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THE VEGETATION OF THE EASTERN MOORLANDS OF YORKSHIRE

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(With Plates I—IV and Three Figures in the Text)

INTRODUCTION

It is about 16 years since I began to study the Eastern Moorlands of Yorkshire. At first I paid attention to their insect life; then the geology was studied; and finally, the botany became of increasing and paramount importance. It would be in 1905 or 1906 that the "moor" emerged as a definite problem requiring solution (**4**), and it early became clear to me that this problem could not be solved by the exclusive study of any one aspect, but that if sound conclusions were to be reached all the aspects of the moors would have to be considered—the flora, fauna, geology and even the works of man, which form an impressive whole, one part influencing the other in countless ways and degrees. This interdependence I have emphasised in my book (**7**), but in the present paper I shall deal solely with the vegetation, indicating its chief types and their distribution.

THE DISTRICT

The Eastern Moorlands are a most distinct and natural division of Yorkshire (see Fig. 1). They nowhere attain a greater altitude than 1500 feet (about 457 m.), and form an elevated tableland surrounded by lower country, except on the sea-board. On the eastern edge of the Vale of York, the moorlands terminate in the fine escarpment of the Hambleton Hills which, in places, rise 600—800 feet (about 180—244 m.) above the plain. The northern boundary coincides with another great escarpment, that of the Cleveland Hills, which overlooks the plain of the River Tees and trends from west to east until the sea is reached near Saltburn. The noble sea-cliffs extending from Saltburn to Scarborough may be said to constitute their eastern margin, though this as a rule falls a mile or two short of the edge of the cliffs, except in a few localities. In the south, the moorlands are separated from the chalk Wolds by the wide and low-lying Vale of Pickering, but their boundary lies three or four miles to the north of the northern edge of the Vale, and coincides more or less with the summits and slopes of the Tabular Hills which extend from the Hambletons to Scarborough. Within these lines the great moors occur measuring about 30 miles (51 km.) from east to west, and 16 miles (about 25 km.) from north to south, and containing between 300 and 400 square miles (about 768—1024 sq. km.) more or less clothed with heath vegetation. They are by no means continuous within these natural bounds and are broken up into larger and smaller areas separated by cultivated valleys—the dales—but with few exceptions these areas are united to one another by narrow necks or peninsulas of ericetal vegetation. The deep valleys or dales radiate north and south from an

elevated central watershed that forms, as it were, the backbone of the district, and that runs from the Cleveland Hills to Robin Hood's Bay between Whitby and

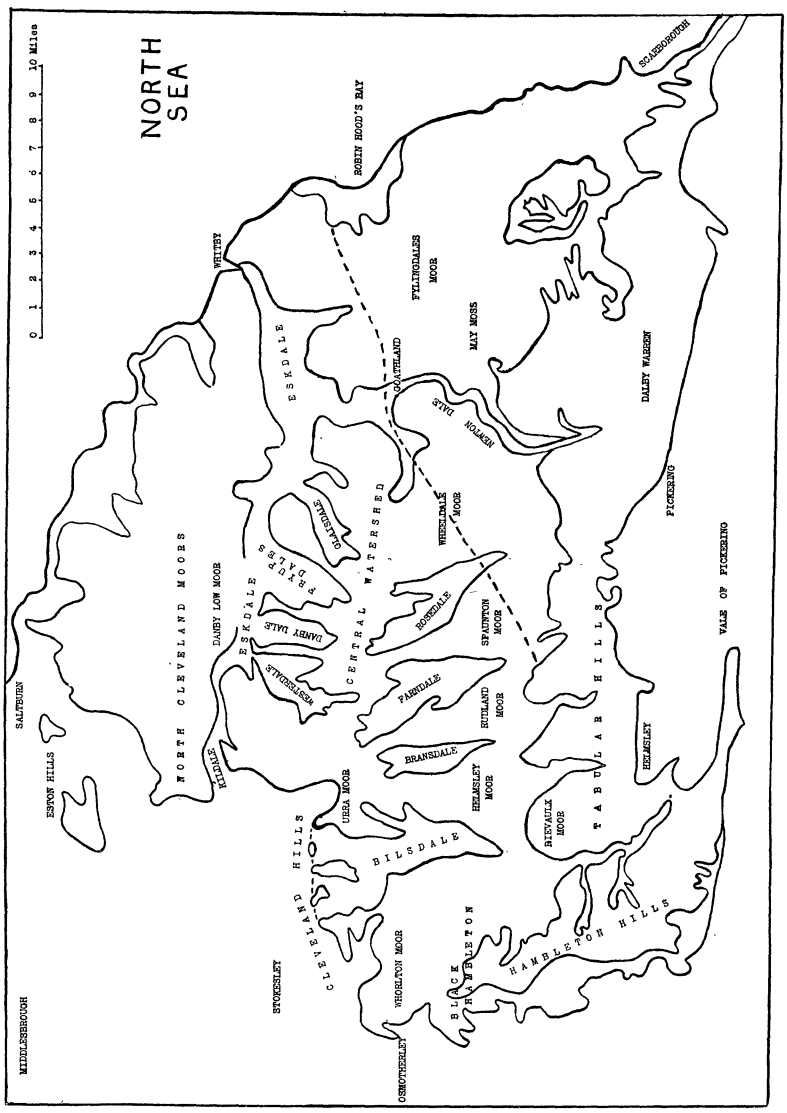


FIG. 1. Map of Northeastern Yorkshire, showing the deep valleys (dales) which radiate north and south from the central watershed; for further description see Text.

Scarborough, and it is on the high ridges and gently inclined plateaux between the dales that the moorlands are best developed.

Geology

Geologically the region consists of strata of Bajocian (Inferior Oolite) age, sandstones, coarse grits and sandy shales being the characteristic surface rocks of

the moors, with Liassic rocks cropping out in the deeper valleys. In the south, on the Tabular and Hambleton Hills, the Middle Oolites occur, strata that are mostly calcareous, but which are occasionally arenaceous, and which are sometimes covered by moor and sometimes not, and where the dependence of the ericetal vegetation and the formation of humus on special kinds of rocks is most clearly indicated.

Another significant geological feature is the absence of glacial deposits over most of the higher moors. Long ago this was noted by the Geological Survey, and A. Geikie, writing in 1885, says: "The absence of drift over most of the country is one of the most remarkable features of the geology. Boulder clay of the usual type extends to a height of 800 feet (about 244 m.) up the valleys that trench the northern front of the tableland, but it is not met with in the interior, nor has any trace been found there of local glaciation. These uplands appear to have formed an insular space round which the ice-sheets swept but which remained unsubmerged" (**2**). Later researches have but established his assertion more securely, and it is an indisputable fact that *the larger area of heather-clad land in North-eastern Yorkshire is not on glacial deposits.*

It may also be pointed out that the moor edge closely coincides with the upper limits of the glacial drift, especially in the northeast and east of the district. The drift consisting of more heterogeneous materials produces, on the whole, better soils than occur on the unglaciated moors, and consequently they have been more amenable to reclamation. To a certain extent this coincidence is artificial, for moors flourish and have flourished in the past on such deposits, particularly where they are thin and sandy. The influence of the drift is well-shown near the village of Egton in northeast Cleveland where the Inferior Oolite sandstones and grits are so thickly covered with boulder clay that the moors are much restricted in area. In fact were it not for this coating of drift nearly the whole of North Cleveland would be overspread by heath vegetation which almost invariably comes in where the drift dies away. On the escarpments of the Cleveland and Hambleton Hills, the moorland boundary is determined solely by the outcrop of the Oolitic sandstones and grits which form the summits of the former escarpment, but in the latter they project into the plain as a series of bold heatherclad spurs below the great escarpment of the Middle Oolites.

The soils derived from the strata are usually sandy though on some moors clayey shales cover a considerable area and give rise to cold wet land. The sandy soil varies much in thickness, partly owing to the protective covering of raw humus but chiefly owing to the character of the surface rocks which may vary from a quartzite-like grit through finer yellow sandstones to coarse grits composed of quartz grains nearly as large as peas. The surface of the moor is often littered with large stones and rocks, though where the humus is deeper such boulders may be buried. In this respect the Eastern Moorlands present a marked contrast to the heaths on Tertiary sands, such as those of Hampshire, where boulders are totally absent. Plate I, Phot. 1, illustrates the excessively rocky nature of some moors, and it must be borne in mind that such conditions prevail on land that is comparatively level, and are solely due to atmospheric erosion, for, as was said above, the evidences of glacial action are lacking on the larger part of the elevated moorland.

In Fig. 2 I have represented the general characteristics of the moorland soil. The pan however is somewhat exaggerated; usually it is no more than 0·75 cm. thick but in a few localities it may swell out to 5 cm. or more. That pan exists on all the moors has not yet been established and, although it has been detected in many places, there is no evidence that it extends continuously for miles as is the

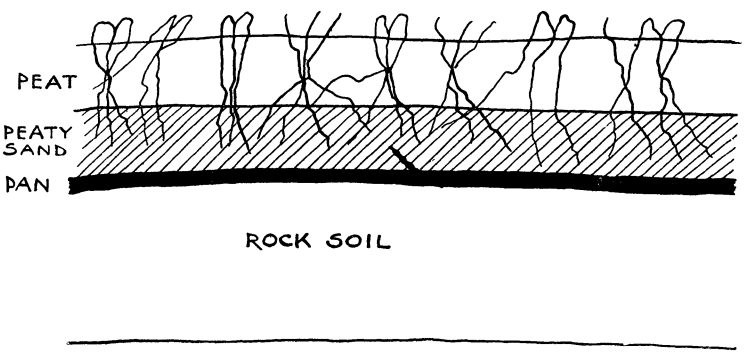


FIG. 2. Diagrammatic vertical section of Moorland soil (see description in Text).

case in the North German "Heide" region (**10**). A band of small stones and pebbles of grit often takes its place, and occasionally these have their upper surfaces thinly coated with a deposit of pan. The following sections were measured under a *Calluna-Eriophorum* moor:

Sections in the "Mosses," Arden Great Moor (see p. 11).

(1) Peat 60—100 cm.
Discontinuous line of white grit pebbles.
Clayey sand (no traces of pan).

(2) Peat 60—200 cm., variable.
White pebbles.
Pan 0·75—1·25 cm.
Clayey soil.

Pan does not appear to exist under very deep peat in this district, and the layer in the above section was very thin and irregular. An analysis of pan gave the following percentages: oxides of iron, 45 14; oxides of manganese, 0·19; alumina, etc., 7·85; lime, 1·30; magnesia, 0·90; silica, 21·60; sulphuric acid, 0·37; phosphoric acid, 0·15; organic matter combined with water, etc., 22·50.

Generally speaking, the humus of the Eastern Moorlands is very thin on the moor edge but gradually increases in depth as the central watershed is approached, where in favourable situations it may attain a thickness of 6—11 m. Further details concerning the soil are given later.

Local Terms

It may be as well to give certain local terms which are of some interest as they frequently refer to distinct botanical aspects of the moors and occasionally indicate differences of great importance in the soil.

Carr. A carr is generally a flat marshy area often covered with brushwood and is a word rarely used for moorland, but I have one record of a peat carr where the word is applied to what is elsewhere termed a moss. The *Nardus-Scirpus-Eriophorum* community described in Section *d* (p. 16) refers to this locality.

Fen. This word only occurs once in Northeastern Yorkshire. The head of the great valley of Newton Dale, which runs through the district from Pickering to Goathland, is occupied by a vast morass called Fen Bogs. Part of it approximates to real "fenland," and part of it is true moss moor.

Heath. There is a farm called Providence Heath on the edge of the moors between Robin Hood's Bay and Staintondale, but with this exception the word is never found in this district, though much of the moorland belongs to the heath formation.

Mire. A marsh or boggy place. Murk Mire Moor is an instance.

Moor. Everywhere used for heather-clad land, and in a few cases for swards clothed with grass, furze and bracken with no heather in their vegetation. I have no record of the word being employed in the German sense. I suspect that some of the low-lying moors that formerly existed in the Vales of York, Pickering and Stokesley have been swampy rather than heathery, but of this I am not yet certain. "Moor" is also used for the ling or heather itself, especially when in flower. Two or three local authors at the close of the 18th and beginning of the 19th centuries used it as a term for peaty soil. Thus Marshall says: "The soil is invariably a Black Moor. The moor of fens appears obviously enough to be composed of the decayed roots and other parts of vegetables" (**12**). I may also add that "Black-a-more" is an ancient name for a large part of the district.

Fat Moor. Used when the humus or peat is of considerable thickness, 2—4 feet (about 0·5—1 m.) or more.

Thin Moor. Used when the humus is thin or absent and the soil sandy and stony. Corresponds to the "heath" of the South of England. The ground may be either wet or dry.

High and Low Moors. These merely refer to the altitude above sea-level. High moor must not be thought synonymous with the German "Hochmoor." The latter is applied to peat bogs with the centre higher than the circumference, usually termed mosses in this country.

Moss. This term is comparatively rare but occurs in about a dozen instances. As elsewhere it is always applied to moorland bogs with great thicknesses of peat, 3—10 m. Such moors are often called fat moors.

Swang. Another term for moorland and other bogs, e.g. Moss Swang, Gale Swang (where *Myrica* grows). Usually applied to bogs in hollows, and by some etymologists it is connected with Old Norse *svinka*, to swing or shake as a bog does. Derived from Old Norse *svangr*, a hollow place. Moss Swang is a peat bog in a hollow (see Plate II).

Syke. A term for a small rivulet draining out of a bog or the bog itself. We have Foul Syke, Moss Syke, Seavy Syke (where Seaves = *Juncus* spp. grow), etc.

THE VEGETATION

The first scientific account of the vegetation was given by Baker (**1**), who endeavoured to trace the relationship subsisting between the plant life and the geology and climate of North Yorkshire: in the floristic part of the work the range and status of the moorland plants are carefully described. He was perhaps the first to point out that the moorland or "swamp heatherland vegetation attains its greatest perfection and covers without intermission the widest tracts of surface over the Lower Oolite and Millstone Grit, whilst those of the Vale of York are all based on sandstone and with them *Drosera anglica*, *Vaccinium oxycoccus*, *Listera cordata*, *Lycopodium selago* and *selaginoides* [= *Selaginella spinosa*] descend to their lowest stations where they meet and mingle with such species as *Gentiana pneumonanthe*, *Mentha pulegium*, *Centunculus minimus*, *Radiola millegrana*, *Lycopodium inundatum*, etc." Baker compares this vegetation with that of the calcareous rocks of the Middle Oolites of the Tabular Hills, and gives a list of species which are characteristic and of "xerophilous" habit, such as *Aquilegia vulgaris*, *Helleborus viridis*, *Convallaria majalis*, *Anemone pulsatilla*, etc., ericetal plants being practically absent from the calcareous areas.

This broad difference in the vegetation of the two areas he attributes to the nature of the rocks, not so much in relation to their chemical composition but in relation to their mechanical and physical properties. Most of Baker's interpretations of the facts of distribution are based on Thurmann's principles of eugeogenous and dysgeogenous strata. The moorlands coincide with eugeogenous rocks which yield much detritus, are softer, absorbent and more humid as compared with the dysgeogenous which yield detritus but sparingly, are harder, non absorbent and comparatively dry. Hence the restriction of the swamp heatherland vegetation to the eugeogenous tracts, and Thurmann's "xerophilous" species to the dysgeogenous limestones of the Middle Oolite. How nearly Baker approached modern conceptions is well-shown by his description of Rombald's Moor near Ilkley and where he speaks of the "florula of the upper zone on a eugeogenous hill" as "composed of *Drosera rotundifolia, Cerastium triviale, Rubus chamaemorus, Galium saxatile, Erica tetralix, Calluna, Vaccinium myrtillus, Juncus effusus* and *squarrosus, Empetrum, Scirpus caespitosus, Eriophorum, Agrostis vulgaris, Aira flexuosa, Festuca ovina* and *Nardus*. These forms are not however so restricted in their distribution as the dysgeogenous xerophytes but certainly attain a greater degree of frequency and luxuriance in the eugeogenous tracts. Under the more boreal and humid climate they grow abundantly and cover wide areas of surface without keeping up any clearly marked rôle of lithological restriction" (**1**).

In 1909, W. G. Smith briefly indicated the main characters of the vegetation in relation to the geology (**13**), and in Tansley's "Types of British Vegetation" (**15**) he gives an account of the heaths of the district which he classifies as follows:—

Dry Series.

(*a*) Typical Callunetum on sandy humus.
(*b*) *Calluna-Vaccinium* heath on rocky slopes of upper valleys.
(*c*) *Calluna-Pteris* heath on shallow to deep sandy soils.

Wet Series.

(*d*) *Calluna-Nardus* heath on moister humous soils.
(*e*) *Calluna-Tetralix* heath on peaty humus with abundant water.
(*f*) True *Calluna* moor on deep peat.

In my book (**7**) I have to some extent adopted a topographical classification of the vegetation, as this plan brings saliently into view many striking characteristics. It is, however, somewhat difficult to evolve a classification that is at the same time both natural and exhaustive. For though the topographical features of North-eastern Yorkshire have characteristic types of vegetation, such an arrangement separates types that in a botanical classification would be brought together. Thus the wide, open and fairly level central watershed is dominated by the *Calluna-Eriophorum* moor which is also exceedingly well developed in narrow deep valleys, well sheltered and at much lower levels. For the purposes of this paper I shall somewhat closely follow the arrangement I have adopted in my book, beginning with an account of the vegetation of the elevated and comparatively level uplands, and ending with that of the slacks and gills in which we find an epitome, as it were, of the plant life of the Eastern Moorlands.

(*a*) The Heath Formation

The outstanding aspect of the vegetation is the dominance of the *Calluna* moorland which covers by far the widest area on the high ridges and plateaux between the dales, and the summit edge of the Tabular Hills. It presents several facies characterised not only by the relative abundance of other species but also by differences in the form of *Calluna* itself. Towards, but not on, the central watershed this plant attains its most vigorous and luxuriant development on peat at least six inches deep and frequently more—"fat" moor as it is locally termed. On slight inclinations *Vaccinium myrtillus* becomes very abundant, especially where the heather has been burnt, and we meet with such spaces clothed with nothing else but bilberry. On wetter moors of this type *Erica tetralix* is often subdominant, though here again the burning of *Calluna* often favours the subordinate species.

If we descend from these *Calluna* moors along one of the ridges dividing the dales, we find that the moor as a rule becomes drier and the humus shallower, though the heather is still the chief element in the vegetation, characteristic associates being *Vaccinium myrtillus*, *Erica cinerea*, *Empetrum nigrum*, and *Potentilla tormentilla*. Very occasionally, *Empetrum* becomes sub-dominant. Wherever *Calluna* grows closely few species and individuals manage to live amongst it, especially when the plant is in its prime; but when old age creeps on it becomes straggly, the stems fall away from one another, and a space is often left in the centre of the clumps. Mosses, principally that fine species *Hypnum cupressiforme* var. *ericetorum*, colonise the bottom of this space; *Cladonia* lichens also settle therein. Sometimes perfect rings of heather with a plant of *Juncus squarrosus* or other species in the centre may be observed.

On some of these "thin" moors the comparatively dwarfed growth of *Calluna* is a striking characteristic. In North Cleveland, the Kellaways Rock, a porous sandstone at the base of the Middle Oolites, is often clothed with short *Calluna* which is quite closely grown and dominant. Sections in the soil show that peat properly so-called is absent, being replaced by sandy humus underlain by a coarser sand at the base of which there may be a thin layer of "pan." Here the influence of the rock is distinctly visible, but on Allerston High Moor between Sleights and Pickering, the Kellaways Rock at an elevation of about 290 m. is clothed with peaty *Calluna* moors with much *Vaccinium myrtillus*, the size of the *Calluna* being two or three times as great as on the North Cleveland moor.

A few "thin" moors are wet, and two types may be recognised—the *Calluna-Nardus* moor and that dominated by *Scirpus caespitosus*. The first is characteristic as a rule of the moor edge, that is to say where the boundary falls away in gentle inclinations; but the type may be found covering considerable areas some distance from the edge Parts of Danby Low Moor may be taken as an instance: *Calluna* is interspersed with tussocks of *Nardus*, *Erica tetralix*, *Juncus squarrosus* and *Cladonia* spp., and these plants grow on a humic sand quite distinct from the deep rich humus of a "fat" moor.

The second type of wet "thin" moor is very rare in Northeastern Yorkshire. It occurs in badly-drained localities and is much damper than the *Nardus* moor,

while the humus is shallow and often rests upon clayey shale. The two principal plants are *Scirpus* and *Erica tetralix*, usually in about equal proportions, though sometimes the one and sometimes the other is slightly dominant. Other frequent though quite subordinate species are *Eriophorum vaginatum*, *Molinia caerulea* var. *depauperata*, *Juncus squarrosus* and *J. conglomeratus*. The surface is hummocky, doubtless owing to the decay of moss cushions or to the root-stocks of higher plants. *Nardus*, *Vaccinium myrtillus*, *Empetrum* and *Erica cinerea* are totally absent from this distinct type of moor.

Intermediate between these types is another in which *Erica tetralix* is the chief species, followed in order of abundance by *Nardus*, *Scirpus* and *Eriophorum vaginatum*. So far as my observations go, moors on which *Scirpus* plays a prominent part only occur on the northern side of Eskdale where they are few and far between. *Scirpus* and *Erica tetralix* form conspicuous elements in the vegetation of deep peat bogs, as we shall see in section (*d*).

As a rule, the thin *Calluna* moor passes right to the edge of the steep slopes which constitute the sides of the great dales, and where this edge falls away gradually, there is a tendency for grasses to become sub-dominant, *Nardus* as just mentioned being characteristic both on wet and drier ground. *Aira flexuosa*, *Festuca ovina*, *Agrostis canina*, *Triodea decumbens*, and *Aira praecox* are also frequent in such situations but they rarely become at all dominant, especially the two last. In fact the grass heath is quite rare on the Eastern Moorlands and plays a very minor rôle in the vegetation. *Ulex europaeus* is numerous on the moor edge, though usually more abundant on the steeper slopes.

I have already referred to the dominance of *Vaccinium myrtillus* due to the burning of the heather moor, and as this process largely influences the plant life, it is needful to consider its effects. The character of the vegetation on the burnt areas or "swiddens" depends upon a number of factors—the nature of the soil, the environing plants, the effect of the burning, the position in regard to slope, drainage, etc. Where the fire passes over the heather with the wind behind it, the plants come again much earlier than when the burning has been against the wind and so more thorough. In the former case the fire does not attack the underground parts to any large extent, and consequently they send forth new shoots and reappear more rapidly; whereas in the other case the whole of the heather may be destroyed and can only be renewed from seeds. The first species to appear on a well-burnt moor are usually liverworts, mosses and lichens. The principal liverwort found under such conditions is *Lophozia inflata*, and it invariably assumes a blackish colour and occurs in thin flat patches, but near water it is usually vivid green. If the moor be at all damp, the only bog-moss seen on the "swiddens" is *Sphagnum papillosum* var. *confertum*, a species that shortens and crowds its branches when growing in drier situations. *Webera nutans* is often very numerous, whilst at a later stage *Polytrichum commune* and *Ceratodon purpureus* are not infrequent. Some "swiddens" at an early stage are almost covered with *Cladonia* lichens, a feature often seen in the development of plant communities (**10**).

At later stages the flowerless components of the vegetation are ousted by the flowering plants and a very mixed flora sometimes results. Often a kind of turf

develops consisting of *Calluna*, *Vaccinium myrtillus*, *Potentilla*, *Juncus squarrosus*, *Agrostis canina*, and *Polytrichum*, whilst occasionally swards composed of *Agrostis canina*, *Aira praecox*, and *Festuca ovina* overspread the burnt spaces. On dry heaths, *Erica cinerea* becomes dominant. A very striking association is that supplied by "swiddens" on which *Empetrum* is interspersed with large spreads of *Rumex acetosella*, a combination which I have not elsewhere observed.

On the Tabular Hills, "thin" heather moors are frequent at the edge of the escarpment; *Calluna* is dominant and interspersed with *Empetrum* and *Erica cinerea*. The humus is shallow, somewhat dry and usually underlain by a mass of small stones derived from the subjacent rock, the Lower Calcareous Grit, out of which all traces of calcareous matter have been dissolved by the rain. On other parts of this range the moors are somewhat "fat," especially towards the western end where not only is the elevation greater (375—405 m.) but probably the rainfall as well. On Black Hambleton, the westernmost part of the range, *Vaccinium myrtillus* and *Empetrum* are frequent, with here and there small patches of *Eriophorum vaginatum*.

Rievaulx Moor, north of Helmsley, is clothed with well-grown *Calluna* with scattered bushes of *Empetrum*, *Nardus*, and *Erica cinerea*. Self-sown pines (*Pinus sylvestris*) from the neighbouring plantations are numerous, and each tall tree is almost invariably surrounded by a family of younger pines springing up amidst the *Calluna*. As the edge of the escarpment is approached such trees become rare. The humus is several inches deep and this depth is often considerably increased, though very irregularly, by masses of humus formed of decayed *Polytrichum*, over which spread fine growths of *Empetrum*. Where the moor has been burnt this species and *Vaccinium myrtillus* are dominant. The vegetation of a neglected cart-track showed some interesting features. A large length of it traversed an old "swidden," and here *Nardus* was conspicuously abundant on the track, forming a whitish-green band across the moor. But where the road entered undisturbed *Calluna* the grass was practically absent, being replaced by *Calluna* with an occasional bush of *Ulex*. A most distinct feature of the low banks of the track were spaces, often burnt, clothed with luxuriant carpets of *Empetrum* with *Vaccinium vitis-idaea* as an associate of some frequency. In fact the latter plant is quite numerous on this moor. I may here remark that *Empetrum* seems to be just as numerous on the southern moors of the district as on those in the extreme north, the distance between them, about twenty miles, evidently not being sufficient to produce any marked difference in its abundance, though we might naturally suppose that the further south we went the rarer it would become.

On the Tabular Hills the moors reach their southern limit in a somewhat irregular manner, though this is determined in almost every instance by the nature of the rocks. Above the Lower Calcareous Grit comes the Lower Limestone which is occasionally somewhat sandy and is then clothed with grass heath. Lying on this stratum is the Middle Calcareous Grit which is often highly arenaceous and accordingly we find it overspread with *Calluna*, especially on Dalby Warren near Pickering, and on Wass Moor and Scawton Moor west of Helmsley. The latter moors are quite detached from the main moorland area and are surrounded by well-cultivated lands on the plateau formed by the limestones of the Upper Oolite

at an average altitude of 210—270 m. The southern boundary of the moors is partly artificial, for man has undoubtedly reclaimed much thin heather-clad land and grass heath on the Tabular Range, but it is significant that cultivation ends where arenaceous rocks come to the surface.

On the Tabular Hills it is very instructive to note how *Calluna* follows the outcrop of the Lower Calcareous Grit. As already stated there is no calcareous matter in the upper layers of this rock; in fact it is a yellowish marine sandstone which bleaches to a white colour. It dips southwards and passes beneath truly calcareous rocks, and we can in several localities observe how *Calluna* is restricted to the sides of the valleys in which the grit forms the middle of the slope. In March, 1913, I made a closer examination of one of these patches of heath in a small valley north of Helmsley. The season was too early to render a complete record of the association, but the most striking features were the dwarfed growth of the heather—about 15 cm. high—and the sub-dominance of *Rosa spinosissima*. The latter species was somewhat sparingly distributed amongst the *Calluna* on the centre of the slope, but on the summit and towards the base it was abundant, though in these situations *Calluna* was thinner with much *Hypnum* spp. and *Agrostis* spp.

On some of the moors in the north and east where there is a thin layer of glacial deposits, usually sand and gravel, and where the ground is damp, *Molinia* occurs freely amongst the heather, in a few localities becoming dominant, though it never covers any wide area, as pointed out by W. G. Smith (**13**). In the valley of Newton Dale, *Molinia* is dominant on very deep peat and is in juxtaposition to *Myrica* bogs with *Eriophorum* and *Calluna*, and to great reed (*Phragmites communis*) beds. Elsewhere it is of sporadic occurrence on many wet *Calluna* moors.

(*b*) The Moss Moors

The peaty *Calluna* moors described in the last section as occurring near the central watershed pass directly into moss moors on the highest parts of the district. The altitude of the watershed ranges from about 450 m. on Urra Moor in the west to 240 m. on Brow Moor on the coast-line at Robin Hood's Bay. Owing to the comparative flatness of the ground in some places, its excavation into shallow depressions in others, and the much heavier rainfall, these moors are very wet at all times of the year. Peat of great thickness accumulates, and what is sporadic on drier moors, the presence of little pools of *Sphagnum* with patches of *Eriophorum*, is often the permanent condition of the "mosses." It is but rarely, however, that *Eriophorum* becomes the sole constituent of the vegetation; as a rule it is as abundant as the heather which grows amongst it, while in other localities this type is often superseded by thick peaty Calluneta with very little cotton-grass. On Urra Moor, this type is well-developed with numerous pools full of floating *Sphagnum*, probably *S. cuspidatum*, which when drier also contain *Eriophorum angustifolium*, a species that prefers wetter situations than its more dominant congener, *E. vaginatum*. Here and there on the watershed will be found great spreads of *Juncus squarrosus*, and on one of the "mosses"—Yarlsey Moss (Plate III)—there is a considerable amount of *J. conglomeratus*, probably a secondary growth

arising after peat digging. The illustration of Loose Howe[1] gives a very good idea of the moors of the watershed at an altitude of about 420 m. The foreground is largely *Calluna* moor but the lighter patches in the background indicate the presence of *E. vaginatum*. Near the summit of the ridge, the peat is about 2 m. deep (Plate I, Phot. 2).

In the shallow depressions of the watershed the peat is much deeper than on the high ridges, perhaps as much as 6—10 m. in some places, but owing to the absence of good sections it is not always easy to ascertain its thickness. The "mosses" in these hollows often exhibit a characteristic convexity of outline, especially noticeable in the case of the Harwood Dale Peat Holes on the Scarborough and Whitby highroad and on the great morass of May Moss between Sleights and Pickering. May Moss covers an area of very nearly a square mile, and is characterised by the great abundance of *Erica tetralix* in its surface vegetation. In fact this species is here distinctly dominant, *Eriophorum* and *Calluna* being somewhat subordinate.

The moss vegetation of the watershed varies from half a mile to nearly two miles or more in breadth from north to south and extends almost unbrokenly from east to west for a distance of 12 miles at the heads of the great dales. On the summits of the Cleveland Hills west of Urra Moor it is practically absent, since the line of this escarpment is south of the watershed and as a consequence the land falls rapidly southwards from the summit edge. On the Tabular Hills, the *Calluna-Eriophorum* vegetation is best developed on Arden Great Moor in the extreme west at an elevation of 1200 ft. (about 360 m.). Elsewhere this type is quite sporadic on this range.

I believe that much of the vegetation of this region has been disturbed by man owing to peat digging and turf graving, and it is not improbable that some of the moss moors have been excavated and re-excavated two or three times in the course of centuries, but of this I cannot yet be certain.

(*c*) Slope Vegetation

Except on the escarpments of the Cleveland, Hambleton and Tabular Hills, the slopes usually form the sides of the great dales and their tributaries, often rising to a height of 300—400 ft. (about 90—120 m.) from the floor of the valleys. They vary much in altitude, steepness, contour and direction, all of which exert an influence on the vegetation and on the amount of cultivated land they bear. In some dales, the sides are reclaimed almost to the moor edge; in others fields extend about half-way up the slopes; whilst in the gills or head-waters of the dales which rise high on the moorlands, the vegetation is practically undisturbed. Moreover, the conditions of life are complicated by the outcrop of beds of shale, sandstone and limestone which run along the slopes, one stratum above another, and which produce different kinds of soil. Again, runnels of water from springs and the downwash of rain cause considerable erosion even on gentle inclinations, and the accumulation of fine detritus at lower levels forms a more varied soil than

[1] See this JOURNAL, **1**, 1913, Plate 1.

that of the higher moors. Thick peat rarely accumulates except in hollows caused by springs, and in many places the humus is extremely thin.

Consequently, regarded as a whole, the conditions of plant life on the slopes are favourable to a more varied and luxuriant vegetation than that of the peaty moors, a vegetation which ranges from heather-clad land, through intermediate types, to woods of oak and birch. Genuine peat plants do not always find suitable stations on the steeper sides and are therefore somewhat rare or disappear altogether.

The characteristic species is undoubtedly *Pteris aquilina*. It is *the* plant of the slopes, in the larger dales frequently extending unbrokenly for miles; and, after the *Calluna*, forming the most salient aspect of the vegetation of the Eastern Moorlands. In some cases, where closely grown and somewhat rank, scarcely any other species are associated with it: a few grasses and a little *Vaccinium* and *Polytrichum* alone maintaining a precarious existence beneath its too protecting shade. A more open growth enables *Agrostis canina* and *Festuca ovina* to form a green sward beneath the fronds, and *Ulex* is not uncommon.

Traced upstream in shallow valleys, the bracken becomes rarer and rarer on the slopes and is ultimately confined to small patches close to the streams. This decrease is no doubt largely due to an increase in the thickness of the raw humus which forms to some depth on slight inclinations, and many shallow valleys have their sides dominated by *Calluna*.

A most frequent type of slope vegetation is that in which *Calluna* and *Pteris* are almost equally abundant, bosses of the former plant being irregularly interspersed amongst the ferns. Other species are also characteristic of this type, moorland grasses for instance, and more particularly *Vaccinium myrtillus* or *V. vitis-idaea*, an association well-developed on the northern side of Baysdale, where the latter species occupies a prominent part in the vegetation; *V. vitis-idaea* is of sporadic occurrence on most moorland slopes, but it never becomes dominant.

Everywhere a keen struggle for supremacy takes place between *Pteris* and *Calluna*, and where they adjoin the lines are often of almost geometrical regularity. This is not wholly natural, being partially due to burning, which, on slopes, has the effect of encouraging the fern at the expense of the heather. The deeply-striking roots and quicker growth of *Pteris* enable it to spread on to the "swiddens" before *Calluna* has a chance to assert itself. We may observe recently-burnt areas in June, with the delicate green shoots unfolding above the blackened ashes and stems of the former vegetation, and as the firing is usually restricted to fairly regular and definite areas, the resulting masses of fern are of similar patterns. It is not improbable that, in some localities, many *Calluna*-clad slopes with a little *Pteris* here and there have been covered with rank forests of the fern by burning.

On the northern side of Eskdale, between Commondale and Danby, the *Calluna* dispersed throughout the *Pteris* is almost wholly of the form known as *incana*. The reasons for the dominance of downy *Calluna* in this area are not at all clear. The slope does not appear to differ from others to any marked extent, except perhaps in its somewhat sandier soil. It is to be noted, however, that this side of Eskdale is the only considerable slope which faces south in Northeastern

Yorkshire, and consequently is much exposed to the sun, and it seems not unlikely that the downiness is an extra protection against loss of water, owing to the full exposure to the sun's rays and the drier sandy soil.

Indications are not wanting of a zonal arrangement of plants on the slopes. The altitude of the district is too inconsiderable appreciably to affect the species we are here considering; the principal factors in determining plant zones are the soils, not only those derived from the different strata, but also those formed at the foot by downwash. But it is only here and there that we find distinct lines of vegetation running along the hill-sides. The most striking instance occurs on Dalby Warren near Pickering, and was first pointed out by Fox-Strangways (**8**). The warren is divided by no fewer than six small branch valleys falling into Thornton Dale; these run from east to west, and as a consequence their slopes face north and south. It is along these slopes that the zonal arrangement is displayed. Here a thin band of limestone is intercalated between two sandstones, one of which forms the floor and lower slopes, and the other the upper slopes and summits of the ridges separating one little dale from another. The calcareous soil of the limestone is covered by grass or *Pteris*, while the sandy soil is always clothed with *Calluna*. The junction between the two is quite distinct, the bracken forming a central band with *Calluna* above and below, so that the divisions of the strata can be followed by the eye at some distance. The restriction of *Calluna* to the outcrop of the Lower Calcareous Grit, previously mentioned, is a similar phenomenon.

A distinct zonal arrangement may be observed on the slopes of the Cleveland escarpment and in some of the larger dales. Below the heather moor of the summit level comes a band of *Vaccinium myrtillus* which usually clings to the rocky, exposed situations formed by the outcrop of the hard estuarine sandstones. Below the bilberry comes the great zone of bracken coinciding very closely with the outcrops of the Upper Liassic shales; whilst the lowest slopes, where unreclaimed, are usually characterised by masses of *Ulex* with grassy interspaces on the accumulated downwash. Sometimes a belt of wet land clothed with Junceta occurs below the *Ulex* zone when the slope has a flattish expanse at the foot.

There can be little doubt that the position of slopes with regard to the points of the compass influences the vegetation, and it can here and there be noticed how *V. myrtillus* favours slopes which are exposed to the north and east. In the valley of Eller Beck, near Goathland, the slopes face east and west and are thickly covered with bracken, but in a small tributary valley with a northward-facing slope bilberry is very abundant. Where the two valleys join the two plants mingle on the angle of the slope. Similar features are presented by Black Hambleton, for there is comparatively little *Pteris* on the northern slope of this hill, *Vaccinium* and *Calluna* being the chief plants, but the fern becomes more abundant on the western side. I do not press these facts as conclusive evidence of the influence of position and exposure to the north, for there has been so much burning that the natural status of the vegetation has been considerably disturbed, but the bilberry is a plant that can withstand much exposure, as its presence on the summits of the Pennines shows (**14**). In Little Fryup Dale the eastern-facing

slope is practically dominated by this species which forms a shrubby turf cushioned with masses of *Cladonia* lichens (*C. sylvatica*, etc.) and in which *Pteris*, *Empetrum* and other species are numerous.

That the bracken marks the site of former woods on the slopes I think there can be little doubt, though I believe that the presence of this species in isolated patches by stream-sides far in the heart of the peaty moors simply indicates that it has spread to such situations from lower down-stream, and not that every one of these patches of fern necessarily was once overgrown by trees; as was previously mentioned, burning largely determines the spread of this species. On most of the slopes trees and shrubs appear amongst the vegetation, the principal species being hawthorn, oak, birch, mountain ash, Scots pine, holly and juniper (Plate IV, Phot. 1). Of these perhaps the oak and birch are the most numerous, though sometimes the mountain ash and hawthorn are frequent, but these two species rarely form woods or scrubs as do the two former. Scots pine usually seeds from plantations and would in some localities be even more abundant were it not for the burning and sheep grazing (**3**). Juniper is quite rare, but I have one record of a scrub of these plants on a bracken slope.

Where the large slopes of the dales converge into the narrower gills which form the headwaters of these interesting valleys, we find some woodland types consisting chiefly of birch and oak. Plate IV, Phot. 2 shows one of these wooded gills. Here we have a narrow valley with a small but active stream falling into the main dale from the south, the whole of the ravine being well-wooded. The chief tree is the oak, next comes the birch, and there are a few mountain ashes and one Scots pine. The highest trees, both in growth and position, do not rise above the level of the moors on either side, though occasionally seedlings will be found at some little distance from the edges. The most striking feature of the undergrowth is the dominance of *Vaccinium myrtillus* which frequently attains a metre or more in length; towards the summit of the ravine it becomes much shorter whilst *V. vitis-idaea* and *Pteris* are very abundant amongst it, more so than in the gill itself.

Sometimes the undergrowth in the slope woods is chiefly *Calluna*, but *Pteris* is undoubtedly the typical species in such situations.

(*d*) Slack Vegetation

In the foregoing sections I have briefly indicated the types of moorland vegetation in Northeastern Yorkshire, but it is quite possible to study most of these within a limited area where, owing to the peculiar configuration of the ground, most of them are developed in contiguity. Such a congestion of moorland associations we find in small valleys—locally termed "slacks"—which on the North Cleveland moors, in the Vale of Goathland and between Robin Hood's Bay and Scarborough form a very striking feature of the scenery. As definitely established by the researches of Kendall (**11**), the slacks are the old drainage channels of glacier-lakes during the Ice Age. The general appearance of these valleys may be gathered from the view of Moss Swang (Plate II) which shows the broad flat streamless floor and steep slope that form their salient characteristics. In them we observe a veritable epitome of the vegetation of the Eastern Moorlands,

Calluna moors, bracken slopes, *Sphagnum* bogs, Junceta, *Eriophorum-Calluna* bogs, *Tetralix* moors, etc. Speaking generally it may be asserted that the floors of the slacks are almost invariably clothed with the *Eriophorum-Calluna* moor, for owing to the absence of definite streams, the slight fall, and the accumulation of water on the floors, the slacks are always the site of peat bogs, sometimes more than 20 feet thick (about 6 m.), though in the upper and lower reaches this thickness is considerably diminished.

The annexed diagram (Fig. 3) shows the distribution of plant life in one of the North Cleveland slacks, Ewe Crag Slack, and the features there shown may be taken as fairly typical of their vegetation in general. It will be noticed that Junceta prevail at the beginning and towards the end of the valley with an intermediate area of *Calluna-Eriophorum* bog, a feature which can be seen in other slacks. In some the *Juncus* swamp is even more dominant, and I know of instances where this type of vegetation extends for two or three miles in shallow valleys with *Calluna* moors on the surrounding slopes. I think the occurrence of the Junco-Sphagneta in the upper and lower reaches of these valleys may be due to the circumstance that here the peaty water is more highly mineralised and more aerated, for in these situations active streams flow out of the central morasses. That *Juncus effusus* and *J. conglomeratus* (the chief species of this association) actually need such water may be inferred from their luxuriant and abundant growth in that of springs where of necessity a much greater quantity of dissolved mineral salts must be present. In old peat holes that have become water-logged *Juncus* very often constitutes the first stage in the re-filling, afterwards being superseded by *Eriophorum* when the *Sphagnum* has become thicker and the new humus more solid, but it is somewhat rare to see *Juncus communis* and *Eriophorum* associated together. Früh and Schröter (**9**) classify *Juncus* as a "Flachmoor" plant and *Sphagnum* as a "Hochmoor" plant, and in their list of plant associations of both classes the

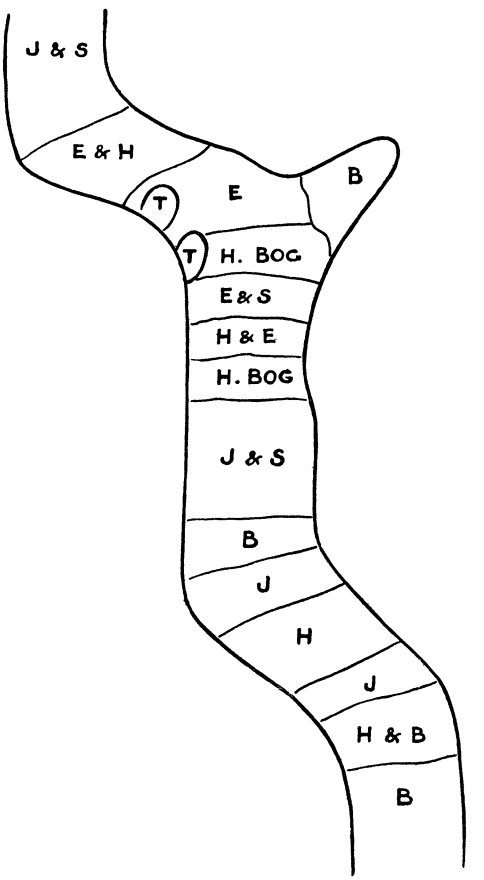


FIG. 3. Diagram showing the distribution of plants in Ewe Crag Slack. *J*, *Juncus*; *E*, *Eriophorum vaginatum*; *T*, *Erica tetralix*; *B*, *Pteris aquilina*; *H*, *Calluna vulgaris*; *S*, *Sphagnum*.

Junco-Sphagnetum is not mentioned, yet it forms a really striking aspect of the moorland vegetation in this region. It is not improbable that *Juncus* has become dominant on the moss moors of the slacks and elsewhere owing to the extensive turbaries that exist or have formerly existed in these localities and that in time the Junceta will be displaced by the *Calluna* and *Eriophorum* bog.

It is in the slacks that *Myrica gale* is most numerous in this district, but it is not found in all. Its distribution is curiously partial and is perhaps one of the most interesting and puzzling features of the vegetation. In the Robin Hood's Bay area, the floors of the slacks are thickly clothed with *Myrica*, usually in association with *Calluna*, *Erica tetralix* and *Eriophorum vaginatum*; and yet in the North Cleveland slacks it is quite absent, though so far as can at present be ascertained the geological and physical conditions are identical. Nor does the species occur on the mosses of the central watershed or on the western moors. I have drawn a dotted line across the map (Fig. 1) to indicate its range—it will be observed that the plant is restricted to the southeastern area of the moors. This line must however be regarded merely as approximate, as the species may flourish elsewhere, but in any case it cannot be at all numerous in the excluded area, and even within its area *Myrica* does not exist in every suitable valley—I know of places where it is quite dominant in one slack and practically absent from another close by, though here again the conditions appear to be identical.

A typical haunt of *Myrica* is Tranmire Slack, north of Lastingham, where it is abundant, occurring here and there in damp places amongst *Calluna*. Little *Sphagnum* bogs with sporadic *Juncus communis* have clumps of *Myrica* growing on them together with a few individuals of *Erica tetralix*. This slack presents many features of ericetal vegetation. Looking at the valley from an adjacent height, the first impression we obtain is the superlative dominance of *Calluna* from the highest to the lowest slopes. *Pteris* manages to exist on the immediate sides of the streams, and occasionally sends out long tongues into the heather. Lighter patches indicate the presence of *Tetralix* "swiddens," whilst darker green blotches mark the site of the little bogs of *Myrica*. In Newton Dale, on a deep peat-moss I have noticed *Myrica* quite abundantly, though subordinate to the *Calluna-Eriophorum* vegetation. Here *Vaccinium oxycoccus* was quite frequent as a *Sphagnum*-bog plant, but singularly enough I once found this rather rare species abundant on a "swidden" situated on a gentle slope at the bottom of a shallow slack. *Calluna* and *E. tetralix* were co-dominant on an old "swidden" almost surrounded by bracken. *Polytrichum* and *Sphagnum* formed the ground vegetation, and on these mosses *V. oxycoccus* was abundant nearly all over the burnt area. Like several other typical peat-moss species, *V. oxycoccus* is absent from the Junco-Sphagnetum.

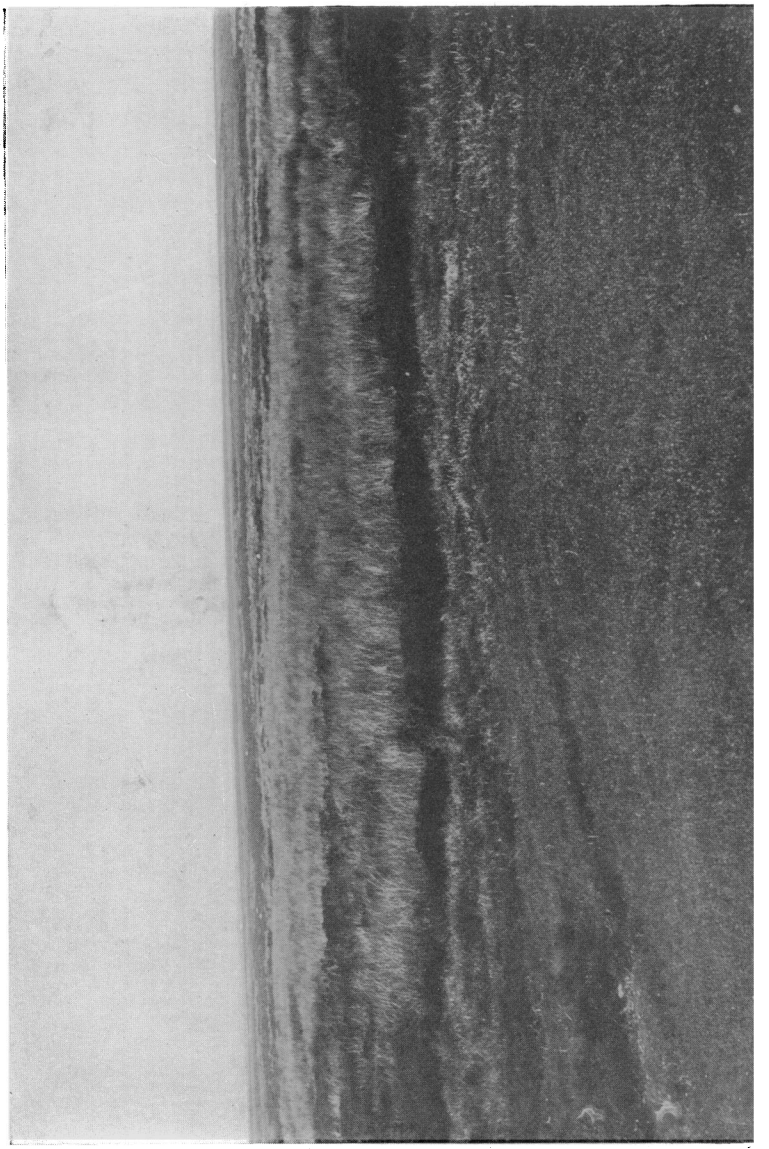
A peat-bog in the Kildale valley, with a marked convexity of surface and with a depth of 3—6 m., possesses a vegetation somewhat resembling the *Scirpus* heaths already described. The most abundant species are *Nardus* and *Scirpus* with a sporadic diffusion of *Eriophorum angustifolium*. Intermingled with these are beds of *Carex glauca*, and scanty patches of ill-grown *V. myrtillus* and *Calluna*. Towards the margins the peat is drier and supports grasses, such as *Nardus*, *Agrostis canina*, *Molinia*, *Aira flexuosa* and *Anthoxanthum odoratum*. At one

Phot. 1. Boulders of fossiliferous grit, Castleton, showing the very rocky character of some parts of the Moorlands of Northeastern Yorkshire.

Phot. 2. Peat at Loose Howe, under *Calluna-Eriophorum* moor on central watershed, altitude about 435 m.

Moss Swang, a peat-filled glacier-lake overflow-valley, with *Calluna-Eriophorum* vegetation on the floor, and *Pteris* and *Quercus-Betula* scrub on the slopes, altitude 220—320 m.

ELGEE—EASTERN MOORLANDS OF YORKSHIRE (see pp. 1—18).



Yarlsey Moss : Juncetum surrounded by *Calluna* and *Calluna-Eriophorum* moors, on central watershed, altitude about 470 m.

ELGEE—EASTERN MOORLANDS OF YORKSHIRE (see pp. 1—18).

Phot. 1. Juniper (*Juniperus communis*) and Holly (*Ilex Aquifolium*), Baysdale, with *Pteris* slopes behind.

Phot. 2. Great Hograh Gill, Baysdale: an oak-birch wood with *Pteris-Vaccinium* undergrowth, altitude 220—230 m.

place, in some old diggings there is a rich growth of *Eriophorum angustifolium* and *Erica tetralix*, a feature which is in strong contrast to the drier grass-land on the summit of the diggings. Here and there *Ulex* occurs, even towards the centre of the bog, and it is obvious from these facts that the peat-bog flora is gradually being ousted by the invading ring of grasses and gorse.

CONCLUSION

In concluding this brief survey, it has only been possible to indicate the salient aspects of the vegetation of the Eastern Moorlands of Yorkshire; we may—expanding the classification adopted by W. G. Smith (**15**, p. 112)—arrange the chief types as follows:—

Pteris slope, passing into the

Heath Formation.

Dry
- *Calluna-Pteris* heath on sandy slopes.
- *Calluna-Vaccinium* heath on rocky and stony edges of the dales.
- Callunetum on thin and sandy humus.
- *Calluna-Empetrum* heath (very occasional).
- *Calluna-Erica cinerea* heath, usually on burnt areas.
- *Vaccinium* heath on exposed slopes (rare).

Wet
- *Calluna-Nardus* heath on damp humus.
- *Calluna-Tetralix* heath on wet humus.
- *Tetralix-Scirpus* heath on wet humus over clayey sand.
- *Tetralix-Scirpus-Nardus* heath on wet humus over clayey sand.

Moor Formation.

Callunetum on deep peat ("fat" moor).

Moss Formation (on deep peat bogs).

Calluna-Eriophorum moss.
Eriophoretum (very rare).
Tetralix-Calluna-Eriophorum moss.
Myrica-Calluna-Eriophorum moss in slacks.
Nardus-Scirpus-Eriophorum moss (very rare, only observed once).
Junco-Sphagnetum (very frequent in suitable situations over the whole district).

As compared with similar formations in the west of Yorkshire (**14**) those of the east show a far more extensive area of pure heather moor which in the west is not so wide-spread as the Eriophoretum and grass heath. Eriophoreta occur very rarely on the eastern watershed, *Calluna* nearly always being a prominent element amongst the *Eriophorum*. And in conclusion, it may be remarked that in passing from Ireland to the east of England, drier moorland types become dominant. The very wet green *Sphagnum* bogs of Ireland are succeeded on the Pennines by the Eriophoretum, and these on the Eastern Moorlands yield to the Callunetum, the "thin" heathy varieties of which extend over a very wide area, probably greater

even than that of the "fat" *Calluna* moor and *Calluna-Eriophorum* moor combined. And this change in the vegetation is undoubtedly correlated with the decrease in the rainfall, a correlation which also holds for the heath area of the North German plain where, as we proceed eastwards, ericetal vegetation becomes more and more restricted as the atmospheric precipitation becomes less (**10**).

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SOME OBSERVATIONS ON A TERN COLONY[1]

By WILLIAM ROWAN

(*With Plate V*)

The work of which this is a brief description was carried out, in 1913, on Blakeney Point, Norfolk. The object was to determine, by means of a census, some of the laws that control the choice of site, the nesting materials, and the pigmentation of eggs. The work of previous years provided the basis for the methods employed. Many improvements in method suggest themselves, and future work should prove of decided value. This is the first systematic attempt at such a census, to our knowledge, and we know only too well its many weak points, but publish the results mainly as a suggestion to ornithologists and workers in Animal Ecology. The work involved is long and tedious, and results are few.

[1] Blakeney Point Publication No. 10—reproduced here (slightly condensed) from *Knowledge* (Feb., 1914) by kind permission of Author and Editor.