Irish Peats and their Drainage for Afforestation

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INTRODUCTION :

Systems of drainage, like peats evolve with time and this evolution has been extremely obvious in forestry. In Northern Ireland our evolution has been proceeding actively since 1949. Evolution is brought about by progressive changes of state and where this process is applied to ideas a healthy, forward looking state of mind is indicated. It is essential, however, that the ideas are soundly based on scientific fact. In the case of the drainage of peat there appears to be a dearth of such facts. As a result foresters sometimes have doubts about their solution to the drainage problem. This paper does not purport to supply basic scientific facts required, but is designed to stimulate a more basic approach and to build a foundation from which a more fundamental consideration of the problem may be made.

O'Leary (1955) said:
"Before an intelligent approach can be made towards the large scale exploitation of bog for any purpose—even for fuel production—it is necessary to appreciate to some extent the broad history of peat deposition and the main features of the principal peat types, so that the problems of development may be dealt with effectively".

In essence what will be attempted in this paper will be the preparation of a literature survey of peat and its drainage problems with reference to afforestation in Ireland. Together with Dr. Black's paper it will, if not directly solving our problems, analyse them basically. The analysis may then be used as a check list to determine the extent of our success to date and plan future research work.

O'Leary's quotation, then, is where this paper must begin—with an explanation of the principal peat types in Ireland. By a process of elimination we will arrive at the main type of peat confronting foresters and it will be investigated in greater detail.

PART I: FORMATION AND CLASSIFICATION OF PEAT

HISTORICAL:

Peat has been studied for many years, not only in Ireland where it is so familiar, but in Britain and on the continent as well. As far back as 1535, John Leland described peat lands in England and Wales using such familiar descriptive terms as Moor, Moss, Marsh, Fen and Carr. Gorham (1953) quotes Gerard Boate (1652) as the first person known to attempt a classification of peat lands.

Boate was Doctor of Physics to the State of Ireland and his classification is contained in his treatise on Ireland's Natural History which was published in 1652. It is interesting to know that this treatise was prepared "by remote control" in that Gorham (1953) comments that it appeared to be completed before Boate set foot in Ireland. His sources of information were his brother and other gentlemen resident in Ireland. Other workers and commentators through the ages were William King (1685), a Fellow of the Royal Dublin Society, Arthur Young (1780) and Griffith (1810-1811). Many well founded views on the formation and action of peat were expressed by these men and also the authors (anon.) of Reports of the commissioners appointed to enquire into the nature and extent of several bogs in Ireland: and the practicability of draining and cultivating them (Vols. I-IV 1810-14). Less well founded, however was the view of Dr. Anderson of Aberdeenshire expressed in 1794. He supported the hypothesis of early Dutch naturalists that a peat bog was a living growing organism, and that the surface vegetation merely grew upon its dead outer skin—Gorham (1957). Rennie (1807) in opposing this hypothesis stated that he would "dismiss this new species of vegetable from the list of plants, till its habits and qualities are distinctly ascertained. I would only suggest, that of all devouring monsters it must be the most dreadful, according to the Doctor's account, for, as I shall show, ploughed fields, large trees, loaded boats, men and women, and the largest animals, houses, nay, streets and whole cities, have been swallowed up in its all devouring jaws". It is however to the modern workers that we must turn for an appreciation of peat based on sound scientific facts.

FORMATION AND CLASSIFICATION

Peat for all its apparent simplicity is a most difficult substance to define. To be exceedingly brief one can put it in a nutshell and say that it is a form of humus which, like mor, forms a covering above the mineral soil from which it is sharply demarcated. (Tamm, 1950). It is the effect of climate topography and soil on this humus formation that complicates the basic product. McConaghy and McAllister (19—) state that under natural conditions the amount of humus usually reaches, and is maintained at, an optimum value if conditions such as drainage, soil base supplies, etc., remain satisfactory. Any definite deterioration in these conditions may seriously upset the balance between oxidative decomposition (i.e. to carbon-di-oxide decomposition) of organic matter and may completely change the type of humification. Such changes are responsible for the formation and accumulation of peaty organic matter.

In describing peat it is necessary to consider the conditions under which it is formed. Also, in describing peat formation it becomes classified automatically. Many different classifications exist, each however, more or less suited to a particular country or environment. For example a German school of classification uses the terms :—

Hochmore — or high bog.
Neidermoore — or low bog.
Ubergangsmoore — or transition bogs.

Barry (1954) comments that while this classification was intended to fit the bogs of North West Germany and the Netherlands it primarily applied fairly well to Ireland's raised bogs but not to the western blanket and high level bogs. On considering further the classification and terminologies of other European schools it becomes more evident that all are completely or partially unsuitable and that a classification locally evolved in Ireland, if possible in this case for Northern Irish conditions, is required. While a substantial amount of work has been done and commentaries written in the Republic of Ireland (Barry 1954, Condon 1961, Jessen 1949, McEvoy 1954, and Mitchell) only the division described by McConaghy and McAllister (19—) appears specific to Northern Ireland. This classification by formation is as follows :—

I. Acid-peat or raw humus soil developing by an acid type of humification under conditions of good drainage.

II. Peats developing under drainage conditions which may be due to impermeable or slowly permeable subsoils or to high water table.

III. Peats accumulating under waterlogged conditions due mainly to the influence of rain water, high humidity and low temperatures.

I. Raw humus or "mor" humus

This type of peat is formed under cool humid conditions where drainage is good with no appreciable reserves of lime or other bases. In essense the raw humus here forms part of a typical podsol profile and its depth although generally shallow is variable. The authors state that in some podsols there may be a distinct separation in the zones of humus and of iron enrichment within the B horizon. This may occur as the level of water table rises and is accompanied by an increase in the depth of surface peat which changes from the "mor" or acid humus type developed under free drainage to bog peat. The lower parts of the profile may begin to show some mottling due to reducing conditions and oxidising conditions coexisting and a Gley horizon becomes evident. This process is also described by Tamm (1950—pp. 130-131). As the ground water level continues to rise the growth of surface peat increases and the movement of humus and sequioxides from the surface decreases. The ultimate development is peat bog. Tamm (1950—p.118) reckons that the limit of the peat's thickness at which podolisation ceases seems to lie at about 12 inches. Fraser (1933) terms this soil a gley-podsol and states that it is found below the greater area of the more shallow peat in places where the topography is fairly regular or on slopes which are not very steep. This peat type is often referred to as "soligenous" in that its ground water is derived from the soil. Peats formed by this process are common on the quaternary deposits (i.e. areas of deposits of glacial sands and gravels) in counties Tyrone ınd Londonderry. This is undoubtedly the Moraine Heath type of peat recognised by Fraser (1933).

Since the peat is generally little over 12 inches deep and since only limited areas have been acquired for afforestation it presents a relatively small problem.

Drainage, however, is not so serious a problem and it is recorded that quite extensive reclamation of this type for grassland has been successful in Tyrone and Londondeery (Sherrard (1953).

II. Peats developed under poor drainage conditions

The peat developed under these conditions is similar to that well described by Fraser (1933) and termed Basin Moor. McConaghy and McAllister follow another of the more common present day terminologies and use the name Basin peat. The term Basin bog is also frequently used. Fraser (1933) cites the English Fens as the best example of this type of peat formation but notes that the process is similar in regions of low elevation at the free water surface of shallow lakes or in basin-like depressions where water collects through faulty drainage and where water movement is hindered to such a degree that floating and marsh plants may become established. In the still, shallow water conditions growth is greater on the water margin. Plant debris accumulates on the bed of the lake and in time the rim is raised to the level of the water surface. The marsh plants continue to build up the margin producing a saucer like effect. This stage Fraser (1933) terms Low moor. The process continues towards the centre of the water area and as it does the original marginal area becomes drier. Eventually when the surface levels out the stage of Transition or Flat moor is reached. The final stage in this progression is High moor when the profile assumes the shape of an inverted saucer due to the continued growth of vegetation in the centre of the previous pool towards which much of the surface water flow. McConaghy and McAllister (19—) quote good examples of this type of peat at Lough Gall, Co. Armagh and in Co. Fermanagh. The vegetation succession referred to above is similar to that seen on the shores of many of our lakes to-day. Reed (*Phragmites*) occurs on the water margin also the Reed-mace (*Typha*). Sedges (*Carex spp.*) then follow the reed formation. This succession, in turn may then be followed by Alder and Willow.

Basin Bog may also occur in areas which are not basins or hollows, as such, but where the subsoil is impermeable giving what may be termed a suspended water- table. (McConaghy and McAllister 19—). Basin Bogs are of yet smaller consequence in the Northern Ireland afforestation programme.

III Peats accumulating under water-logged conditions due mainly to the influence of rain water, high humidity and low temperature.

The description of this type of peat commences where we have just left off in that in one of its forms it overgrows Basin Bogs. The change occurs when the developing vegetation, principally sphagnum spp., on these bogs is influenced more by precipitation than ground water. The result, terminologically, of this evolution is Raised Bog. It is so called because of the convex profile it assumes when seen in section. Raised bog types are often termed "ombrogenous" due to their being completely removed from the influence of water from mineral soil.

By virtue of a "hollow-hummock" cycle *calluma* invades the developing medium and a *calluma* type peat eventually emerges. These bogs are extremely common in Ireland especially in the central plain where Jessen (1949) considers their development "magnificent and unique". They are also common in Northern Ireland and several areas such as the Garry Bog have been acquired for afforestation. Raised bogs have been recorded also originating on convex floors, e.g. at Cluain Sosta, where Barry (1964) reports this as a reversal of the classical concept of raised bog formation.

On the higher areas another type of climatic peat is formed. These areas have a well distributed rainfall of from 50 inches to 90 inches, relative humidities are in excess of 80 and precipitation exceeds evaporation over the most of the year. They also have constantly low mean annual temperatures. Formation commences when peat forming plants, e.g. Sphagnum moss, forms on the almost perpetually wet humus layer. Due to the water retaining power of the sphagnum, etc. and to the high precipitation, aeration of the humus layer ceases and the plant remains accumulate to form peat. These plant remains derive from the vegetation familiar to us all, i.e., *Eriophorum spp, Scirpus/Tricophorum caespitosus, Molinia caerula, Narthecium Ossifragum, and Erica tetralix.*

Due to the constant nature of our humid, cool, climate accumulation of this type of peat often exceeds 20 feet.

The term "Blanket Bog" has been coined to describe adequately such a peat formation in that it covers the entire ground surface, slopes and plateous alike. The terms terrain-covering bog (Osvald) and climatic moor (Fraser 1933) are also often used but for simplicity and general understanding Blanket Bog is recommended for use.

In summary now let us look at the three basic peat types again.

I. Acid peat or raw humus in areas of originally good drainage —eventually deteriorating to gley-podsols. Peat relatively shallow. Predominant vegetation *calluna*. Does not present a very serious drainage problem. Area available for afforestation relatively small.

II. Basin Bog/Fen Peat type, formed in waterlogged therefore anaerobic conditions, water Base Rich. Limited application for forestry due to rarity of occurrence. It is principally of interest in that it underlies Raised bogs.

III. Blanket Bog—developed in areas of high rainfall, high humidity and low temperature. Formed therefore from precipitation alone and therefore relatively infertile. Pseudo-fibrous in character (Fraser 1933) and almost gelatinous. Extensive areas available for forestry.

This latter type of peat presents us with our main problem but before passing on to deal specifically with it a word of warning is necessary. While peat has, above, been segregated into three classes it is stressed that the classification of a substance so variable into only three basic types is an over simplification. The worker with peat must at all times realise that there are many variations brought about by both the individual and combined effects of topography, soil and climate and of course the influences of these factors on the vegeation.

As proof of variability of formation in Ireland we have Type I above modified in the western counties of Kerry, Galway, Mayo and Donegal, where low summer temperature, high humidity and high rainfall develop a Blanket peat over the podsol peat. (McEvoy 1954).

There is also the phenomenon of flush peats where mineral rich water passes through the surface of the ground. Such peats may be found in both Raised and Blanket bogs. Fraser (1933) recognises four basic types, Rush Flush, *Molinia* Flush, *Eriophorum vaginatum* Flush and Iron Flush.

Also in an effort to illustrate the variability in Blanket Bog, Condon (1961) in a manner after Zehetmayr (1954) divides it into five types. Dickson (1962) also divides Blanket Bog into types recognising three basic categories. Zehetmayr's, Condon's and Dickson's approaches are exercises in an objective approach to a problem which at first sight appears simple. The problem is of course the effective draining and afforesting of Blankket Peat.

Barry (1954) states "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 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". Barry acknowledges that part of this statement is due to Waksman (1942).

PART II

BLANKET BOG — ITS CHARACTERISTICS AND DRAINAGE

It might be asked at this stage why distinguish between Blanket Bog and Raised Bog and Barry (1954) answers this question in stating that the practical importance of distinguishing between the two types in Ireland stems from the fact that they are fundamentally different as regards such characteristics as drying and rewetting, combustion, chemical constituents, responses to drainage and load bearing qualities for machine use.

Moisture Content

From the work of Dickson (1962) and the observations of Condon (1961) moisture contents of 91% may be expected in the upper 20 inches of Blanket peat. Dickson's figures are given for Lough Navar, Beaghs and Ballypatrick Forests and Condon's for Glenamoy. It is interesting to note that the Glenamoy figure increases to 93.8% in the range of 20 inches-40 inches. From this it drops to 90.1% between depths of 10 ft. and 11 ft. These figures of course indicate stagnation levels where tree roots can not survive. Drainage therefore must be so intensive that the moisture content in the upper layers can be reduced to a degree where healthy root growth and pentration can be promoted. A similar problem also faces those wishing to win peat for fuel. In the latter case effective use of machinery and drying of the processed product may only continue with a greatly reduced water table. It is therefore reassuring to know that others share our problem.

Drainage

The effect of drainage on a peat soil is much more complicated than for a mineral soil. Strictly speaking only surface water (rainfall and snow melt) is easily removed by drainage. The bulk of the water in peat is capillary bound or absorbed by the colloids of the peat. By removing the surface water it is prevented from being taken up by absorption. One of the basic characteristics affecting the movement of water in peat is the degree of humification and O'Hare (1955) stresses that in the same peat profile there is as great a difference in texture as between a heavy clay soil and a sandy loam. This greatly influences the water holding capacity. An indication of the degree of humification is however easy to obtain using the VON POST system. Small samples of peat are squeezed in the hand. If a sample is fresh, clear water is squeezed from the peat. As humification progresses the colour of the exudate changes to brown through yellow. A scale[1] ranging from 1-10 has been drawn up with H1 corresponding to a colourless liquid exudate and H10 to the state when a fully humified amorphous exudate flows through the fingers leaving no residue in the hand.

[1]H1-H4 Clear—Turbid Brown
H5-H7 $\frac{2}{3}$ mass passes through fingers.
H8-H9 70% mass passes through fingers.

For example if the water which runs off is clear or yellowish the degree of decomposition of the peat is not sufficient to permit drying by drainage alone (Tamm—1956).

A slightly decomposed peat has most of its water capillary bound and therefore drainage however intensive has little effect. A well decomposed peat on the other hand responds to evaporation, shrinks and cracks thus permitting the run off of precipitation through the fissures. This and the amount of water capable of being removed from peat by transpiration is of supreme importance when assessing the drainability of a particular peat area. Such an assessment prior to drainage is considered by Tam (1950) to be extremely important and he advocates the use of a Martonne type index which is in essence a matematical expression of the degree of humidity, viz. :—

$$\frac{N}{T+10} = \text{Martonne coefficient}$$

N = Mean annual rainfall.
T = Mean annual temperature.
T+10+ Above+10°

Similar coefficients have been drawn up for Sweden by Hesselman (1932) who called it the humidity coefficient.

Wright (1959) summarises the drainage difficulties in peat thus "—Peat can never be dried by drainage to any significant extent as which peat is composed holds water so tenaceously that lateral flow to an open drain is extremely slow". For practical purposes he restricts it to 2-3 feet on either side and quotes the Lon Mor square chain block of peat isolated in 1936 by trench excavated to the underlying morraine. After 22 years Wright quotes no appreciable change in peat depth or floristic composition of the vegetation. He further states that the function of drainage on deep peat is therefore to remove stagnant water from the site and to give local aeration in early years to trees planted on excavated material. "It is the transpiration of the tree crop which will eventually dry out the peat". (Wright) 1959).

The matter of lateral flow in soils generally is also discussed by Tamm (1950). Unfortunately he does not deal specifically with peat but figures for fine sand of 165-550 yards per annum (Rindell 1919) indicate that peat by virtue of its colloidal structure as opposed to the particle structure of the sand will be infinitely slower irrespective of slope.

This is substantiated by work recorded via Commonwealth of Soils Studies of the rate of free water movement in peaty soils measured with S_{35} revealed a movement of 4-6 cms. per day in the upper horizons of a pine/sphagnun/cottongrass peat. In the underlying soil it was 50-58 cms. per day. In a peaty soil under Alder, Birch and Spiraea, movement was 11-12 cms. per day and in the underlying soil 150 cms. per day. The above work quotes 1 metre per day for movement in the peat/soil zone of contact. Strikingly low as these movement figures may be the movement quoted for Glenamoy peat of 1 cm. per day emphasises clearly the extent of our problem.

The water tenacity of peat is thus well shown. The next step is to examine actual and possible effects from draining.

Possibly the first British worker to approach this problem was Fraser (1933) who reports his findings in what is still a standard reference work. Fraser's work was however limited by the lack of draining machinery. Unfortunately the bulk of references on the drainage of peat refer to peat types other than Blanket Bog. Particular reference is made to cultivation of agricultural crops on peat. A good synopsis of this work is given by Burke and O'Hare (1962) but, as Burke (1961) states, the information is often contradictory. Parkin (1957), O'Carroll (1962) and Dallas (1962) further added to the amount of empirical information. It was not, however, until the classical experiments at the Peatland Research Station of the Agricultural Institute, Glenamoy, Co. Mayo, were commenced that the drainage of Blanket peat could be scientifically assessed. Glenamoy peat is basically similar to the bulk of the Blanket peat in Northern Ireland, if any thing being more gelatinous with a lower hydraulic conductivity. The findings at Glenamoy have been well illustrated in the previous paper.

To recap, research workers have concluded that drains at 12 feet are required for proper watertable control. This spacing gives good control of watertable and affords rapid watertable lowering after rain. It is felt that the maximum distance apart might be increased to 15 feet without serious loss of drainage efficiency. (Burke and O'Hare 1962, Burke 1961 and 1963, Peatland and Experimental Station Guide).

Drainage spacing is one problem of concern, but having decided on an optimum figure one must consider an optimum depth. This is also important from an economic aspect as well. Interim reports on a borehole pumping experiment at Glenamoy have also been quoted indicating that $3\frac{1}{2}$ feet is the optimum level to aim for, but, due to the long term nature of the experiment, results are not yet accepted as final. (Burke, O'Hare, etc.).

Until recently the Glenamoy figures were the only indication of the measurable effect of drainage on water-table in Blanket peats apart from research findings in the Forestry Divisions of the Ministry of Agriculture and the Department of Lands. The results of water-table experiments carried out by Bord na Mona have now been kindly provided. These are for investigations carried out by stand pipe measurements on Western Blanket Bog near Bellacorrig, Co. Mayo. (Tionnsca Abhann Einne—T.A.E.). Measurements were taken across peat fields of 185 ft., 175 ft., 100 ft., 75 ft. and 50 ft. The drains bounding the fields were approximately 4 ft. deep. Original water levels were taken in February 1953 and final levels in April 1954. Intermediate readings were taken in March, April, May, June and October 1953.

Briefly the results bear out the Glenamoy findings showing that the drains have an optimum lateral effect of between 6 and 9 feet. Drops in water level on all fields at midfield may be attributable to evapo-transpiration. A surprising fact is the immediacy of the effect of the drains. In some cases drops of 6" occur in one month.

It is interesting to note that the result of drainage research has been applied in Western Mayo by Min Fheir Teoranta at Geesala. This company produces grass, from reclaimed Western blanket bog, for the manufacture of grass meal. The basic drainage system there is one of 2 ft.-3 ft. drains at 120 ft. spacing. Due to the difficulty of working harvesting machinery over open drains this system is supplemented by mole draining at 12 ft.-15 ft. and about 3 ft. deep. However, some subsidence has occurred as a result of the moleing and local wet areas impossible for machinery have resulted. This experience together with the results of observation has led to a recommendation for the future of a drain matrix at 60 ft. with no mole drains. The success of this venture and of that of the Irish Sugar Company at Gowla using basically similar methods, illustrates that peat can at least be dewatered sufficiently to successfully root grass and to carry quite substantial harvesting machines.

The foregoing information assures foresters that a certain control of water table in Blanket peat may be obtained by varying drain intensities. However, in the interests of economy it is essential that the minimum drainage system capable of growing an optimum crop is required.

The questions now posed are:

1. How effective do we require the drainage to be?
2. How deep will the tree roots go given an optimum root pervious zone. There is an absolute dearth of information on rooting of conifers on deep peat. Steven (1923) is probably the only worker to have approached the problem on a broad scale. His work, however, is of limited value since it preceeded mechanical drainage and ploughing. Yeatman (1955) studied the problem authoritatively for upland heaths and the necessity for a similar approach is indicated

for deep peat. Limited local studies are reported by Jack (1965) but these only stress the necessity for further investigation.

A substantial amount of work has however been done on the subject of optimum rooting level for forest trees on low and raised bogs principally by Heikurainen. Dittich (1954) recommends for "low grade" trees such as *Picea, Pinus* and *Betula* the ground water must be lowered to at least 1½ feet below surface.

In essence the answer to the first question above must be — deep enough to provide a rooting medium capable of sustaining a wind stable crop, certainly not less than 18 inches. Fraser's (1962) interesting paper concluded that drainage significantly increased rooting depth especially on peat.

A considerable amount of the information available on the effect of drainage on water-table comes from agriculturalists and until more facts are produced for forestry these must act as guidance together with the forestry figures we have. A standard reference on this subject is Roe (1936) who working at the University of Minnesota investigated the degree of drainage that produced the best practical results with field and horticultural crops. He found for grass that best results were obtained with a 1½-2 feet depth to ground water level. While fen peat is vastly different in its water holding properties it is interesting to note that Nicholson and Firth (1958) found a ground water level of 2½-3 feet optimum for most crops and 2 feet optimum for potatoes and celery. This example illustrates two marginally interesting points—the difference in permeability of fen peat which enables a ground water level of 3 feet to be achieved and the rooting depth required to provide nutrient for a vegetable crop.

The second question posed above is more difficult to deal with, in other words, it may be asked if it is possibfle to provide a rooting medium of 3 feet, will the roots pentrate to this level. We do know that in Blanket peat a nutrient gradient occurs down the profile, the highest gradients being at the surface. (Brown, Carlisle and White 1964, 1966; Corden 1961; Binns 1962; Walsh and Barry 1958; O'Hare 1955).

Consideration must be given at this stage to the Division's present system and some comment made on it. The drainage layout currently in use is described by Dallas (1962). This layout produces drains approximately 24" deep at 15 feet spacing. For maximum effect it will be remembered that 12 feet spacing at 3 feet depth is optimum. The above is at least a compromise but it must be asked is it adequate? At this stage reference could be made to the results to date of Divisional experiment—Killeter 1/61. This experiment had as a secondary aim the study of the effect of draining on peat vegetation. Drainage patterns used were:

(i) Deep (11"-12") double furrow ploughing at 10' intervals.

(ii) Deep (24"-30") single furrow ploughing at 30' intervals with shallow (9") double furrow ploughing at 10' intervals between.

(iii) Single furrow ploughing (24"-30") deep 6 feet apart.

From ground water level readings taken in standpipes in 1964 and 1966 it appears that the greatest effect comes from the 6 feet spacing single furrow ploughing which provided 33 cubic feet of peat per plant above the water table (Jack 1964). This may be compared with a volume per plant of 15 cubic feet resulting from double furrow ploughing at 10 feet intervals. In profile both water tables were at drain bottom level with a convex rise between drains.

O'Carroll has carried out similar stand pipe experiments at Glenamoy (22/62) and these quite well verify Jack's findings above. This work was done with a combination of normal double furrow Cuthbertson ploughing and single furrows 18" x 24" deep. The single furrow drains in this experiment seemed able to control the water table over a distance of 30 feet keeping it well below the bottom of the double furrow drains.

During the author's recent tour of the main peat utilisation centres of Ireland two facts commenced to impress themselves forcibly. The first of these was the tremendous amount of pre-operational survey work deemed necessary by both Bord na Mona and the Agricultural Institute at Glenamoy. O'Hare (1955) outlines this work well. He quotes: "It may be argued that all this mapping, profile sampling, soil sampling and what not, is unnecessary and that bog is bog no matter where it is. Nothing could be further from the truth. Within the peat types of Ireland, indeed, sometimes in the same profile there is as great a difference in texture as between a heavy clay soil and a sandy loam".

O'Hare then proceeds to state that at Glenamoy, humification on the Von Post Scale varies froim H5-6 at the surface to H9-10 on the bog floor. From survey data such information as humification index and moisture precentage for each $\frac{1}{2}$ metre zone is known. "Information of this type is essential when planning the distance apart at which field drains will be opened and the depth at which main drains will be maintained".

During the extensive literature search just completed the necessity for a more objective consideration of our development areas was further stressed. Continental workers also insist on a detailed survey before work is commenced and drainage systems are all based on scientific facts accumulated for each peat type. This is illustrated well in the works of Werts (1963), Segeberg (1964), Baden (1964) and in Spravochnik po Torfu Sec. 6-2. (Bord na Mona Translation).

More thorough examination of peat prior to embarking on an afforestation drainage programme would undoubtedly be profitable. The second of the facts referred to above is the great lack of a medium for the exchange of information on deep peat. We have in Ireland, two forest services, Bord na Mona, Irish Sugar Company, Agricultural Institute, and Min Fheir Teoranta intimately concerned with peat drainage and yet there is no mechanism for assembling and exchanging information between these bodies. This matter has been raised previously by Barry (1954) and by Mitchell (1954) who wanted an International Institute to consider the problem. At this stage Bord na Mona must be complimented for producing peat abstracts, which unfortunately are not generally known of.

It is hoped that this paper will have refreshed in the minds the basic method of peat formation and illustrated the complexity of the problem of dealing with peat. It was stressed at the start that the paper would not be an "open Sesame" to the problem of producing an efficient drainage system. I hope that it, together with the preceeding and succeeding papers, will make people think longer and deeper about peat.

The only definite statement that the study stimulates the author to make is that due to the variable nature of peat, a stereotyped system of drainage cannot be placed on an area of Blanket Bog and success expected. Each area must be considered on its own and drainage systems planned for each taking into account the data accumulated for each. With a planting programme of over 4,000 acres, 80 per cent of which is Blanket Bog the process of education commenced today must continue and as well as indoctrinating Forest Officers in the basic sciences of peat formation and exploitation the work must be carried on to the foresters on the actual job.

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