor to surface the peat types in a Central Plain raised-type bog are commonly about as follows:

(1) 9 ft. (say 2 m.) of reed-swamp-fen peat or peats sometimes with timber on the mineral floor and within the peat. (*Pinus sylvestris*, *Quercus robur*, *Taxus baccata*).

(2) Up to 3 ft. (say 1 m.) of forest peat. A very distinct pine layer (*Pinus sylvestris*) flat-rooted characteristically in the reed peat and accompanied locally by *Quercus* and *Betula*.

(3) (*a*) 6 ft. (say 2 m.) Bog peat of mixed mesotrophic-oligotrophic species; showing a conspicuous content of *Eriophorum* spp., *Trichophorum*, *Narthecium*, *Menyanthes*, *Rhynchospora*, *Vaccinium oxycoccus*, *Sphagnum* and other mosses, with some *Molinia coerulea* and *Myrica gale* locally. The whole usually about H 6—H 8 on the Von Post humification scale.

(*b*) 3 ft. to 6 ft. (say 1-2 m.). Bog peat generally resembling the last but less humified with a marked increase in the amount of *Sphagnum* present.

A thin layer of *calluna* peat, traces of *Betula*, and even a minor growth of *Pinus* may occur between 3*a* and 3*b*. More often than not, in Ireland, within the whole of 3 but especially in 3*b* there is vertically, a marked irregularity or, even, alternation in the degree of humification at any one boring-point.

The surfaces of our raised-type bogs wherever undisturbed by burning, grazing, or drainage, exhibit the typical *regeneration-komplex* or hummock-hollow formation associated with the *höchmoore* but there occur also, crossing these bogs or originating in relict lakes, pool complexes or " springs " within their boundaries, the flushes and paths of soaks of which an example has been so ably described by Osvald (1949).

The Blanket Bog. The depth of the Western blanket bog is on average about 8 ft. (say 2·5 m.) but in flat bog, resting over hollows, depths of 25 ft. (7·5 m.) are not rare. Neither are depths of a mere 2 ft. to 4 ft. (60 cm.—120 cm.) over convex slopes. Blanket bogs,

by definition as it were, cover wide areas rather uniformly and contain known units of up to 15,000 acres (6,000 ha.).

Their top-surface contours and bog-floor contours about coincide. But not entirely so, because it is in the former hollows that the greater depth of peat has been built up and here, below the woody layer, (which does not dip in conformity with the dip of the bog-floor) there may be found an amount of *Phragmites* and other topogenous or topo-soligenous peats reminiscent of those in the lower halves of our raised-bog profiles. On the other hand over the former and present-day ridges and domes of mineral soil or bare rock the peat is thinner and the pine-layer—where the extent of former mineral soil permitted its growth—is rooted wholly or partly in such soil. The sub-strata in question are usually acid, siliceous, and include many drift types—of gneiss, schistose, granitic, metamorphic-quartzite, and other origin. Iron-pan is commonly present, at and just below the junction with the peat.

From bog floor to surface the peat-types in a Western blanket bog (at a non-basin site) are commonly about as follows:

(1) 6 ins. to 3 ft. (15 cm.—90 cm.). Amorphous peat, completely humified or nearly so. Pine at foot, within the layer, or at its junction with (3); which position will depend on the nature of the site—particularly the local topography and gradient of the bog-floor.

(2) 1½ ft. (45 cm.) Pine wood peat and stumps in situ.

(3) 2 ft.—6 ft. (60 cm.—180 cm.) blanket-bog mixed peat, very well humified to moderately humified, say H 9 to H 6; the humification decreasing with approach to top surface. Recognizable plant remains include, most commonly, those of *Eriophorum spp.*, *Molinia caerulea*, *Schoenus nigricans* and *Narthecium*, and the whole, when not more fully humified, constitutes a peat or peats markedly more sedge fibrous or grassy fibrous than are those of the raised type bog peat. In the uppermost 2 ft. or so (0·5 m.) *Sphagnum* spp. and other mosses become conspicuous, but the grassy or sedge fibrous texture of the peat is usually well maintained to the top.

The surfaces of the greater Western blanket-bogs carry on the flat a ramification of pools and lakes belonging, it would seem, to three or four distinct generic types and deserving of special study. Among these bodies of water as well as on the more firm sloping ground *Schoenus* is often very abundant, or in some cases, co-dominant with *Molinia*. There are the usual bog species as well (e.g., *Eriophorum* spp.) and Ericaceae. *Menyanthes trifoliata* occurs in the pools and, in the most swampy areas, on the ground between them. *Molinia* and *Molinia-Juncus* flushes abound and run along or somewhat below the surface—their courses becoming more readily recognizable with increasing unevenness of surface configuration.

The High-level Bog. The average depth and the profiles of the sub-type " high-level blanket bog " everywhere in Ireland so far as seen, appear to compare quite closely with those of the Western blanket bogs proper. But there are fewer places where the maximum depths of the Western bog are reached; and the fibrous bog peat (as distinct from the amorphous lowermost peat) seems to be composed of finer fibres than is the equivalent bog peat in the West. Perhaps it is the sub-recent prevalence of *Molinia* and *Schoenus* in the West, on the one hand, and, on the other, of *Eriophorum vaginatum* and *E. angustifoliam*, *Calluna*|*Erica tetralix*|*E. Cinerea*, and *Rhacomitrium lanuginosum*, at the greater altitudes elsewhere, that accounts for this difference.

Distribution of the Main Bog-types in Ireland. The accompanying map is based on observations from field work carried out to date and is intended as a key to the distribution of the main bog-types, viz., *raised-bog* and *blanket-bog*, and of the latter's sub-type, *high-level bog*, in Ireland.

It affords interesting comparisons with the allocation in his contents and text by Jessen (1949) of the terms " raised-bog " to the sites shown on his key-map (facing p. 110, *op. cit.*): and also with the distribution of " ombrogenous höchmoore " and " soligenous peat " on the map of Ireland's peat bogs which appears as Fig. 36 in Granlund (1932).

On the present map are shown:

(i) The main mountain and hill groups—approximating to all land over 1,000 ft. (300 m.) elevation.
(ii) the location of the main peat bogs based on the Geological Survey (1918).
(iii) the 30 in., 40 in. and 50 in. (750 mm., 1,000 mm. and 1,250 mm.) isohyets of average annual rainfall, 1881-1915, according to the Rainfall Atlas of the British Isles (1926).

The key to the distribution of the bog types is as follows:

Blanket bog. All of Ireland lying west of the transition belt ABCD is the region of known blanket bogs *par excellence*. Where the occurrence of peat bog and elevation greater than 1,000 ft. (300 m.) over sea-level are seen to coincide east of this belt the bog type is high-level (blanket) bog.

Raised-type bog. The triangle EFG encloses the area known to contain the main groups of raised-type bog; and special symbols are used (see " Legend " on the map) to mark the location of particular bogs or bog-groups which have been found to contain noteworthy amounts of younger sphagnum peat (peat-moss material) in upper profile.

These latter would appear to be the nearest equivalent we have in Ireland to the classical " höchmoore " of N.W. Germany and

South Sweden. They appear to reach their best development with us in watershed situations at low elevations in those parts of the country having the least annual rainfall and the greatest degree of difference between mean summer and winter temperatures.

PART 2

DISCUSSION

From the combination on this map of the field evidence for the distribution of our bog types, and of the known distribution of rainfall, it would appear that the 40 in. (1,000 mm.) isohyet is rather decisive in Ireland, marking a convenient boundary as between the region of raised-type bog and the region of blanket-bog. In support of this theory it can be shown that where an abrupt increase in elevation brings about heavier rainfall locally, well within the 40 in. rainfall zone, there the bog type changes locally likewise, and a sub-type of the blanket bog is found. This is probably most strikingly exemplified in the case of the Slieve Bloom Mountains where, standing amid extensive *Eriophorum* bogs at *circa* 1,500 ft. (450 m.) elevation one may look down in every direction upon the raised-type bogs of the surrounding plain.

Conversely, if the theory is correct, bogs in places having less than 40 in. annual rainfall even though in or about the blanket-bog region should be of the raised type. To test this, East Clare was visited and it was found that in the area marked by the most westerly sphagnum moss bog conventional sign on the map in a number of bogs of the size-class 100-200 acres (40-80 ha.), north and south of Tulla on Carboniferous limestone and drift, there were in drained face-banks about 2 ft. (60 cm.) of younger sphagnum peat—peat moss material—then a retardation-layer about 6 in. (15 cm.) thick consisting of non-mossy peat, dark, coarsely-fibrous and containing *Molinia* in one case at least, and then a further 1 ft. to 2 ft. (30-60 cm.) of rather young moss peat. Samples taken in one of these bogs with a Hiller-type borer showed sphagnum moss peat to 1·5 m. then older sphagnum/sedge fibre at between 1·5 and 2 m. depth, then a further occurrence of moss peat (*circa* H 5) to 3 m., which was the limit of sampling.

Table 2 shows the values from pH metre readings of those samples:

TABLE 2—Creevosheedy Bog, Co. Clare

Samples taken 14th November, 1952

	Depth	*pH value* (mean of two readings)
50 m. into the bog from S. edge ..	(1) 0·5-1 m.	5·3
	(2) 1·0-1·5 m.	5·4
	(3) 1·5-2 m.	5·7
200 m. into the bog from S. edge ..	(4) 1·5-2 m.	5·8
	(5) 2-2·5 m.	6·2
	(6) 2·5-3 m.	5·5

The special interest for the bog-investigator of the discovery of a bog type resembling *höchmoor* in East Clare lies in the fact that although having less than 40 in. of annual rain, according to the Rainfall Atlas, the area has more than 225 mean rain-days per annum according to Fig. 24 in Tansley (1939), and is sandwiched between areas of heavier annual rain, on the Atlas.

Tansley's caption clearly links the occurrence of blanket bog *with the greater number of rain-days* rather than with the higher annual rainfall and in his favour we may point to the >40 in. <225 days situation giving raised-bog at Tregaron[1] and to the <40 in./ >225 days situation giving blanket bog in Caithness.[2] It would seem that the position is not the simple one of annual rainfall *versus* number of rain-days but that (e.g.) high latitude in one case (as at Caithness) may turn the scales in favour of blanket-bog formation while in another (say East Clare) the combination of higher mean annual temperatures and of more favourable edaphic conditions may do so in favour of raised-type bog formation.

So far we have adverted to bog-types only (as distinct from peat-types) and among those simply to the two main types in Ireland—the raised-bog and the blanket bog.

A third type of bog which is commonly listed in classifications such as Tansley's is the " Valley Bog." It is not thought necessary to include it here because it does not appear to occur in Ireland except

1. In Cardiganshire, mid-Wales. See Godwin, H. and Mitchell, G. F. (1938), also Godwin, H. and Conway, V. M. (1939).

2. In the extreme north of Scotland. See Crampton, C. B. (1911).

in so far as it underlies present-day raised-type bogs and blanket bogs, or where the removal for fuel of the upper peat from either of those types of bog has exposed it to view.

The field-evidence seems to suggest and logic supports the view that it would be unwise to raise this type of formation to the status of a bog-type in Ireland to-day. This is the more imperative on account of the confusion already existing as between bog-type and peat-type classifications.

Eutrophic fens, usually small or relict, widespread callows, and mesotrophic marshes occur, and complete the picture of the peat lands of Ireland. Certain of the fens present conditions apparently resembling those that obtained in similar habitats before the onset of bog-growth. For example, near Droichead Nua there is a small fen of *Cladium mariscus* with *Phragmites communis*, *Mentha aquatica*, *Juncus effusus*, *Parnassia palustris*, etc.; that probably resembles closely a former fen stage beneath, say, the great Shannon bogs. (It is as well to note perhaps that those are not, to-day, " valley bogs " either. They are raised-type bog over *Cladium* fen/*Phragmites* reedswamp peats).

The practical importance of distinguishing between the blanket-bog and raised-type bog regions in Ireland stems from the fact that, as has become increasingly clear within the past few years, the characteristics of their peats differ fundamentally.

For instance, their drying/rewetting and combustion characteristics, the chemical constituents (e.g., wax content) of their profiles, their responses to drainage and the feasibility of using upon them certain machines and methods, differ greatly.

In short they differ inherently not only in their present constitution (the resultant from their former environmental conditions) but in their present environments—whether as subjects for fuel-utilization or for reclamation, including afforestation. Examples are not wanting where a particular technique proven successful on the one type has failed on the other.

The reality of the distinction made here between those two main bog types in Ireland will not have been in any way vitiated should it prove difficult or impossible to draw a fixed and final line of demarcation between them on the ground, up and down the country. The classification is a natural one, based on genetic, morphological, and physiographical factors and characteristics, and as Tansley says so well in a somewhat similar connection (p. 272, Vol. I, 1939):

> " The difficulties . . . are of the kind which we meet in attempting to classify biological phenomena (everywhere)—they are so complex that while we can recognize well-marked ' types ' representing the prevalent combinations of different factors, we cannot draw sharp boundaries."

It would be quite wrong, however, to suppose that this bilateral division of our bog types is represented on the Continent by the most common division there, viz., into " high bog " and " low bog."

(This point requires special emphasis since it is known that this is precisely what has happened in the past, darkening the understanding of both European and Irish peat-scientists and technicians.)

For long the German school has classified bogs as

(1) *Höchmoore* or " high bog," formed of plants growing in " soft " waters poor in nutrients.

(2) *Neidermoore* or " low bog " of plants growing in " hard " waters rich in nutrients; and

(3) *Uebergangsmoore* or " transition bogs," of vegetation intermediate between the two extremes.

The peats of these " bog types " are therefore, respectively,

(1) Oligotrophic,

(2) Eutrophic, and

(3) Mesotrophic. It is evident that any one or two or all three of them may occur in vertical arrangement, usually in the order (2), (3), and (1) from floor to surface, in any bog anywhere, according to the letter of the classification.

According to its spirit, however, it is evident that the classification was intended to fit the bogs of North-west Germany and the Netherlands primarily; that it applies rather well *to the several peat-layers* of the raised-type bogs of Ireland, at least within the triangle EFG, an our present map, but that it is difficult to see how it can be applied to our western blanket-bog or to its subtype, our high-level bog.

This is a rather serious drawback for students of our bogs and peats and more so for our peat-technicians. The Russian school of peat-investigation based on the methods of the German and Scandinavian schools, similarly recognizes two main types of bog or peat (viz., " high bog " and " low bog "). It states that these two types of bog and their peats differ in their profiles, their degree of physical decomposition, ash content, real density, mechanical strength of their sods and briquettes, and in other significant ways. Different formulæ are used for the prediction of the behaviour following drainage, of " high bog " as distinct from " low bog " peat.

Results which are coming in now from laboratory investigation using the methods just referred to tend to show that the peats—even the upper peat—from our Western blanket-bogs display the characteristics of " low-bog " rather than of " high-bog " peat. Should this suggestion continue to find support from the results of continuing field-work it would be a noteworthy addition to the evidence already available that our blanket bogs differ fundamentally not only from our raised-type bogs, in Ireland, but from the bogs of Europe as a whole, excepting only those of Western Norway.

Here again there is a difficulty because when, in 1952, the blanket-bog of West Norway was visited it was found that, at Hustadmyr north of More og Romsdal at only 100 ft. (30 m.) above sea-level, in a district whose situation, topography and subsoil

resembled closely those of the Gweedore district in Donegal, the surface vegetation and the peat as seen in drainwall profiles resembled not those of our Gweedore blanket-bog but, identically, those of our high-level bogs around Lough Firrib in the Wicklow highlands at around 2,200 ft. (*circa* 660 m.) elevation. The only difference discoverable at Hustadmyr was the occurrence there, in the lower peat or on the mineral soil, of larger pine. Specimens of up to 30 in. (75 cm.) butt diameter were seen. Clearly the difference of 10 degrees of latitude (Hustad 63 N, Lough Firrib 53 N) has approximated to a difference of 2,100 ft. in altitude as between the two places.

We see at once the unwisdom of making direct comparisons between outwardly similar situations. In this case (e.g.), if a particular reclamation technique on Hustadmyr should fail it would not follow that similar efforts on our Western blanket-bog would not prove a complete success.

The Classification of Peats. The situation regarding the classification of bogs and peats—the terms have repeatedly been used as if they were synonymous—has become more and more confused as each classifier has added his particular " stone " to the " cairn." What is wanted now is not a " new " peat-type classification but, rather, a *clarification* of the existing systems.

Von Post, Osvald, Jessen (Europe); the Frazer School (Scotland); Godwin, Pearsall, Tansley (England); Dachnowski-Stokes and Waksman (U.S.A.); and Mitchell (Ireland) are among the leading workers who have contributed in their various ways to our understanding of peat-materials and their classification. The works of over twenty such authorities—their subject-matter having to do directly with, or having relevance to, the bogs and peats of Ireland—have been examined at Droichead Nua and a number of points of interest have emerged rather clearly from this study. Examples are as follows:

(1) At least sixteen different habitat factors and characteristics of the material have been used as distinguishing characters. They range from colour of the peat-ash to local *versus* regional distribution of the (bog) type.

(2) The criteria most commonly employed have been topography, water-relations and climate, and the ways in which these have been interpreted have differed greatly from system to system so that classifications based on identical criteria differ in value.

(3) The most concise statement that can be made about the conditions governing the nature of a particular peat-type is the following: " The nature of the peat depends upon the plant association which has given rise to it and which in turn has been controlled *by the climate, physiography and other locality factors of the district and in particular* by the nature and amount of the mineral nutrients in the waters *of the locality and of the spot* in which the plants were growing."

The passage is taken from Waksman's suggested definition of peat (1942), less the words in italics, which are added here to broaden the scope of the reference at two points, in order to make it clear that factors other than the nature of the water have been operative and that peats other than ground-water fed peats are included.

(4) The classification of the bogs and peats of Scotland by the Frazer School, Frazer, G. K. (1933), Muir, A. and Frazer, G. K. (1940), Frazer, G. K. (1943), etc., into (i) Zonal or Climatic (blanket-bog peats) and (ii) Azonal or Local (raised-bog, basin peats) resembles closely, in effect, the bilateral classification of the bogs of Ireland into (i) Blanket Bog and (ii) Raised-type Bog. But the nomenclature seems unfortunate since it is evident that varying climatic conditions contribute equally (so far as we know) to the build-up of various kinds of bog-peat. For instance the evidence is clear in Ireland that a particular " climate " is associated with the development of sphagnum moss peat on the raised-type bogs of the Central Plain. (Incidentally, if the west coast " climate " favours bog-growth so overwhelmingly it is a fair question why basin situations within the western blanket-bogs do not show as great depths of peat as do similar situations in the (? non-climatic) bogs of the east-centre). As for the distinction " regional " *versus* " local " this will not fit in Ireland because we have in the districts of our " Azonal " raised-bogs a number of aggregates of bogland each exceeding 10,000 acres (4,000 ha.) separated only by adventitious eskers and stream-courses.

The term " climatic bog " if used to denote our Western blanket bog would be additionally unfortunate in that it would lend implicit support to the view that in that region the present " inhospitable " peat-cover is final, something that cannot be improved or eradicated. Happily, however, indications are now becoming available from widely differing sources that this is not the true position.

(5) Von Post's " topogenous peatlands " and his " paludification bogs," the latter subdivided into " ombrogenous " and " soligenous," together with Osvald's " terrestrial " " telmatic," and " limnic " peats have been the terms principally made use of by Jessen (1949).

His classification, thus, of the bog-types and peat-types of Ireland, respectively, is entirely correct and adequate theoretically and is, no doubt, fully in accordance with reality. But, in the field, the *elucidation* of those types, as set up, is another matter. Jessen himself (who regards both raised bog and blanket bog as ombrogenous) prepares us for this by pointing out that " intermediate types between blanket and soligenous bogs are common." Von Post, earlier (1937), expected that Ireland would show " a puzzling intermingling of the two main paludification types "—the ombrogenous, and the soligenous bog—in fact " a multiformity of types."

The rather numerous combinations of plant remains used by Jessen as the framework of his peat-types classification constitute the most lucid statement in existence on the botanical content of our

peats and are, of course, identifiable. But the degree of variation within these (even in peat at identical levels over the same bog) is so great as to render their quantitative assessment impossible. So that in bog-surveys for industrial and land-use purposes one has to be content with a more simple scale, based on the ocular evidence of *principal* botanical content, giving not more than, say, six main peat-types.

PART 3

CONCLUSIONS

To attempt a two-point crystallization, as it were, of the opinions of various eminent workers in the field of bog and peat classification:

The first point is that the nature and relative amounts of the waters feeding a site are of paramount importance in bringing about a particular bog and hence, peat-type. A succession of such types will in time arise from changes in the nature and in the relative amounts of such waters.

The second point is that one of the principal distinguishing characters of any peat-type is its botanical composition and that, so far as our present knowledge goes, it seems probable that the main botanical content may well be, as between peat-types, the differentiating character, i.e., that which has the greatest number of accessory characters.

It would be strange indeed if the origins and relative amounts of the aerial and terrestrial waters feeding a particular bog, or feeding its preceding fen, were not of primary importance considering that our bogs and their peats as they stand consist in greater part, from surface to bog floor, of water (e.g., Experimental Station field-data, 1953-4 show moisture-contents 93 %—96 % for all samples from undrained bogs in various parts of the country).

At the moment we simply do not know to what extent this water is of aerial or terrestrial origin, to what depths rainfall exercises an influence, from what depths ground waters arise, or in what direction or directions (if any) the water, of whatever origin, within and below the peat-strata, is in movement. This great gap in our knowledge applies equally to raised-type bog and blanket-bog. Perhaps scientific bodies and industrial concerns will join forces to close it ? The knowledge in question is essential to our understanding of bog-formation and regression on the one hand and, on the other, to the most effective and economic design of drainage methods, and patterns and of drainage-maintenance plans. Hence it is of fundamental importance to all who are engaged in peat land utilization, whether for fuel production, agriculture or afforestation.

An ancillary problem is that of working out to what relative degree ground-water (percolating via plant-roots or otherwise) and aerial water are influencing the growth or decay of our western

blanket-bogs. European authorities have long been mystified by the prevalence of *Schoenus nigricans* on those bogs, so much so that one investigator termed them fens. The species *Schoenus nigricans* and *S. ferrugineous* are on the mainland of Europe definitely confined to ground-water fed habitats, and in the eastern Mediterranean the former has been recorded in salt-marsh.

Bertsch (1947) gives *Schoenus ferrugineous* (dominant) with *S. nigricans* (locally abundant) as successors to *Cladium mariscus* in the formation of a calcareous fen.

Tansley (1939) mentions the theory that salt spray driven by inshore gales changes the soil reaction of the maritime blanket-bogs in the direction of the more normal habitat of *Schoenus* and this theory finds support in Gorham (1953) who mentions that Webb (1947) has shown that in the West of Ireland where blanket-bogs are prevalent, the chloride content of bog-surface water; is about 0·5 m. mole/1; while in the east, where raised bogs are developed it is only 0·2 m. mole. Gorham mentions also that in Sweden Witting (1948) has observed the concentration of calcium, magnesium, sodium and potassium in bog pools to diminish in passing from west to east.

A contribution of immediate relevance to this whole problem of the influence of atmospheric salts (not merely from salt-spray but from the air and rain), on vegetation is that of Ingham (1950), which seems to have escaped attention up to now. Ingham describes experiments which seem to show that cellulosic and other materials can absorb, *from the air*, nitrogen and other compounds more than sufficient to maintain plant fertility. It would appear from the combined evidence of Webb and Ingham that an unascertained proportion of the plant nutrients in our soils are derived from the sea and are wind-borne; and that differences may well exist, in the respective amounts of such substances contained in the air and rain, and so potentially available for plants, as between the west and the east of Ireland. If this idea could be substantiated it would represent a discovery of the greatest importance from both agronomic and academic view-points, for Ireland and universally.

Assuming that the water-relations problems had been overcome there would remain the problems of present-day climatic trends and their present effects on our bogs in the west and on high ground. As is well known, there has been a marked breakdown of the high-level blanket peats in the present century in Great Britain and Ireland. Crampton and MacGregor (1913) ascribe this, on Ben Armine, Sutherlandshire, to a falling-off in the amount and constancy of precipitation but others think it merely a matter of the equivalent of senile decay having set in on the bogs in question.

My observations in the Wicklow highlands recently, 1949-51, have shown that along the broad Seefingan-Kippure ridge at elevations between 2,056 ft. (617 m.) and 2,473 ft. (742 m.) where *Rhacomitrium* and *calluna* associations were recorded by Pethybridge and

Praeger in 1905 large areas are more or less devoid of vegetation now and the 8 to 12 ft. (2·5—3·5 m.) depth of peat is being washed downhill.

Five stages in this erosion/denudation process are traceable in the Wicklow Highlands, ranging from Stage I (the appearance of surface blow-outs; as on Liffey Head bog at 1,700 ft. (510 m.) to Stage V (recolonization of mineral detritus by plants such as *Rumex acetosella*, as on Kippure summit at 2,473 ft.) (742 m.). At greater elevations, as on Mullaghcleevaun, 2,788 ft. (835 m.), and Lugnaquillia, 3,039 ft. (912 m.) there is now a post-erosion sub-alpine sward, where it would appear there was formerly a cover of blanket-peat. For instance in 1951 north-east of Percy's Table on Lugnaquillia at *circa* 3,000 ft. (900 m.) there was found a vestigial peat " hag " 3 ft. (90 cm.) high. On the same visit, in April, 1951, at 2,300 ft. (690 m.) a fresh deposit of eroded peat was found, up to 1 m. thick and measuring 3 m. by 1 m., resting on frozen snow from previous months. It would appear then that at the greater altitudes erosion is extremely dynamic to-day.

In the western blanket bogs also, down to sea-level, various stages of erosion may be seen, rather localized and somewhat puzzling in their distribution.

Now it seems to be commonly held among physicists, meteorologists, glaciologists and animal-ecologists to-day that there has been an appreciable rise in mean temperatures, at least in N.W. Europe, perhaps up to 2°C., over the past century, with most of the increase accruing in the past half-century. This or its consequences may be responsible for the breakdown of the high-level bogs.

If so and if the change is not merely a temporary oscillation it could mean:

(*a*) that in the long-term view both high-level and western blanket bogs are in the nature of " wasting assets ";

(*b*) That the scales are becoming weighted in favour of tree-growth, hill-pasturage improvement and reclamation generally on our peat-lands.

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AFFORESTATION OF PEAT SOILS

By T. McEvoy, M.Agr.Sc.

(*Paper presented to the International Peat Symposium Dublin, July, 1954*

THIS paper proposes to deal in broad outline with the place of peat soils in Irish Forestry, to summarize experience gained to date, and to examine generally the technical problems involved in afforestation on peat.

In order to see the problems in their proper perspective it is necessary to sketch in the background of forestry in Ireland and to relate it to European conditions in general.

The Place of Peat Soils in the Irish Afforestation Programme

Apart, perhaps, from the blanket bog areas of the west, Ireland is situated in the temperate forest zone and was, in fact, heavily forested up to early historic times. Yet its forests dwindled until they occupied little more than 1 per cent of the land surface in scattered plots and these woods were mostly of artificial origin. Before World War II these woods supplied less than 10 per cent of the country's total timber requirements. In order to fulfil the forest policy, which is to supply as far as possible all our timber needs, it is necessary to make a substantial withdrawal of lands from present agricultural use. In order to create the least possible disturbance of agricultural production this must be made almost entirely from what, in the official statistics, is classed as " other lands," i.e., land which is neither arable in the broadest sense of the term nor existing woodland. The official description is " grazed and barren mountain, turf bog, marsh, water, roads, etc." The area is roughly 5¼ million acres, of which about 60 per cent is estimated to be peat-covered.

The Irish climate, with its mild winter and abundant rainfall, favours gramineous vegetation and has given agriculture a strong bias towards stock-raising on open range; and rough grazing has always played an especially important role in the economy of the farm. It is extremely difficult to purchase the better class rough grazings, which are the most productive forest sites, giving very high yields of spruce—up to 200 cubic feet or 6 tons of timber per acre per annum. In practice it is necessary to spread acquisition over a wide variety of soil types and to accept a high proportion of peat

soils of varying degrees of fertility and suitability for tree growth. In recent years it is estimated that more than half the plantable land acquired would come within the definition of peat (with peat 12″ deep or more). In terms of area this has meant the acquisition of close on 10,000 acres of peat soils per annum. It will be appreciated, therefore, that afforestation of peat is relatively more important to Ireland than to almost any other country.

Peat Afforestation on the Continent

On the Continent in France, Germany, Denmark, the Netherlands, the pressure on peat lands has been towards agricultural reclamation. This followed, naturally, from greater density of population, intensive land use and scarcity of arable as compared with forest land. In Scandinavia the forest industry was based on slow growth rates, long rotations, low cost production methods; and the low stumpage values of timber up to World War II precluded expensive preparatory work on bogland. Consequently, the approach was highly selective and only the more fertile peats in the drier and warmer climatic regions were considered capable of economic afforestation. It will be seen that Continental experience is, on the whole, limited and the probabilities are that Britain and Ireland must play a leading part in future developments in this line.

Peat Afforestation in Britain

It is necessary to pay more detailed attention to British work on afforestation of peats. Britain has large areas of peat, especially in the high-rainfall areas of the North and West of Scotland and in the Welsh mountains. Private planters in Scotland tackled peat areas and imported from Belgium the technique of turf planting, i.e., inverting a square sod of surface peat and planting the tree in this sod instead of burying its roots in a pit. This proved a marked improvement on previous methods, especially with spruce, and the Research Staff of the British Forestry Commission concentrated from about 1927 onwards on applying machinery to turfing and draining, the aim being more thorough preparation of the planting site at reduced cost. With the development of efficient tracked Diesel tractors and the design of special heavy peat ploughs, success was achieved; and it became practicable to plough with furrows and continuous inverted furrow slice (or " ribbon ") at 5 or 6 feet espacement. This treatment resulted in more effective drainage and aeration than was economically possible by hand methods, and trees did better on the ribbon than on turves. This ploughing technique, or some adaptation of it, has become standard practice in Britain on peat soils, except where rock outcrops or steep slopes make it impracticable.

Side by side with the development of the mechanical treatment of the planting site went investigation of the chemical requirements

for satisfactory tree growth and the deficiencies of peat soils in this regard. After some rather desultory initial experiments with lime and a variety of fertilizers, it became clear that phosphate was easily the most significant mineral deficiency in peat soils, and small applications of phosphatic fertilizers (e.g., Basic Slag, Ground Mineral Phosphate) have given remarkable results even on Scirpus moorland. Satisfactory growth of a variety of conifers has been obtained over a period of some twenty years as a result of initial dressings of as little as 2 oz. per plant, while untreated control plots have stagnated or died.

While many problems will undoubtedly arise in the future, research has emphasized two basic necessities in peat afforestation: (1) Intensive drainage and aeration by ploughing at close spacing, and (2) addition of phosphates. It appears that for certain pines at least, the mineral requirements are extremely low and that small applications of phosphate can have an enduring beneficial effect on tree growth. In contrast with agricultural crops, trees remove very little mineral matter from the soil and the closed circulation of minerals, soil-roots-leaves and twigs-soil, contribute to this result. But the phosphate seems also to accelerate the decomposition of peat and the release of nutrients by fungal or mycorrhyzal action. The exact *modus operandi* is still a matter of conjecture and is a field of fundamental research still largely unexplored.

Peat Afforestation in Ireland: Introduction of New Techniques

The Irish Forest Service followed with keen interest these developments in Britain and in 1951, when machinery imports again became freely available after World War II, twenty-two tractor-and-plough units were purchased. Considerable experience has been gained in the use of this type of equipment and ploughing is now accepted practice on peat soils. The use of phosphatic fertilizers has also been adopted on poor sites and preliminary results are promising. The groundwork had been done in Britain and Irish investigations are concentrated on ascertaining the optimum quantity, form and time of application according to site fertility and tree species.

As a consequence of these developments it is now possible to establish plantations on bogland which requires intensive preparation and application of phosphates within an all-in cost of £20, including fencing, draining, ploughing, plants, planting and fertilizing. Percentage of planting failures is reduced and little or no cleaning of competing vegetation is required. With costs more than halved as compared with hand methods and satisfactory growth, afforestation of bogland can be an economic proposition.

USE OF PINUS CONTORTA ON PEATS

At this stage it becomes necessary to refer to what is, perhaps, the greatest divergence as between British and Irish afforestation practice. Irish foresters have been cautious in the use of spruce (which is regarded as a more exacting " successor " species) on poor peats, especially when heathers (*Calluna* and *Erica* spp.) are present in any quantity. In such cases reliance has been placed on *Pinus contorta* (Douglas), an importation from the Pacific coast of North America. Although this species is widely distributed in its native habitat where it is estimated to account for one-third of the total growing stock, it has been little studied for afforestation work by United States or Canadian foresters. It is practically unknown in artificial afforestation outside Britain, New Zealand and Ireland. New Zealand has planted only about 3,000 acres of *Pinus contorta*, and in Britain its use has also been very limited—although its value as a " pioneer " is coming to be more highly appreciated.

In Ireland *Pinus contorta* has proved invaluable, frequently thriving in conditions where everything but Mountain Pine (*Pinus montana*), which is hardly a timber tree, failed. The oldest forest plot is now thirty-three years planted; but there are some 3,000 acres twenty years or over; and some 20,000 acres under twenty years. Almost all is on peat soils or on soils with at least a skin of peat. In view of the special Irish experience with this species some silvicultural notes with special reference to peat soils may prove of value.

This species has a wide range of variation from the Shore provenance, *P. contorta*, true or restricted sense, to the inland mountain, Lodgepole type, *P. contorta, var. Murrayana, P.C. var. latifolia*, reaching altitudes of up to 11,000 feet. Several distinct provenances occur in Irish forests but preference is given to the lowland or shore type, seed supply being received from the Lulu Islands off British Columbia. This is of more rapid height growth, with dense canopy and is generally more aggressive than the mountain types but stem form is more variable. 1 + 1 plants (one year in seed-beds, one year in transplant lines) are usually well rooted and are most satisfactory for cheap turf or ribbon planting with a dibble. Under favourable soil conditions growth in early years is rapid and this has led to difficulties on peats of moderate to high fertility, e.g., on flushes with strong *Molinia* dominant, *Calluna* sub-dominant. In such circumstances strong, bushy crowns are formed with leaders of 2-3 feet annual growth within three to four years of planting; and many plants tend to heel over when 4 to 8 feet high, especially on exposed sites. Check follows and the trees may grow on vertically but with a twisted butt which detracts from the timber value. On fertile peats there is some evidence that fast grown stands may never regain stability; there are examples of stands in the 40-50 feet height class with all stems leaning away from the wind and numerous recent windfalls. On the other hand a recent survey (1952) of all stands seventeen years and upwards indicates that the great

majority had an adequate proportion of straight stems. It seems that on less fertile peats growth is reasonably slow and upright, especially when the peat itself is firm. or made so by deep drainage. Experience as regards stability points to three significant factors: (1) Avoidance of fertile peats capable of growing spruces; (2) intensive, deep drainage; (3) early attention to thinning—as soon as advanced groups are fit to prune. Further investigation of various provenances in regard to stability and stem form is also indicated.

At the other end of the scale, on the poorest peats characterized by the presence of *Scirpus caespitosus* and weak-stunted growth of *Calluna*, *Erica tetralix*, *Eriophorum*, *Molinia*, etc., *Pinus contorta* tends to go into prolonged check with short yellowish needles persisting only one year. On such sites, there are indications that small phosphate applications can have a dramatic effect which persists over many years. Pinus contorta has proved extremely sensitive in its response to phosphate and there is grave danger of forcing frowth to the point of instability. Determination of critical rate of application, therefore, requires the most careful investigation and trial plots were laid down in 1952-53.

Use of Spruce

The new afforestation techniques also called for a new approach to selection of species. Owing to difficulties in establishing spruce on peats of intermediate fertility by the older methods, *Pinus contorta* came to be used as a substitute. It now seems evident that these are better suited to Sitka Spruce, with ploughing and phosphate application to overcome the initial check customary with this species. It would be dangerous, however, to push spruce too far on infertile peats where the crop might go into check after a promising start boosted by phosphate. On the more fertile moist peat types (*Molinia* and *Juncus* types) spruce is the normal selection—Sitka in the western and exposed areas, Norway in the Midlands and valley bottoms where spring frosts are severe.

Classification of Irish Peats

In the second part of this paper it is proposed to examine the problems of forestry in relation to the two main Irish peat types—Raised and Blanket Bogs. The third general classification, Valley Bogs, covers a restricted area and from the practical forestry angle approximate either of the two main types.

Raised Bogs

These are well-defined entities, usually with a considerable depth of peat, the upper layers consisting of only slightly humified, highly acid, *sphagnum* peat. While there is evidence from estate planting that, with heavy expenditure on drainage and fertilization, trees can be made to grow on *sphagnum* peat, the Forestry Division has not

undertaken any large-scale afforestation of virgin raised bogs. In many parts of the Central Plain where these bogs occur, turbary for local users is already scarce and the raised bogs still extant are likely to be developed within reasonable time by local initiative, by Land Commission turbary schemes, or by Bord na Mona. Systematic development for fuel is accepted as a priority use by the Forestry Authorities and the cut-over bog will normally be a better forestry subject than the virgin bog.

Unfortunately, much private turf-cutting has been haphazard, and the cut-over has been left in a very irregular and uneven state, with fall for drainage difficult or impossible. These difficulties are accentuated where first cutting failed to reach the marl base and second cutting followed, perhaps generations later, without any proper face-bank or method, leaving high banks of *sphagnum* peat alternating with deep bog-holes. Such areas cannot be afforested economically and are in danger of remaining a permanent eyesore of waste land. On the other hand there is adequate evidence of successful forestry on systematically worked raised bog under the traditional hand methods in which the top layer of young *sphagnum* peat was discarded as fuel and thrown back to form, with the spoil from various depths, the new levelled surface. The Forestry Division includes such afforestation in their normal programmes at many forests, using Scots Pine, Norway Spruce and *Pinus contorta* as the main species. Provision of satisfactory drainage outfalls is the most critical factor.

It is noted with satisfaction that Bord na Mona, in its operations, is mindful of the state of the cut-over bog, providing for an adequate depth of spoil on a level cut-over surface and for satisfactory drainage outfalls. The cut-over resulting from use of the Bagger machines should not be markedly different from that after hand cutting and the afforestation problems are likely to prove similar.

In the case of raised bog developed by milled peat methods the cut-over will usually consist of undisturbed bottom peat of the alkaline fen type. This is of high fertility and afforestation should not present insoluble problems.

Irish Central Plain bogs contain unusually large tree stumps and often entire boles of *Pinus sylvestris*. As well as presenting a problem to the fuel cutter these may prevent the use of mechanical drainage equipment and increase afforestation costs considerably. The depth of spoil over the marl needs also to be considered. In view of the unfavourable nature of the substrate, it seems desirable to leave not less than 3 feet of spoil in order to allow for settlement and losses by decomposition.

The decision on final use as between agriculture and forestry of cut-over raised bogs is, of course, a matter of high policy but the case for forestry may be put briefly as follows: Ireland is generously endowed with arable land by European standards—3-4 acres per head. On the other hand she is critically short of forest, with only

1/10th acre per head. She produces an agricultural surplus but only a fraction of her timber requirements. There is, therefore, a strong case for reversing the Continental order of priority as between agriculture and forestry, especially while output from the present arable acreage remains so much below its potential and could be raised substantially at a low " per unit " cost. Finally, planting of cut-over bogland would obviate the necessity for transferring a corresponding acreage of rough grazings from agricultural to forest use.

Blanket Bogs: Origin and Variations

Blanket bog covers large expanses in the western counties, especially in Kerry, Galway, Mayo and Donegal, where low summer temperatures, high rainfall, constantly high relative humidity and acidic rocks prevail. While ecologists attempt to draw sharp genetic distinctions between blanket, valley and raised bog and heathland, from the forestry point of view there appear to be many gradations between the types. While blanket bog is definitely associated with well-recognized climatic conditions its degree of development or maturity is greatly affected by soil and topography, base-rich, free-draining soils and the steeper slopes being resistant to the peat-forming process. While in the case of the broad, flat, pool-studded expanses, peat formation may have begun under lake conditions, it is clear that such conditions are not a necessary pre-requisite for blanket bog formation. Numerous observations over a number of years of western soil profiles under blanket bog suggest strongly that on sloping ground and in undulating terrain, the post-glacial soils were rather coarse, free-draining, acidic sands and gravels such as would support a pine-heath vegetation. Under a leaching climate a strong podsol profile developed with impermeable hardpan and consequential drainage impedance at the mineral surface. Then followed the development of an exaggerated A^0 podsol horizon to a thickness usually of several feet. The blanket bog is, therefore, very frequently a variant of the podsol under Sub-Atlantic climatic conditions. Under drier conditions the parent material would give rise to heath or dry pine forest. In fact on a steep, sandy ridge (where drainage conditions are naturally very favourable) surrounded by typical pool peat at Oweninny, Co. Mayo, there is developed a strong heath community (Callunetum) on a dry, firm, heather peat which, however, exceeds 2 feet in depth.

Even within the extreme oceanic climatic region it should be realized that, in response to soil, topography and seepage of mineral-charged water, there are numerous variations of blanket bog which are of significance to the forester and which (in addition to the important exposure factor) have been taken into account in choosing the initial areas for afforestation.

Outside the extreme western type drier variants of blanket bog occur under the influence of local climate in the mountain ranges.

On the gentle slopes of the Old Red Sandstone hills of East Clare and South-east Galway—the Slieve Aughty mountains—apart from hollows, the peat is firmer and drier and usual depth is less than 18 inches as compared with 24-28 inches under similar topographic conditions in the extreme West. Again, on the Old Red Sandstone ranges of the South (Galtees, etc.) on gentle slopes and plateaux, firm peats of less than 12 inches in depth over podsol with hardpan are frequent. In the vegetation *Calluna* is dominant over a continuous but diffuse, layer of *Molinia*, with *Scirpus* occasional. This appears to be a transition between blanket bog and heath, the latter community being of extremely limited occurrence under Irish climatic conditions.

Afforestation on Blanket Bog and Related Types

Some private attempts at afforestation of western blanket bog were made during the last century but these were usually on a small scale, exact records of treatment are lacking, and in general, little success was achieved. Probably the most ambitious effort was at Ballynahinch (Co. Galway), where a wide variety of species (e.g., Austrian, Corsican, Scots and Maritime Pines, Norway Spruce, *Picea alba*) were planted some fifty to seventy years ago. These failed to form a crop but stunted specimens still survive, especially of *Picea alba*. Plantings on adjoining mineral soils did well.

The only other large-scale effort before the establishment of the Forest Service was at Knockboy (Co. Galway) by the Congested Districts Board between 1891 and 1900. About 1,000 acres were planted, 3,000,000 trees and some twenty-five species then known to European foresters being used. The area was particularly ill-chosen and would afford little prospects of success even by up-to-date methods. The plantation is one mile from the coast on rising ground, elevation 50 ft.-250 ft., in a most exposed peninsula, open to Atlantic winds from north, south and west. The southern half was on poor peat about 10 feet deep and, after repeated planting failures, was abandoned to turbary use. The northern half varied from solid granite outcrop to peat of depths up to 3 feet over solid granite. Mountain pine scrub has reached 8 feet in height on this peat but other species made little headway except in sheltered hollows amounting in all to about 15 acres where the peat had an admixture of mineral matter. On these pockets, *Pinus radiata* has done best (50 ft. high, 10 ins.—Q.G.B.H.). *Cupressus macrocarpa* and Maritime Pine also did well, followed by Sitka Spruce, *Thuya plicata*, *Abies alba*, Grey Poplar (*P. canescens*).

After this inauspicious start the State did not look favourably on projects for large-scale afforestation of western peats. After the establishment of the Forest Service from 1904 onwards attention was directed towards the Midlands and the south-eastern highlands where conditions were more favourable. About 1935, after considerable experience with peat in the east, work extended to the Slieve

PHOTOGRAPH I

NEPHIN BEG PILOT PLOT, JULY, 1951

Drain and ribbon after peat draining plough, turves beside drain. Vegetation beginning to respond, e.g., *Myrica* 10 ins. (against rubber boot).

PHOTOGRAPH II

NEPHIN BEG PILOT PLOT, APRIL, 1954

Area treated with Basic Slag on right of soil sampler; untreated area on left. *Molinia* extremely vigorous, especially along slagged "ribbon." *Calluna* and *Myrica* also show strong response.

PHOTOGRAPH III

NEPHIN BEG PILOT PLOT, APRIL, 1954

Pinus contorta plant on right treated with 2 oz. Basic Slag. *Molinia* and *Myrica* now dominant. *Calluna* on left.

PHOTOGRAPH IV

NEPHIN BEG PILOT PLOT, APRIL, 1954

Pinus contorta plant without slag treatment. *Molinia*, strong *Myrica*. *Calluna*, some *Eriophorum vaginatum*.

Aughty peats on the Galway-Clare border. In 1936 a forest was established at Pettigo (Co. Donegal) on blanket bog, but planting was confined to the more fertile areas with manual preparation and turf planting. In 1951, with the introduction of new techniques which promised results on deep peats, action was taken to establish a number of forests well distributed through the western blanket bog regions, and afforestation on blanket bog types is now proceeding at the following centres:

Co. Kerry—Brosna.
Co. Galway—Maam Valley, Ballynahnich, Ross, Cloosh Valley.
Co. Mayo—Doolough, Nephin Beg.
Co. Sligo—Lough Talt.
Co. Donegal—Gweedore, Ballybofey (Crohonagh).

In addition, the more difficult peats at Pettigo, Co. Donegal, and some other forests, are now being tackled.

It is, of course, too early to draw definite conclusions in such a long-term business as forestry necessarily is, but there are at least preliminary indications that the new methods will yield tangible results where older methods were a complete failure.

Description of Pilot Experiment

As an example, the first plot planted on deep blanket bog in the spring of 1951 at Nephin Beg Forest is worthy of detailed description.

Situation : 7 miles north of Newport, Co. Mayo.

Elevation, Exposure : 130 ft.; good shelter from west, south-west and north-west by mountain range 830 ft.- 2,340 ft.—exposure slight to moderate.

Peat : Deep peat, brown and fibrous for first 20 ins. at least, lying between a peat-covered, sandy ridge and the broad quagmire flats bordering the Srahmore River; there are slight flush effects along seepage channels; very soft and waterlogged before ploughing.

Vegetation, 1951 : Dwarf, diffuse vegetation without definite dominants: main species: *Molinia, Eriophorum vaginatum, Calluna vulgaris, Erica tetralix, Sphagnum* spp; *Narthecium, Schoenus nigricans* and *Rhynchospora alba ; Myrica gale*, local, mainly along seepage channels.

Treatment : Drains opened with single mouldboard draining plough. Ploughed 20 ins. deep with double mouldboard planting plough, furrows 10 ft. escapement, ribbons 5 ft., the sods lying on their sides, not inverted. Due to waterlogged soft peat, cleats had to be used to extend tracks to $3\frac{1}{2}$ ft. Planted with 1 + 1 *Pinus contorta*, Lulu Island origin, at 5 ft. x 5 ft. with semi-circular spades. Five acres were treated with 2 oz. basic slag applied around each plant on surface of ribbon shortly after planting; remainder was left unslagged as control strips. Photograph I shows area in July, 1951—turves used beside drain. Vegetation is beginning to respond, especially *Myrica*.

Inspections in August, 1953, and April, 1954, indicate considerable changes. Photograph II (April, 1954) shows slagged area to right of soil sampler and unslagged area to left. Drainage is effective vegetation has increased considerably in vigour and height on both types. *Calluna*, *Molinia* and *Myrica* (up to 30 ins.) have responded well, the two former tending to form a closed community with *Erica tetralix* occasional, ousting weaker species of waterlogged conditions such as *Rhynchospora* and *sphagnum*. The surface of the ribbon remains bare except for vegetative invasion of *Molinia* and germination is largely confined to the slagged patches. Here the moss, *Ceratodon purpureus* (Hedw.) Brid., forms dense colonies and the surface peat has blackened and is evidently decomposing. In a few cases strong plants of *Juncus communis* have become established on the slagged patch. *Molinia* is strongest along the margin of the ribbon, especially close to the point of application of the slag.

The contrast in the development of the *Pinus contorta* after three growing seasons shows clearly in Photograph II. The slagged plants are well furnished and average around 30 inches, with leaders of 10-16 inches last season. A typical vigorous plant had successive annual growth of 4, 8 and 16 inches. The first row of unslagged plants between drain and soil sampler are intermediate in development, while the plants on left of drain average rather less than 12 inches, with short yellowish needles and growth of 3-4 inches last season. Photographs III and IV show the contrast between typical slagged and unslagged plants.

In view of the strong response it is now thought that smaller phosphate applications would be safer and sufficient; and adjoining trial plots tend to support this view on the basis of one season's growth. In the first year 1 oz. of either Basic Slag or Ground Mineral Phosphate has given results not noticeably inferior to the heavier application. Pending further observations, phosphate applications on *Pinus contorta* in general are being reduced.

Afforestation After Milled Peat Operations

It is understood that Bord na Mona intends to use the milled peat method on western blanket bogs. The outlook for forestry on the subsequent cut-over area is not as clear as in the case of the Midland raised bogs. The residual bottom peat will be highly acid, highly humified, of low fertility and permeability, with pine stumps as a further possible obstacle. Drainage and aeration may prove difficult as compared with fibrous, slightly humified peats. Where this peat is underlain by a sand with shallow, leached layer over hardpan, the best prospects would appear to be in deep ploughing, breaking through the pan in order to allow free vertical water movement and mixing sand from A and B horizons with the peat. In this case optimum depth of peat after milling would be 9-12 inches or even less. Pilot plots on a sample area (when available) would be worth while.

Conclusion

From this summary of afforestation work on peats it will be seen that the Forest Service is fully alive to the problems and possibilities involved. Substantial areas have been acquired and a determined effort is being made to convert bogland to productive forest land. Satisfactory results have been achieved already on peats outside the western blanket bog region. There is now a steadily increasing concentration of planting operations in western districts and representative areas of all peat types are under investigation and trial. The present attitude is one of qualified optimism and it is hoped to overcome all obstacles and to foster the development of an integrated timber production and utilization industry in the West, thereby making a major contribution based on natural resources towards the rehabilitation of the Congested Districts.

DAY EXCURSIONS FOR 1954

The Society's practice of holding day excursions to places of forestry interest was continued during the year. All outings were well attended and many lively and interesting discussions arose.

The first outing was on Sunday, April 25, when we visited Ballinagee property of Hollywood Forest, Co. Wicklow, by kind permission of the Minister for Lands.

The main theme of this excursion was the preparation and planting of the poorer mountain peat types. Particular reference was made to the application of machinery to ground preparation; to the selection of species and to the use of artificial manures as an aid to establishment.

Our second outing was to Gloster, Roscrea, the estate of Major E. T. T. Lloyd. The woodlands here, though not of large extent, provided material for some very interesting debates and during the day many different aspects of sylvicultural management were fully discussed. In the evening we were entertained to tea by Major and Mrs. Lloyd. To private woodland owners this was both an interesting and profitable excursion.

Our next outing was to Slievenamon Forest. Discussions here centred round selection of species and seed provenance. Two small stands of Silver Fir and Eucalyptus provoked what were probably the most interesting of the sylvicultural discussions.

In September we visited Glaslough Demesne by kind invitation of Sir Shane Leslie. Unfortunately, Sir Shane was not able to be present as he was then in hospital, nevertheless, the day was most enjoyable and interesting. Of particular interest was the Pinetum and the large specimen trees scattered through the woods.

Our last excursion was to Glenealy Forest in October, again by kind permission of the Minister for Lands. The main interest of this outing was in the Eucalyptus stands. Many different species were used in the plantings but full information on all the plots in respect of both species and treatment, was given by the Conveners.

ELEVENTH ANNUAL EXCURSION

For the eleventh annual excursion the Society travelled to the Lake District where we were the guests of the British Forestry Commission. The visit, which lasted from the 1st to the 4th June, was an outstanding success and the Society owes a great debt of

gratitude to Mr. Barrington, Conservator for North-west England, and to the other officers and friends who were to a very large extent responsible for the success of the excursion.

FIRST DAY

After a halt for coffee in Carnforth we visited Dalton Forest where the District Officer, Mr. Crossland, welcomed us on behalf of the Forestry Commission.

Dalton Forest comprises a series of detached blocks with a total area of 833 acres, of which 743 acres are plantable. The annual planting programme is 70 acres and the plantable reserve is 345 acres. Of principal sylvicultural interest was an area of outcropping carboniferous limestone at Dalton Crags. Although heavily eroded the area provides potentially a soil of high fertility. The immediate problem is to establish a pioneer crop to protect the surface and accumulate leaf fall for soil improvement. The final crop is intended to be beech.

Our next stop was at Foulshaw Woods (Westmoreland) where a central block of 447 acres contains over 20 feet in depth of peat, the base of which is at tide level. This is a recently acquired area and the approach to its afforestation has been to a great extent experimental. In the spring of 1953 a series of trial pilot plots was laid down as a guide to the establishment of likely species on five main vegetational types, namely: (1) Pure Molinia; (2) Pure Calluna and other heathers; (3) Myrtle; (4) Bracken Shelf; (5) Groups of Natural Birch. A sixth plot was turfed and left for natural regeneration of Scots Pine. The pilot plots for each type were S.P., Thuya, P.C. Red Oak, sessile oak, Tsuga. The plots which show most promise are P.C. Tsuga and S.P., and Red Oak which, so far, is doing remarkably well on a sphagnum peat. Direct sowing of Scots Pine has also been tried on a small scale.

On the second day we travelled by bus from our headquarters in Windermere to Thornthwaite forest in Cumberland. This forest comprises an area of 5,515 acres made up of a number of detached blocks lying to the east, west and north of Bassenthwaite Lake, with extensions westwards through the Whinlatter Pass. The geological formation is Ordovician (Skiddaw slates) and only the lower slopes and benches carry appreciable deposits of glacial drift. Rate of planting is slightly over 100 acres per annum and the species used are Doublas Fir on the lower slopes, European Larch and Japanese Larch on the intermediate slopes, and Sitka Spruce and some Norway Spruce on the higher slopes. Planting has been taken successfully to 1,600 feet and experimentally, to over 1,700 feet.

The first planting was carried out in 1920 and the first thinning in 1937. Over 2,000 acres are now at the thinning stage. Last year 225,000 c.f. were extracted at a cost of 6*d.* per c.f.

During the last seven years 35 miles of forest roads were constructed. Of these 17 miles of main roads and 9 miles of feeder

roads are capable of carrying motor traffic. The cost of roads amounted to £100,000 of £25 per acre. All main roads and feeders have 9 ft. of metalled surface. Tarmacadam was used on the steep slopes (gradient 1′ to 4′ or 5′) to prevent undercutting and erosion.

The administrative centre of the forest was a spacious tarmacadamed area on which a number of buildings stood. The forest office is a two-roomed wooden structure 11′ by 20′. It is linked with two telephone points in the forest. In the mechanics shop (50′ x 40′) we saw a bus being sprayed and a lorry engine undergoing repairs. In the coachbuilding shed a lorry body was under construction. A point of interest was the extensive use made of buses in the running of the forest. Buses were used for bringing in labour, as mobile offices, shelters, stores, repair units. Other features of the administrative centre were a loading bank, wet weather shed, creosote tank, petrol and oil store, etc.

Fire-fighting equipment consists of a jeep with a petrol-powered pump attachment and a light mobile petrol powered pump which can be carried by two men. Special fire-fighting reference maps are kept in the District Office, Foresters' Office, Local Fire Brigade, and Local Army H.Q. Fixed rendezvous are marked on the maps and by reference to these points delay and confusion can be avoided in times of emergency.

During our tour of the forest we were most impressed by the high degree of organization brought to bear on all forest operations. The tarriff table system, described as an accurate method of measuring standing thinnings, was explained by the District Officer, Mr. Begley.

Those who participated will for long remember Thornthwaite for its many points of sylvicultural interest and for the many fine views it afforded of the enchanting countryside in which it is situated.

In the evening the Society entertained those associated with our excursion to dinner, which proved a most enjoyable function.

THIRD DAY

On Thursday the Society visited Grizedale Forest (Lancashire). This forest comprises some 5,807 acres distributed as follows: Plantations acquired, 222 acres; Plantations laid down up to September, 1953, 4,016 acres; Nursery, 1 acre; Plantable reserve, 593 acres; Agricultural land, 893 acres; Unplantable and others, 82 acres; Total, 5,807 acres.

Grizedale Forest covers a compact area of the High Furness fells centred on Satterthwaite and extending from Coniston Water on the west to Esthwaite Water on the east. Two small detached blocks lie to the north of Hawkshead. Large areas of existing woodland were acquired with the Grizedale Hall estate, and over half a million hoppus feet of timber was felled from these during the last war. Planting started in 1937 and has proceeded at an average, but rather variable, rate of about 240 acres a year. Thinning of the first

formed plantations started in 1952; in addition there is a steady programme of work in the remaining woods. Existing estate cottages have been augmented by fourteen new houses built under Ministry of Works contract and completed in 1948/49.

Climate is relatively mild and the rainfall high (about 70 inches per annum) and well distributed. The higher ground above 800 feet is fully exposed. The geological formation is Silurian, with a characteristic broken topography of rocky knolls, interspersed with stretches of glacial drift and peaty hollows. Variable site conditions provide scope for planting a wide range of tree species.

The agricultural land remains under Forestry Commission management and a feature of the forest is the close integration of land use made possible by this arrangement. As the poorer grazing has been taken progressively for planting the principal farms have turned over largely to dairying, and this change will be helped by the extension of mains electricity which an increased population has now made economic.

Grizedale Hall, used as a prisoner-of-war camp for German officers during the war, is at present unoccupied, but the associated buildings have all been put to good use, and house one of the Commission's principal seed-stores, tools and equipment, offices, garages and repair shops. The walled garden is converted to a small nursery for raising ornamental and other trees for special purposes; part of it, with the associated glass houses, is employed by Research Branch for work on vegetative propagation and tree breeding. The former estate sawmill, in full production during the war, at present cuts only small lots of timber for estate use.

The remaining estate woodlands are being preserved and managed with particular attention to their amenity value. They include interesting examples of former oak coppice, typical of the Furness area, under conversion to high forest, and older specimen trees and plantations of coniferous species now being planted on a large scale. Natural regeneration of both hard woods and conifers occurs freely under suitable conditions and has been helped by the virtual extermination of rabbits.

Red, fallow and roe deer are present in small numbers. There are no grey squirrels. Acute fire risk occurs for short periods only.

With the approach of large-scale thinning, and to provide necessary access to the more remote parts of the forest, the forest road system is being progressively extended, and nearly eleven miles of all weather roads have been constructed since 1947. This work began initially as part of a post-war labour relief scheme for the Barrow area and many of the men employed on it, and on forest operations, are still recruited from that district.

Grizedale Forest at present provides direct employment for seventy-eight men or, on forest operations only, one man to every 71.8 acres of existing plantations.

ACKNOWLEDGMENT

In June, 1954 an International Peat Symposium under the auspices of Bord na Mona was held in Dublin. We wish to thank Bord na Mona for permission to publish some of the papers presented to the Symposium which we hope will be of interest and benefit to our readers.

ANNOUNCEMENT

The Council of the Society has authorized payment at the approximate rate of £1 per 1,000 words, subject to a maximum payment of £5, for any one article, for all original articles or notes of forest interest, which may be published in *Irish Forestry*.

The Editor is particularly anxious to receive short notes touching on any aspect of forestry interest, even if of a local nature only, such as unusual frost damage in windthrow, insect or fungal attacks, etc. We are planting in conditions of soil and altitude in which we have little experience, exotics which have been inadequately tested and the field for observation and record is very wide indeed.

He would also like to hear from Associate Members, not necessarily on tJchnical matters but touching on the general aspects of forest policy and the views of private woodland owners.

To encourage those who may be diffident about authorship these contributions may be in the informal style of " Notes " or " Letters to the Editor."

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