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THE SCOTTISH GEOGRAPHICAL MAGAZINE.

BOTANICAL SURVEY OF SCOTLAND.

II.

NORTH PERTSHIRE DISTRICT.

By ROBERT SMITH, B.Sc., University College, Dundee.

THE objects aimed at in the present survey, and the methods employed, have been explained in my former paper dealing with the Lowland district of Midlothian (8).¹ The North Perthshire map, which is now offered, will illustrate the application of these methods to a Highland district, where the features of the vegetation differ in many ways from those of the more temperate region.

The district now represented is one of much general interest, and includes some of the finest mountain scenery of Scotland. It is part of the basin of the Tay, and is traversed by that river and its tributaries, the Lyon, the Tummel, and the Bran. The altitude ranges from 100 feet (30 metres) in Strathmore to 4000 feet (1216 metres) on the cairn of Ben Lawers. Only a small part in the south-east corner is lowland in character, and is sharply marked off from the mountain region by the great boundary fault which runs diagonally from south-west to north-east, between the Old Red Sandstone of Strathmore and the more ancient metamorphic rocks of the Highlands. By far the greater portion of the area is moorland and pasture, intersected by narrow fertile valleys.

As was the case with the Edinburgh district, the main botanical subdivisions of this district are determined by altitude. Three main regions may be at once recognised :—

¹ These numbers refer to the bibliographical list at the end of the paper.

- (1) Temperate Region, including the sub-regions of cultivation, and of mixed deciduous trees.
- (2) Sub-Alpine Region, including the sub-regions of coniferous and birch-trees, and of hill pasture and moorland.
- (3) Alpine Region.

Each of these regions is inhabited by its own particular plant associations, which require for their development the particular conditions of environment existing within the region. In the following paper these regions are considered in turn, and the relationship between their vegetation and their life-conditions, so far as yet determined, is indicated.

REGION OF CULTIVATION.

[*(Region of Temperate Europe.)*]

The cultivated area shown on the present map belongs almost entirely to the upper sub-region of cultivation with oats as the chief cereal crop, for the few wheat-fields of the district are confined to a small portion of Strathmore in the south-east corner of the area. The line which indicates the upper limit of present or recent wheat cultivation will be seen to run about 500 feet (152 metres), only here and there rising to 600 feet (182 metres). It is thus approximately the same as determined for Midlothian, although here the wheat-fields near the upper limits are fewer and more scattered. Oats are grown successfully up to the limits of cultivation. On the steep slopes facing Strathmore the limiting line is about 800 feet (243 metres), but in the Highland valleys altitudes from 1000 to 1250 feet (304 to 380 metres) are frequently reached, whilst traces of former cultivation can be noted in some parts as high as 1500 feet (456 metres), as, for example, near Craig-choinnich Lodge, on Beinn a' Ghlo. 1250 feet can, however, be regarded as the limiting altitude in general for cereal cultivation in this district. As a rule, the elevations attained on the sides of the valleys facing the south are greater than on those facing the north, as can be well seen in the vicinity of Loch Tay, Blair Atholl, and Pitlochry.

The relationship between the regions of vegetation and the temperature and rainfall cannot be so clearly indicated here as in the case of the Edinburgh district, because of the scarcity of meteorological data. Such statistics, however, as we do possess show that the mean summer temperature over the wheat area is not below 56° F. (13·3° C.), the minimum required under ordinary conditions for the ripening of the wheat (1). In fact, the temperature for all the land under 500 feet (152 metres) in this district, as shown in the map accompanying Dr. Buchan's recent paper (3), is somewhat above the required 56° F., Taymouth, for example, at an altitude of 372 feet (113 metres), having a mean July temperature of 57·3° F. (14·1° C.). The mean summer temperature up to 1250 feet (380 metres) is shown to be over 54° F. (12·2° C.). Above that altitude it may in general be expected to be below that amount, although at Dalnaspidal [1414 feet (430 metres)],

just beyond the limits of ordinary cultivation, it is as much as 54.4° F. (12.4° C.).

In Midlothian the rainfall of the wheat region hardly exceeds 30 inches per annum. In this district it seems to be greater, for Stanley (lying just outside the present map), the only recording station in this part of the wheat region given in Dr. Buchan's paper (2), has an annual rainfall of 31.49 inches. Thus, although the summer temperature of the district is favourable for grain production, the greater moisture, especially in the Highland valleys, on the other hand, tends to render this production unprofitable. The rainfall increases greatly towards the west, even exceeding 60 inches in the vicinity of Killin. The other records of mean annual rainfall for this region given in Dr. Buchan's paper (2) are:—Inverbraan, 39.81 inches; Pitlochry, 37.01 inches; Bonskeid, 36.87 inches; Dalnaspidal, 59.83 inches.

Where the rainfall is as great as this, cereal cultivation is very much reduced, and is replaced by pasturage. The diminution in the cultivated area towards the west is very clearly observable on the map; a similar diminution towards the west is also indicated, although less markedly, on the Midlothian map.

The flora of the cultivated area is largely made up of introduced species, many of which are more or less casual in their occurrence. A distinct diminution in the number of these species is observable as the altitude is increased. The data which have been collected in the *Flora of Perthshire* by the late Dr. Buchanan White (9) permit us to estimate the number of species occurring in each sub-region of cultivation. Thus out of some 280 species which may be regarded as inhabitants of cultivated ground, only about 100 are found in the upper parts of the region above the limits of wheat cultivation, or above 500 feet (152 metres) in the Highland valleys.

TREE REGIONS.

The tree vegetation in North Perthshire is of more varied character, and of greater interest than in the lowland district of Midlothian. Yet even here, as can be seen from the map, it occupies relatively a very small portion of the total area, and even of the possible area for tree cultivation, for it is mostly confined to the valleys. Arboriculture is, on the whole, subservient to pasturage and game-preserving.

The different types of woodland represented in the district can all be well observed from the bridge over the river Tay at Dunkeld. If the rich tree vegetation surrounding that point of view be carefully examined, at least five distinct types can be distinguished:—

- (1) On the banks of the river and in the park-lands at low elevation the trees are southern in character. Beech, oak, sycamore, elm, ash, Spanish chestnut, horse chestnut, lime, walnut, etc., occur here mixed, as they have been planted for ornamental effect. Some of the trees, especially the beech and oak, are magnificent examples of their kind.
- (2) On the lower slopes of most of the hills the trees are mainly oaks

in the form of coppice, being cut down periodically and allowed to sprout again from the stumps.

- (3) Above the oak belt the slopes of the hills are almost wholly planted with larch-trees. These are well seen on Newtyle Hill, and on both sides of the valley above Dunkeld.
- (4) Mixed to a certain degree with the larches, especially on the rocky front of Craigie Barns, are clumps of Scots pine, standing out sharply from their deciduous neighbours.
- (5) One other tree besides the larch and pine is well marked on the higher slopes; this is the birch, which covers much of Birnam hill, and occurs on all the other hills in patches mixed with the other species.

View from Dunkeld Bridge, looking down the river.

Spruce, silver fir, alder, etc., also form small clumps, distinguishable by a keen observer, but none of them are in any way so conspicuous as the five types just mentioned, which are the only ones represented on the present map. The grouping of these five species into distinct societies depends upon the fact that each has its own particular conditions of life, and each grows where it finds these present. Thus the mixed deciduous trees find the most favourable temperature for their development on the low grounds; the oaks flourish well on the lower slopes and on the old river-terraces; while the harder larches, pines, and birches clothe the heights.

A further subdivision is employed here than was possible in Midlothian, where only the two main divisions, (1) mixed deciduous woods,

(2) coniferous woods, could be adequately represented. Here it is possible to show the following:—

(a) Temperate woods:—

1. Mixed deciduous woods, mainly beech and oak.
2. Oak woods.

(b) Sub-Alpine woods:—

3. Larch woods.
4. Pine woods.
5. Birch woods.

Old Oak Tree, Birnam.

REGION OF DECIDUOUS TREES.

(*Region of Temperate Europe.*)

In primitive Scotland the oak (*Quercus Robur*, L.) seems to have been the dominant element of this region, and in the district we are considering it still plays an important part—much more so than in Midlothian, where it is largely superseded by the introduced beech (*Fagus sylvatica*, L.). At low elevations, in plantations, park-lands, and dens, the mixture of the two species is the rule, but where the two trees are planted close together the dense shade cast by the beech prevents the growth of the native species.

The oak, however, reaches a higher altitude than its rival. On the map it will be seen that the mixed deciduous woods cease about 700 feet (213 metres) [although small patches of isolated beech-trees may be found over 900 feet (274 metres)], whilst oak woods, such as those near Kenmore, reach 1000 feet (304 metres), and isolated trees occur even higher.

The oak, especially in the form of coppice, is one of the most marked features of the Highland border. It forms a narrow belt of tree vegetation, quite clearly marked, although frequently broken by cultivation, on both sides of the Tay valley from Dunkeld to Loch Tay. It likewise extends up Strath Tummel to Loch Rannoch, but is by no means

Scots Pines. On the Bran, above Amulree.

so distinct in this valley, as it is largely mixed with or replaced by birch. In Strath Garry it constitutes part of the vegetation of the Pass of Killiecrankie, but farther north it diminishes in importance, practically ceasing about Blair Atholl.

We can readily conceive that before human influence restricted the range of the different species a keen competition existed between the oak and Scots pine for possession of the area. The general climatic conditions of the land below 1000 feet are suitable for either species. If the two species start equally well, and in close proximity, the oak tends to crush out the pine, both by reason of its deeper shade and of its stronger branches. Where a clearing has been made, however, and the sun has dried up the soil, or where water has accumulated from ill-

drainage and moss has sprung up and formed peat, or where animals graze on the seedlings, the pines tend to spring up more readily, and may for a time restrain the spreading of the oak. The remains of both species are found in the peat bogs, and probably each alternately dominated over the land. We have in fact in this district a meeting of two great regions of vegetation—the temperate and the sub-Alpine regions—which are similarly indicated in every mountainous country of Europe by deciduous and by coniferous trees respectively. An analogous state of affairs, for example, has been described by Professor Flahault in the valley of Barcelonnette in the Maritime Alps (4). There the oak region is well developed, extending to altitudes between 900 to 1000 metres (2960 to 3289 feet), but wherever man has cut down the trees, and left an open space, especially facing the south, which has been warmed and dried, the Scots pine has entered as an invading species, and tends to prevent the regeneration of the oak wood.

The subordinate vegetation of the mixed deciduous woods is in general character similar to that of Midlothian. The oak woods, however, contain an association of plants which differs in composition from that of more mixed woods with beech as one of the chief species. These differences from the beech association are directly connected with the greater light which penetrates through the oak foliage. More trees are found mixed with the oak, and an undergrowth of shrubs is characteristic. The chief species of this association are summarised in the following classified list:—¹

Trees mixed with the dominant species:—

<i>Ilex Aquifolium</i> , L. (Holly).	<i>Betula alba</i> , L. (Birch).
<i>Prunus spinosa</i> , L. (Sloe).	<i>Alnus glutinosa</i> , Medic. (Alder).
<i>Prunus Avium</i> , L. (Gean).	<i>Corylus Avellana</i> , L. (Hazel).
<i>Pyrus Aucuparia</i> , Ehrh. (Rowan).	<i>Fagus sylvatica</i> , L. (Beech).
<i>Crataegus Oxyacantha</i> , L. (Hawthorn).	[Isolated examples.]
<i>Fraxinus excelsior</i> , L. (Ash).	<i>Populus tremula</i> , L. (Aspen).
<i>Ulmus montana</i> , Stokes (Wych Elm).	<i>Salix</i> , spp.

Chief grasses forming the carpet under the trees:—

<i>Anthoxanthum odoratum</i> , L.	<i>Agrostis vulgaris</i> , With.
<i>Holcus mollis</i> , L.	<i>Festuca ovina</i> , L.
<i>Holcus lanatus</i> , L.	

Other conspicuous social species:—

<i>Rubus idæus</i> , L.	<i>Vaccinium Myrtillus</i> , L.
<i>R. fruticosus</i> , L.	<i>Pteris aquilina</i> , L.

General list of frequent associates:—

<i>Anemone nemorosa</i> , L.	<i>Viola Riviniana</i> , Reich.
<i>Ranunculus acris</i> , L.	<i>Polygala vulgaris</i> , L.

¹ The nomenclature of these lists is that of the *London Catalogue of British Plants*, 9th edition, 1895.

<i>Cerastium triviale</i> , Link.	<i>Calluna Erica</i> , DC.
<i>Arenaria trinervis</i> , L.	(occasionally.)
<i>Oxalis Acetosella</i> , L.	<i>Primula acaulis</i> , L.
<i>Trifolium repens</i> , L.	<i>Scrophularia nodosa</i> , L.
<i>Vicia Cracca</i> , L.	<i>Veronica officinalis</i> , L.
<i>Lathyrus montanus</i> , Bernh.	<i>V. Chamædrys</i> , L.
<i>Fragaria vesca</i> , L.	<i>Melampyrum pratense</i> , L.
<i>Potentilla Fragariastrum</i> , Ehrh.	<i>Stachys sylvatica</i> , L.
<i>P. silvestris</i> , Neck.	<i>Teucrium Scorodonia</i> , L.
<i>Circea lutetiana</i> , L.	<i>Ajuga reptans</i> , L.
<i>Galium saxatile</i> , L.	<i>Myrica Gale</i> , L. (in wet spots).
<i>Valeriana officinalis</i> , L.	<i>Athyrium Filix-fœmina</i> , Roth.
<i>Scabiosa succisa</i> , L.	<i>Lastrea Filix-mas</i> , Presl.

In this district, as in Midlothian, the flora of the deciduous woods includes a number of species which in all probability were formerly much more abundant, but which have, through disforestation and other causes, become restricted to a few isolated stations. The chief of these, as determined from White's *Flora of Perthshire* (9), are given in the following list:—

- Vicia Orobus*, DC.—Kinloch-Rannoch and Glen Tilt.
Lathyrus niger, Wimm.—Killiecrankie.
Campanula latifolia, L.—Aberfeldy, etc.
Veronica montana, L.—Dalguise and Castle Menzies.
Melampyrum sylvaticum, L.—In various localities.
Origanum vulgare, L.—Near Blair Atholl.
Stachys Betonica, Benth.—Rumbling Bridge, Strathbran.
Neottia Nidus-avis, Rich.—Rumbling Bridge, Craigie Barns, Moness, near Kinloch-Rannoch, Pass of Killiecrankie, and Lawers Den (July 1900, R. S.).
Epipactis palustris, Crantz.—Near Pitlochry and Blair Atholl.
Polygonatum verticillatum, All.—Near Pitlochry, Killiecrankie, and Blair Atholl.
Convallaria majalis, L.—Near Pitlochry, Killiecrankie, and Glen Tilt.
Gagea fascicularis, Salisb.—Near Inver, and Pitlochry.
Paris quadrifolia, L.—In a few stations.
Milium effusum, L.—Dunkeld, Moness, and Glen Tilt.
Calamagrostis epigeios, Roth.—Near Dunkeld.
Festuca sylvatica, Vill.—Strathbran, Inver, Acharn, and Allt Girnaig.
Bromus giganteus, L.—In a few stations.
Scolopendrium vulgare, Symons.—Acharn and Killin.
Equisetum hyemale, L.—Kenmore.

REGION OF CONIFEROUS AND BIRCH TREES.

(Region of Sub-Arctic or Sub-Alpine Europe.)

As already mentioned, three trees dominate in this region, the Scots pine (*Pinus sylvestris*, L.), the larch (*Larix europæa*, L.) and the birch (*Betula alba*, L.). The woods of the larger valleys are mostly made up

of the first two species, in particular the larch, but in the more remote parts they are almost completely composed of birch. Small patches of alder, hazel, and willow occur, but nowhere cover any extent of ground.

The Scots pine is undoubtedly the native tree characteristic of this region, as it grows well in most parts, and remains of its earlier forest are found buried in many peat bogs. The Black Wood of Rannoch on the south shores of Loch Rannoch is believed to still represent a part of the primitive Caledonian forest, but elsewhere in the district the trees have been comparatively recently planted. The Black Wood is somewhat thin now and much mixed with birch, but it bears an aspect of antiquity, suggestive of its primitive character, such as is quite foreign to most of the other pine woods of the region.

Scots Pines and Larch. On Craigie Barns.

During the past century more larch has been grown than Scots pine, but the prevalence of larch canker, caused by the fungus *Dasyscypha* (*Peziza*) *Wilkommii*, Hartig, on the trees of the newer plantations has checked its introduction, and at present the native pine is tending to replace it. The planting of the larch woods of the Atholl district was one of the greatest steps made by scientific forestry in the country. It was largely the work of John, fourth Duke of Atholl, who, between 1774 and 1826, planted as many as fourteen million plants, covering 10,324 imperial acres. The larch was first introduced into Scotland in 1738, and two of the first trees still stand beside the cathedral at Dunkeld. For further particulars regarding the introduction of the larch the reader is referred to general works on the forestry of the country, and in particular to the work by Mr. Hunter on the woods of Perthshire (5).

It is quite probable that most of the land up to 2000 feet (608 metres) could, after careful study of the conditions, be made to bear coniferous trees furnishing good timber. None of the woods at present reach that altitude, the highest just passing 1800 feet (547 metres), as, for example, Craig hill near Kenmore, or above Meggernie in Glen Lyon. Both species, however, grow better at somewhat lower elevations, and seem very similar with regard to their altitudinal requirements, the pine resisting perhaps somewhat better the extreme conditions at high altitudes. The altitudinal limit for isolated pine-trees given in White's *Flora* is 1900 feet (578 metres) in Atholl.

The pine-trees in many parts seed themselves quite readily, but the seedlings, although numerous and starting well, are usually eaten down by grazing sheep, rabbits, or deer, and thus the natural regeneration of

Seedling Pine on island. On Craigie Barns.

the woodland area is greatly hindered. In the accompanying illustration one of these seedling pines is shown, which has sprung up on a heather-covered island in a little mountain tarn on Craigie Barns, and has there managed to escape grazing animals. Seedlings which have been self-sown can also be seen springing up on some of the islands in the river Tay, where their isolated position has protected them.

The area under birch woods shown on the map is interesting, since it represents the part of the woodland which is quite natural and self-sown. This tree springs up easily and quickly on the clearings of pine or oak woods, on moorland and on pasture, so long as these are not too closely grazed. If allowed full scope it would cover much of the sub-Alpine region. It reaches a considerable altitude, small patches on

the mountains south of Loch Rannoch touching 2000 feet (608 metres), whilst isolated examples—for example, on Beinn a' Ghlo above Glen Tilt—are found as high as 2300 feet (699 metres). The trees at these extreme altitudes are, however, usually small and stunted, compared with those found in the valleys.

The subordinate vegetation in the sub-Alpine woods is of a less marked character than that in the temperate woods, hardly differing,

Scots Pines. On the Tilt near Blair Atholl.

except in the proportion of the individuals present, from the adjoining moorland or hill pasture. This is owing to the comparatively slight shade cast by these woods. In the pine woods heather and its associates usually constitute the plant carpet, whilst in larch and birch woods the ground is more often covered by grasses and bracken, although this rule is by no means invariable.

The birch woods in the shelter of the river valleys may, however, have as rich a vegetation as the oak coppice, and indeed may be regarded as having replaced that association. Thus, for example, a list taken in the birch wood between Loch Tummel and the Falls of Tummel shows a

flora almost identical with that already given as characteristic of the oak coppice.

Many of the woodland species cease about the same altitudes as the trees which shelter them. Thus all these rare species given above as peculiar to deciduous woods do not pass 1000 feet (304 metres), the upper limit of the oak woods. Those which are given in the following

Birches. Strath Bran.

list cease before 2000 feet (608 metres) are reached, the altitude which may be regarded as the maximum limit of tree vegetation.

Ranunculus auricomus, L.

R. Ficaria, L.

Stellaria nemorum, L.

S. umbrosa, Opiz.

S. Holostea, L.

* *Arenaria trinervis*, L.

* *Hypericum perforatum*, L.

* *Geranium pratense*, L.

G. lucidum, L.

* *Ilex Aquifolium*, L.

* *Prunus Avium*, L.

* *P. Padus*, L.

* *Rubus fruticosus*, L.

Geum urbanum, L.

Fragaria vesca, L.

Potentilla Fragariastrum, Ehrh.

* *Agrimonia Eupatoria*, L.

Epilobium montanum, L.

* *Circæa lutetiana*, L.

* *C. alpina*, L.

* *Sanicula europæa*, L.

Conopodium denudatum, Koch.

Hedera Helix, L.

Lonicera Periclymenum, L.

Linnæa borealis, Gron.

Asperula odorata, L.

* Hardly passing 1000 feet

- Valeriana sambucifolia*, Willd.
Pyrola media, Sn.
P. rotundifolia, L.
P. secunda, L.
Primula acaulis, L.
Scrophularia nodosa, L.
Digitalis purpurea, L.
Veronica officinalis, L.
**Nepeta Glechoma*, Benth.
**Stachys sylvatica*, L.
**Lamium album*, L.
Teucrium Scorodonia, L.
Ajuga reptans, L.
Ulmus montana, Stokes.
Alnus glutinosa, Medic.
Corylus Avellana, L.
Salix cinerea, L.
S. caprea, L.
Populus tremula, L.
Corallorhiza innata, R. Br.
**Listera ovata*, R. Br.
Orchis mascula, L.
**Allium ursinum*, L.
**Scilla festalis*, Salisb.
Luzula vernalis, DC.
**Carex remota*, L.
C. pallescens, L.
**C. laevigata*, Sm.
C. sylvatica, Huds.
Holcus mollis, L.
H. lanatus, L.
Arrhenatherum arenaceum, Beauv.
Melica nutans, L.
M. uniflora, Retz.
**Bromus ramosus*, Huds.
**Brachypodium gracile*, Beauv.
**Agropyron caninum*, Beauv.
Pteris aquilina, L.
Athyrium Filix-fœmina, Roth.

The plants peculiar to the old pine forests are almost as few and as rare as in Midlothian district. The following are given in White's *Flora* for this part of Perthshire:—

- Linnaea borealis*, L.—Near Killin. Curiously enough this species does not seem to be reported for the Black Wood of Rannoch, where it certainly might well be expected.
Pyrola minor, L.—Frequent.
P. media, Sw.—Frequent.
P. rotundifolia, L.—“Dunkeld” (1840), Blair Atholl (?)
P. secunda, L.—In several localities.
Trientalis europæa, L.—Frequent.
Corallorhiza innata, Br.—Black Wood of Rannoch.
Listera cordata, Br.—Frequent.
[*Moneses grandiflora*, Gray, and *Goodyera repens*, R. Br., although found in other parts of Perthshire, do not seem to be present within the area of the present map.]

Three species which I have found quite commonly in the pine woods in Norway, and which might be expected in the present woods, are here entirely confined to the Alpine region. These are—*Cornus suecica*, L., *Vaccinium uliginosum*, L., and *Lycopodium annotinum*, L. The last named has been found in an adjoining district, inhabiting a wood near Blairgowrie (9), a piece of evidence favouring the theory of the former presence of this species at least, in the primitive woods of Perthshire, when they more nearly resembled those of Norway at the present day.

Several of the woodland plants may be found within the Alpine region, above 2000 feet (608 metres), where the shelter of rocky ravines or crevices, or of heather or blaeberry, replaces that of the trees at lower

elevations. The chief of these are given here, along with the highest altitudes recorded for them in White's *Flora*.

<i>Anemone nemorosa</i> , L. (2750 feet.)	<i>Pyrola minor</i> , L. (3700 feet.)
<i>Viola Riviniana</i> , Reich (2800 „)	<i>Vaccinium Myrtillus</i> , L. (3900 „)
<i>Lychnis dioica</i> , L. (2500 „)	<i>Lysimachia nemorum</i> , L. (2700 „)
<i>Hypericum pulchrum</i> , L. (2700 „)	<i>Trientalis europæa</i> , L. (2500 „)
<i>Geranium sylvaticum</i> , L. (3000 „)	<i>Veronica Chamædrys</i> , L. (2400 „)
<i>Oxalis Acetosella</i> , L. (2800 „)	<i>Melampyrum pratense</i> , L. (3000 „)
<i>Spiræa Ulmaria</i> , L. (2900 „)	<i>Mercurialis perennis</i> , L. (3300 „)
<i>Rubus Idæus</i> , L. (2450 „)	<i>Urtica dioica</i> , L. (2750 „)
<i>R. saxatilis</i> , L. (3200 „)	<i>Listera cordata</i> , R. Br. (2500 „)
<i>Geum rivale</i> , L. (3000 „)	<i>Luzula maxima</i> , DC. (2800 „)
<i>Pyrus Aucuparia</i> , Ehoh. (2850 „)	<i>L. campestris</i> , DC. (3000 „)
<i>Angelica sylvestris</i> , L. (2800 „)	<i>L. erecta</i> , Desv. (3350 „)
<i>Adoxa Moschatellina</i> , L. (3000 „)	<i>Poa nemoralis</i> , L.

and most of the species of ferns found in the district.

REGION OF HILL PASTURE AND MOORLAND.

(*Region of Sub-Arctic or Sub-Alpine Europe*.)

The limits of this region are more difficult to define here than in the Edinburgh district. There it extends from the borders of cultivation to the highest point of the hills, an altitude which only reaches 2136 feet (649 metres). In the present district the range of altitude is much greater, and the vegetation undergoes considerable change in character towards the highest points; grasses and heather, the species we have regarded as characteristic of the region of hill pasture and moorland, being replaced by mosses, lichens, dwarf willows, sedges, saxifrages, etc.—in short, the vegetation designated as Alpine. The transition between the regions is, however, gradual, and consideration is required before deciding upon the separating characters. In other countries the transition to the Alpine region is usually indicated by the disappearance of the trees. By applying this rule to the present district, we should get somewhere about 2000 feet (608 metres) as the beginning of the Alpine region. Although from the great scarcity of trees such a determination must be regarded as only approximate, still there are other circumstances which show that this figure is of value. A number of the heather associates, in particular *Erica Tetralix*, L., and *E. cinerea*, L., cease about this altitude. *Vaccinium Myrtillus*, L., which below 2000 feet is usually quite a subordinate species, above this begins, on many hills, to be a conspicuous element in the vegetation. *Alchemilla alpina*, L., one of the most characteristic Alpine species, also becomes much more abundant above 2000 feet. On some mountains these changes towards the Alpine condition begin lower than on others, but as the differences in this respect are usually too slight to be shown on a map of the present scale, the contour line of 2000 feet (608 metres) has been used to define the upper limit of the region of hill pasture and moorland.

Here, as on the Pentland hills, a strong contrast can be seen between the green pasture and the brown heather. The Breadalbane range is a good example of the green type, and the Rannoch mountains of the brown. These two types have been distinguished by different colours on the map, so that the area occupied by each may be compared with the formations shown on the geological maps. As in Midlothian the differences in vegetation seem to be mainly due to differences in the physical and chemical nature of the subjacent rock and soil.

The mineral content of the soil plays an important part in determining the association inhabiting it. Where the soil is poor in mineral salts, such as that formed by the disintegration of sandstones or quartzitic rocks, or that composed of almost pure peat, the plant association is poor in number of species, and heather and its associates predominate. Thus if the botanical map be compared with the geological map, it will be seen that the greatest areas of heather coincide with the poor quartzitic hills of Rannoch and Atholl, whilst the greatest areas of pasture, on the other hand, coincide with rich schists, containing calcium, magnesium, and potassium, of the Breadalbane range. Beinn a' Ghlo, Beinn a' Chuallaich, Beinn Mholach, and Schiehallion are all good examples of the heather type on quartzitic rocks; Ben Lawers, and the hills north of Kirkmichael of the grassy type on limestones, and chloritic and mica schists. Some of the smaller patches of pasture occur closely associated with outcrops of limestone, as, for example, beside Loch Moraig, on Tulach hill above Blair Atholl, around Loch Tummel, and in Glen Lyon. In some other cases, such as in Glen Tilt, the chemical nature of the soil does not seem so important in producing the grass association as the regular conditions of moisture on the well-drained slopes of the narrow valley.

The conditions of development of the heather association, shortly stated, seem to be the presence of a peaty soil poor in mineral content, which may be dry and unretentive, or wet and stagnant. The grasses, on the other hand, require a soil rich in minerals which is well-drained on the surface, and with a retentive bottom layer.

There are still, however, other causes which determine the presence of heather or of grass. Thus much of the hill-land adjoining cultivation is pasture, and has evidently been produced from the heather area through the manuring, regular cropping, and treading of the sheep. Regular burning seems in certain parts, on the other hand, to have increased the area dominated by the heather. These, however, I believe to be quite secondary causes, and to act rather towards emphasising the natural contrast between the types than to greatly alter the areas of distribution.

Fuller discussion of these questions I reserve for a paper dealing with a wider area than is here being studied.

HEATHER ASSOCIATION.

This is by far the most characteristic association of the district. In many parts it extends as an almost unbroken covering to the hills. Here as elsewhere it requires a peaty soil for its development. Sometimes this may be a mere surface film a few inches thick, resulting from

the partial decay of species of *Dicranum*, *Hypnum*, or *Racomitrium*, mosses which grow freely on the drier quartzitic mountains of Perthshire, such as Schiehallion and Beinn a' Ghlo, or again it may be a peat layer several feet in thickness, formed mainly from *Sphagnum*, which has grown in the moorland hollows.

The exact part played by this peat in the economy of the heather plant is still doubtful. Microscopic examination of the roots shows, however, that root-hairs are wanting, and that the rootlets are closely invested by the filaments of a fungus, which also penetrates their epidermal cells. There may be some sort of co-operation between this root-fungus (*mycorhiza*), and the heather plant that enables the heather to utilise the food-stuffs of the peculiar humus in which it grows. Be this as it may, it is enough for our present purpose to recognise that the presence of the peat with the associated *mycorhiza* is an important factor in determining the area of distribution of the heather plant.¹

The following associates of the heather agree with it in requiring humus for their development, and in a number of these at least—the *Ericaceæ*, *Orchideæ*, and *Empetrum*—a *mycorhiza* has similarly been found in connection with their roots:—

Peat plants in dry conditions.

- Potentilla silvestris*, Neck.
- Antennaria dioica*, R. Br.
- Vaccinium Vitis-Idæa*, L.
- V. uliginosum*, L. (Alpine).
- V. Myrtillus*, L.
- Arctostaphylos Ura-ursi*, Spreng.
- Calluna Erica*, DC.
- Erica cinerea*, L.
- **Loiseleuria procumbens*, Desv. (Alpine).
- **Pyrola rotundifolia*, L. (Alpine).
- **P. media*, Sw.
- **P. minor*, L.
- **P. secunda*, L. (Alpine).
- Listera cordata*, R. Br.
- Nardus stricta*, L.
- Lomaria Spicant*, Desv.

Peat plants in moist conditions.

- **Rubus Chamæmorus*, L. (Alpine).
- **Schollera Oxycoccus*, Roth.
- Erica Tetralix*, L.
- Myrica Gale*, L.
- Empetrum nigrum*, L.
- **Malaxis paludosa*, Sw.
- Juncus squarrosus*, L.
- **Rhynchospora alba*, Vahl.
- **Carex magellanica*, Lam.
- **C. limosa*, L.
- Molinia varia*, Schrank.

This list hardly differs from that given for the Midlothian district, a fact which testifies to the constancy of this association over a considerable area.

With the exception of the rare or Alpine species, distinguished by an asterisk, the plants of the above list may be regarded as constantly associated with the heather. They occur in almost every one of the many lists of associates which I have compiled from all parts of the

¹ For further information on *mycorhiza* the reader is referred to Frank's *Lehrbuch der Botanik*, vol. i. p. 264, etc., Leipzig (Engelmann), 1892.

heather area. Several others occur in almost as many of these lists, and are characteristic plants of the association, although by no means confined to it, some being almost as abundant in the pasture area. The chief of these characteristic species are :—

Anemone nemorosa, L.
Ranunculus acris, L.
R. repens, L.
Viola Riviniana, Reich.
Polygala vulgaris, L.
Hypericum pulchrum, L.
Linum catharticum, L.
Oxalis Acetosella, L.
Genista anglica, L.
Lotus corniculatus, L.
Lathyrus montanus, Bernh.
Galium saxatile, L.
Scabiosa Succisa, L.
Gnaphalium sylvaticum, L.
Achillea Ptarmica, L.
Crepis virens, L.
Hieracium Pilosella, L.
Campanula rotundifolia, L.
Trientalis europæa, L.
Veronica officinalis, L.
Melampyrum pratense, L.
Euphrasia officinalis, L.
Thymus Serpyllum, L.
Rumex Acetosâ, L.
R. Acetosella, L.

Salix aurita, L.
S. repens, L.
Orchis maculata, L.
Habenaria conopsea, Benth.
Juncus conglomeratus, L.
Luzula campestris, DC.
Scirpus cæspitosus, L.
Eriophorum vaginatum, L.
E. angustifolium, Roth.
Carex echinata, Murr.
C. Goodenowii, J. Gay.
C. pilulifera, L.
C. binervis, Sm.
Anthoxanthum odoratum, L.
Agrostis vulgaris, With.
Deschampsia flexuosa, Trin.
Avena pratensis, L.
Sieglingia decumbens, Bernh.
Festuca ovina, L.
Lastræa Filix-mas, Presl.
L. dilatata, Presl.
Lycopodium Selago, L.
L. clavatum, L.
L. alpinum, L.

While considering the heather association on the Pentlands, it was shown that three well-marked varieties could be distinguished, namely, heath, heather-moor, and *Sphagnum*-moor. The same three varieties are represented in the present district. The driest variety, heath, occurs on those hills with a poor and unretentive soil, especially on steep slopes with a southern exposure. It is well marked on the Rannoch hills, on Beinn a' Ghlo, and on parts of Schiehallion. It can be easily recognised by the presence of *Erica cinerea*, *Antennaria*, *Arctostaphylos*, *Genista*, *Potentilla silvestris*, etc. On wetter localities, especially poorly drained slopes facing the north, such as also occur frequently amongst the Rannoch mountains, the association takes the form designated heather-moor. *Erica Tetralix*, *Molinia varia*, *Scirpus cæspitosus*, *Juncus squarrosus*, and in the lower parts *Myrica Gale* are the species by which it is indicated. With extreme moisture the heather-moor passes into the "*Sphagnum*-moor," where living *Sphagnum*, sedges, *Empetrum*, *Eriophorum*, etc., constitute the dominant vegetation. This association reaches a great development in the wild moor of Rannoch lying to the west of the area we are considering. It is found in all the peat-bogs within our area, and the chief of these which are already represented on the one-

inch map of the Geological Survey have been differently coloured on this map to distinguish them from the general heather association:

The variety of the heather-moor characterised by the abundance of the bog-myrtle (*Myrica Gale*) occurs particularly on the lower slopes of the valleys, especially on the badly drained clearings in the birch woods. It is largely made up of marsh species, being transitional in some ways between the heather-moor and the true marsh associations. The following list from a clearing near Loch Tummel will show its general composition:—

Ranunculus Flammula, L.

Viola palustris, L.

Potentilla silvestris, Neck.

Drosera rotundifolia, L.

Scabiosa Succisa, L.

Calluna Erica, DC.

(Not common.)

Erica Tetralix. (Abundant.)

Pinguicula vulgaris, L.

Habenaria conopsea, Benth.

Narthecium Ossifragum, Huds.

Juncus lampocarpus, Ehrh.

J. acutiflorus, Ehrh.

Eriophorum vaginatum, L.

Carex pulicaris, L.

C. echinata, Murr.

C. ovalis, Good.

C. flacca, Schrel.

C. flava, L.

Molinia varia, Schrank.

(Most abundant species
after *Myrica Gale*.)

Sphagnum, spp.

GRASS ASSOCIATIONS.

The grassy covering of the hills varies considerably in composition according to the particular conditions present, and quite a number of different grasses may predominate. The good mountain pasture is mainly composed of *Agrostis canina*, L., *A. vulgaris*, With., *Anthoxanthum odoratum*, L., and *Festuca ovina*, L. On the best pastures, especially those near the borders of cultivation, these species are largely mixed with such finer grasses as *Poa pratensis*, L., *P. trivialis*, L., and *Cynosurus cristatus*, L. *Nardus stricta*, L., approaches the heather in its requirements, as it seems to grow best on dry, poor soil, with a certain amount of peat always present. It forms an association in some ways intermediate between the heath and the dry pasture. The association dominated by *Molinia varia*, Schrank, is, on the other hand, intermediate between the heather-moor and the wet pasture, as it seems to prefer a wet, ill-drained peaty soil. *Deschampsia (Aira) cæspitosa*, Beauv., *D. flexuosa*, Trin., and *Holcus lanatus*, L., are all characteristic of disturbed ground, such as clearings in woods; the first occurs particularly where the soil is clayey and wet, the second where it is dry and peaty, the third on the better-drained clearings.

A good example of the *Deschampsia flexuosa* association may be seen in the clearings of the pine and larch woods, such as occur above Blair Atholl. On one such clearing, near Loch Moraig, with a dry sandy soil, the ground which has been most disturbed is mainly peopled by—

Deschampsia flexuosa, Trin.

Holcus lanatus, L.

Ranunculus acris, L.

Rubus idæus, L.

Cnicus lanceolatus, Willd.

Veronica Chamædrys, L.

Rumex Acetosella, L.

Urtica dioica, L.

The grass species second in importance on this clearing is *Festuca ovina*, L., which seems to be gradually replacing the dominant *Deschampsia flexuosa*. With it are associated such pasture species as—

<i>Viola Riviniana</i> , Reich.	<i>Veronica officinalis</i> , L.
<i>Cerastium triviale</i> , Link.	<i>V. Chamædrys</i> , L.
<i>Rosa canina</i> , L. (seedlings).	<i>Luzula vernalis</i> , DC.
<i>Galium saxatile</i> , L.	<i>L. campestris</i> , DC.
<i>Scabiosa Succisa</i> , L.	
(in moister parts).	

Mixed with this pasture is a good deal of small heather which may, on the poorest parts, replace the grasses. Where it grows it is usually associated with—

<i>Polygala vulgaris</i> , L.	<i>Erica cinerea</i> , L.
<i>Potentilla silvestris</i> , Neck.	<i>Hypnum Schreberi</i> , L.

A few species characteristic of shady places manage to compete with the invading species, as, for example—

<i>Anemone nemorosa</i> , L.	<i>Rubus saxatilis</i> , L.
<i>Spiræa Ulmaria</i> , L.	<i>Trientalis europæa</i> , L.

Seedlings of birch, in most cases browsed down near to the ground by sheep or rabbits, are struggling to reinstate the arborescent vegetation.

The general flora of the pasture area is large. It includes almost all the species of the heather area and many others besides. The complete list may be easily constructed from White's *Flora of Perthshire* (9). Here two type lists will be given, one from the south slopes of Ben Lawers between 1000 and 1500 feet (304 to 456 metres), and the other from pasture above limestone rock near Balnabodach on Loch Tummel.

Pasture plants on south slopes of Ben Lawers, between 1000 and 1500 feet :—

Gramineæ :—

* <i>Anthoxanthum odoratum</i> , L.	} Chief species.	<i>Sieglingia decumbens</i> , Bernh.
* <i>Agrostis vulgaris</i> , With.		<i>Cynosurus cristatus</i> , L.
<i>A. canina</i> , L.		* <i>Molinia varia</i> , Schrank.
* <i>Festuca ovina</i> , L.		<i>Poa pratensis</i> , L.
* <i>Deschampsia flexuosa</i> , Trin.		* <i>Nardus stricta</i> , L.

Other families :—

* <i>Ranunculus acris</i> , L.	* <i>Sagina procumbens</i> , L.
<i>R. repens</i> , L.	* <i>Linum catharticum</i> , L.
<i>R. bulbosus</i> , L.	<i>Trifolium pratense</i> , L.
* <i>Viola Riviniana</i> , Reich.	* <i>T. repens</i> , L.
<i>Polygala vulgaris</i> , L.	* <i>Lotus corniculatus</i> , L.

* Also found in the Alpine pasture between 2000 and 3000 feet (608 to 912 metres) on Ben Lawers.

* <i>Lathyrus montanus</i> , Bernh.	* <i>Calluna Erica</i> , DC.
* <i>Potentilla silvestris</i> , Neck.	(small and scattered).
* <i>Alchemilla vulgaris</i> , L.	<i>Erica cinerea</i> , DC.
<i>Pyrus Aucuparia</i> , Ehrh. (seedlings).	(small and scattered).
* <i>Galium saxatile</i> , L.	<i>Gentiana campestris</i> , L.
* <i>Scabiosa Succisa</i> , L.	<i>Veronica officinalis</i> , L.
* <i>Bellis perennis</i> , L.	* <i>Euphrasia officinalis</i> , L.
<i>Habenaria viridis</i> , R. Br.	* <i>Thymus Serpyllum</i> , Fr.
<i>H. bifolia</i> , R. Br.	<i>Prunella vulgaris</i> , L.
* <i>Narthecium Ossifragum</i> , Huds.	* <i>Plantago lanceolata</i> , L.
* <i>Juncus squarrosus</i> , L.	* <i>Rumex Acetosa</i> , L.
* <i>Luzula campestris</i> , DC.	* <i>R. Acetosella</i> , L.
* <i>Achillea Millefolium</i> , L.	* <i>Orchis maculata</i> , L.
<i>Hieracium Pilosella</i> , L.	<i>Habenaria conopsea</i> , Benth.
* <i>Taraxacum officinale</i> , Web.	<i>H. albida</i> , R. Br.
* <i>Campanula rotundifolia</i> , L.	* <i>Scirpus cespitosus</i> , L.
* <i>Vaccinium Myrtillus</i> , L.	* <i>Carex pilulifera</i> , L.
(small and scattered).	<i>Pteris aquilina</i> , L. (scattered).

Pasture plants near Balnabodach, Loch Tummel, with lime in soil.
Altitude 700 to 900 feet (213 to 274 metres)¹ :—

Gramineæ :—

<i>Koeleria cristata</i> , Pers.	<i>Poa pratensis</i> , L.
<i>Cynosurus cristatus</i> , L.	<i>Holcus lanatus</i> , L.
<i>Festuca ovina</i> , L.	

Other plants :

<i>Helianthemum Chamæcistus</i> , Mill.	<i>Galium saxatile</i> , L.
<i>Polygala vulgaris</i> , L.	<i>Bellis perennis</i> , L.
<i>Trifolium pratense</i> , L.	<i>Chrysanthemum Leucanthemum</i> , L.
<i>T. repens</i> , L.	<i>Hieracium Pilosella</i> , L.
<i>T. dubium</i> , Sibth.	<i>Gentiana campestris</i> , L.
<i>Lotus corniculatus</i> , L.	<i>Euphrasia officinalis</i> , L.
<i>Rubus fruticosus</i> , L.	<i>Thymus Serpyllum</i> , L.
<i>Alchemilla vulgaris</i> , L.	<i>Plantago lanceolata</i> , L.
<i>Rosa</i> , sp.	<i>Pteris aquilina</i> , L. (scattered).
<i>Galium verum</i> , L.	

In comparing the region of hill pasture and moorland of Perthshire with the same region on the Pentlands, the close agreement in the flora and in the relative importance of the species in the associations is very marked. The highland region is richer in species and bears fewer traces of human influence, but the dominant heaths and grasses are almost the same in both cases.

Two species of the heather association, *Vaccinium Vitis-Idæa* and *Arctostaphylos Uva-ursi*, which are common in the Highlands, are rare in the lowland area, the second being quite absent from the Pentlands.

¹ This list does not pretend to be so complete as the other, but only aims at showing the chief species of the association.

Myrica Gale, likewise rare in the lowland district, is one of the characteristic plants of the Highland valleys, increasing in importance the farther we penetrate into the mountains towards the west. On the other hand, the Cranberry, *Schollera Oxycoccus*, which is comparatively common in some of the peat bogs of the Pentlands, seems to be very rare in the present area.

The bracken (*Pteris aquilina*) is better developed on the slopes facing the south than on those facing the north, although it is most luxuriant under the shade of the birch-trees. It reaches altitudes similar to those attained on the Pentlands, in general ceasing about 1400 feet (426 metres). Dr. Buchanan White (9), however, records it as high as 1550 feet (471 metres) in Breadalbane, and 1800 feet (547 metres) in Rannoch. The bell heath (*Erica cinerea*) is like the bracken in growing best with a southern exposure; it is particularly well-developed on the dry quartzitic hills.

The mountain buckler fern (*Lastræa Oreopteris*) is quite characteristic of steep valley slopes shut off from the direct rays of the sun. Thus it is well developed in Glen Tilt, and in Glen Leathad (a branch of Glen Tilt) it almost completely covers the slopes facing north-east.

The matweed (*Nardus stricta*), which is very abundant in the drier hollows of the Pentlands, seems rather less abundant in the Highland area.

ALPINE REGION.

As already stated, the Alpine region may be regarded as beginning at 2000 feet (608 metres), about which altitude the last of the trees are found, and a number of the characteristic sub-Alpine pasture and moorland species cease. The changes, however, are usually gradual, and it is often about 3000 feet (912 metres) before the Alpine features of the landscape become conspicuous. Between 2000 and 3000 feet the vegetation is generally a poor pasture or moorland, with patches of Alpine species at the sources and on the sides of the streams, or in the shelter of the crags.

An even sharper contrast than in the sub-Alpine region is here seen between the poor Rannoch and the rich Breadalbane mountains, for now the subjacent rocks contribute more to the actual surface soil, being less covered up by superficial glacial deposits. Three main types of mountain between these altitudes have been distinguished on the map. The first is grassy, with an association of plants hardly differing from the pasture of the sub-Alpine region except in the abundance of its characteristic species (*Alchemilla alpina*, L.). It includes all the Breadalbane mountains, and on the map no distinction in colour has been made between it and the sub-Alpine pasture. On Ben Lawers many of the species, which elsewhere cease below 2000 feet, here mount nearly to 3000 feet. On the list given above for Ben Lawers those hill pasture species, which also occur in the Alpine region, are marked with an asterisk. They constitute more than half the number.

The second type of mountain is also largely covered with grasses, but with the blaeberry (*Vaccinium Myrtillus*) very much mixed with them,

and still little heather. This has been distinguished on the map by a special colour, and will be seen to cover several of the Atholl and Glen Almond mountains, such as Ben Vrackie, Farragon, Auchnafree, etc. Ben Vrackie and Farragon resemble Ben Lawers very closely in their geological structure, and were they only of greater altitude might be expected to have a similar vegetation, with grasses dominating over *Vaccinium*.

The third type is still poorer. Grasses are here relatively rare, and peat plants in contrast dominate. Heather, although abundant, is nowhere in very good condition, and is partly superseded as dominant species by *Vaccinium Myrtillus*. This mixture has been indicated on the map by colouring this association the same as that of *Vaccinium Myrtillus*, and dotting the heather colour over it.

The species of the heather association which I have found still lingering on in the Alpine region are given in the following list. To each species is added the highest altitude at which it has been recorded in Rannoch or Atholl; the figures have been taken from White's *Flora*, except in a few cases (indicated by the initials R. S.) where I have found the species at higher altitudes than are given in that work:

<i>Hypericum pulchrum</i> , L.	2600 ft.	<i>Salix aurita</i> , L.	2600 ft.
<i>Oxalis Acetosella</i> , L.	3000 "	<i>S. repens</i> , L.	2800 "
<i>Lotus corniculatus</i> , L.	2800 "	<i>Empetrum nigrum</i> , L.	3600 " (R.S.)
<i>Potentilla silvestris</i> , Neck.	2900 "	<i>Orchis maculata</i> , L.	2650 "
<i>Galium saxatile</i> , L.	2700 " (R.S.)	<i>Juncus squarrosus</i> , L.	3000 "
<i>Scabiosa Succisa</i> , L.	2600 "	<i>Luzula campestris</i> , DC.	
<i>Antennaria dioica</i> , R. Br.	2850 "	<i>Eriophorum vaginatum</i> , Roth.	3000 "
<i>Campanula rotundifolia</i> , L.	3000 "	<i>Carex pilulifera</i> , L.	2850 "
<i>Vaccinium Myrtillus</i> , L.	3600 " (R.S.)	<i>C. binervis</i> , Sm.	2600 "
<i>V. Vitis-Idæa</i> , L.	3540 "	<i>Anthoxanthum odoratum</i> , L.	2800 "
<i>Arctostaphylos Uva-ursi</i> , Spreng.,	2350 "	<i>Agrostis vulgaris</i> , With.	2600 " (R.S.)
<i>Calluna Erica</i> , DC.	3100 "	<i>Deschampsia flexuosa</i> , Trin.	3700 "
<i>Pyrola minor</i> , L.	over 2000 ft.	<i>Festuca ovina</i> , L.	"at all levels"
(R.S.) 3700 in Breadalbane.		<i>Nardus stricta</i> , L.	2600 ft. (R.S.)
<i>Euphrasia officinalis</i> , L.	3000 ft.	<i>Lomaria Spicant</i> , Desv.	3000 "
<i>Melampyrum pratense</i> , L.	3000 "	<i>Lastrea dilatata</i> , Presl.	3450 "
<i>Thymus Serpyllum</i> , L.	2850 "	<i>Lycopodium Selago</i> , L.	3600 " (R.S.)
<i>Rumex Acetosa</i> , L.	3757 "	<i>L. clavatum</i> , L.	2760 "
<i>R. Acetosella</i> , L.	3300 " in Breadalbane.	<i>L. alpinum</i> , L.	3547 "

In addition to those species certain others are found which are almost peculiar to the heather and *Vaccinium* association between 2000 and 3000 feet. The chief of these are :—

Rubus Chamæmorus, L.

Cornus suecica, L.—This species, as has already been pointed out by Dr. White (9), is in almost all its stations associated with *Vaccinium Myrtillus*, L.

Vaccinium uliginosum, L.

Loiseleuria procumbens, Desv.

Betula nana, L.

Lycopodium annotinum, L.

Above 3000 feet (912 metres), and even on bare exposed places at lower elevations, such as the summits of hills, the ground is usually stony and sparsely covered with vegetation. Mosses and lichens dominate, in particular the woolly fringe-moss (*Racomitrium lanuginosum*), which on many of the steep mountain rubbles or “scree” forms the peat on which the Alpine humus plants develop. Stunted plants of *Empetrum*, *Vaccinium* spp., *Lycopodium Selago*, are still frequent, and in addition certain species peculiar to these mountain ridges, such as—

Potentilla Sibbaldi, Hall, fl.

Salix herbacea, L.

Gnaphalium supinum, L.

Carex rigida, Good.

The characteristic Alpine flora is, however, mainly confined to the sheltered crags and wet places about 3000 feet. Its distribution, like that of the Alpine pasture and moorland, seems largely to depend on the physical and chemical nature of the rock giving rise to the soil. The comparative wealth of the Breadalbane range in Alpine species has long been well known, and as was pointed out by Mr. P. Macnair (6) in 1898, the richest area corresponds to certain strata of sericite (chloritic) schist which run in a south-west to north-east direction through this district.

The following tables will illustrate the distribution of the Alpine flora throughout the district included in the map. Most of the localities required for their preparation have been obtained from White's *Flora* :—

I. Species found on all three classes of mountain shown on the map, which are, however, most abundant on the Ben Lawers type.

Thalictrum alpinum, L.

S. hypnoides, L.

Draba incana, L.

Sedum roseum, Scop.

Cochlearia officinalis,

Epilobium alsinefolium, L.

var. *alpina*, Wats.

E. anagallidifolium, Lam.

Silene acaulis, L.

Cornus suecica, L.

Potentilla rubens, Vill.

Galium sylvestre, Poll.

P. Sibbaldi, Hall, fls.

Gnaphalium supinum, L.

Alchemilla alpina, L.

Saussurea alpina, DC.

Saxifraga oppositifolia, L.

Vaccinium uliginosum, L.

S. stellaris, L.

Loiseleuria procumbens, Desv.

S. aizoides, L.

Oxyria digyna, Hill.

Betula nana, L.
Salix Lapponum, L.
S. herbacea, L.
Tofieldia palustris, Huds.
Juncus trifidus, L.
J. triglumis, L.

Luzula spicata, DC.
Carex pauciflora, Lightf.
C. rigida, Good.
Poa alpina, L.
Aspidium Lonchitis, Sw.
Pseudathyrium alpestre, Newm.

II. Species almost or quite confined to the Ben Lawers type of mountain.

Arabis petraea, L.
Draba rupestris, Br.
Erophila vulgaris, var. *inflata*,
 Hook. Also in Rannoch (9).
Cochlearia micacea, Marshall.
Cerastium alpinum, L. Also in
 Atholl (9).
C. arcticum, Lange.
C. trigynum, Vill.
Arenaria verna, L.
A. sulcata, Schlecht.
Cherleria sedoides, L.
Sagina Linnæi, Presl.
S. nivalis, Fr.
Oxytropis uralensis, DC. Also on
 Ben Vrackie (9).
Dryas octopetala, L. Also in
 Glen Tilt.
 [Chiefly on calcareous rocks (9)].
Saxifraga nivalis. Rare in
 Rannoch (9).
Saxifraga rivularis, L.
S. cernua, L.
S. greenlandica, L.¹
S. quinquefida, Haworth.
Sedum villosum, L.
Erigeron alpinum, L.
Gentiana nivalis, L.
Myosotis alpestris, Schmitt.
Veronica alpina, L. Also from
 Glen Tilt, and near Dalna-
 spidal (9).

V. fruticans, Jacq. Also from
 Glen Tilt (9).
Bartsia alpina, L.
Salix Arbuscula, L.
S. lanata, L.
S. Myrsinites, L. Also from
 Schiehallion, Craig Chail-
 leach, and Blair Atholl (9).
S. reticulata.
Juncus alpinus. Also from the
 Atholl Mountains (9).
J. castaneus, Sm.
J. biglumis, L.
Kobresia caricina, Willd. Also
 on Ben Vuroch [Brebner
 (9)].
Carex rupestris, All.
C. alpina, Sw.
C. atrata, L. Also on Farragon
 (9).
C. ustulata, Whnl.
C. pulla, Good.
C. Grahami, Boott.
Phleum alpinum, L.
Deschampsia alpina, R. and S.
 Also on Beinn a' Ghlo (9).
Sesleria caerulea, Ard.
Poa glauca, Sm.
P. Balfourii, Parnell.
Woodsia hyperborea, Br.
Cystopteris montana, Link.
Pseudathyrium flexile, Newm.

III. Species not found on the Ben Lawers type of mountain.

Thlaspi alpestre, L.—Beinn a' Chuallich, on limestone (9).
Astragalus alpinus, L.—Ben Vrackie (9). This mountain
 approaches very nearly the Ben Lawers type.
Phyllodoce caerulea, Bab.—Sow of Atholl (9).
Alopecurus alpinus, Sm.—Glen Tilt (9).

¹ Ben Lawers (Druce, *Ann. Scott. Nat. Hist.*, 1898, p. 243).

The two districts which have now been surveyed—Edinburgh and North Perthshire—taken together furnish us with representative examples of all the main types of vegetation to be found in Scotland. They include between them all the altitudinal regions, and further survey in other parts can only be expected to add to the number of the minor plant associations dependent on other factors than altitude. It may thus be convenient to give the following summary of the regions and plant associations represented in the two districts:—

I. Littoral Region (represented only on the Edinburgh district map).

- a. Submerged vegetation.
- b. Salt marshes.
- c. Seaside rocks.
- d. Sandy shores and dunes.
- e. Seaside "links" or fixed dunes.

II. Temperate Region, 0 to 1000 feet (0 to 304 metres).

- a. Region of Cultivation.
 1. With wheat cultivation, upper limits 500 to 600 feet (152 to 182 metres).
 2. Without wheat cultivation, upper limits 1000 to 1250 feet (304 to 380 metres).
- b. Region of Deciduous Trees, mainly Oak and Beech.
 1. Mixed Deciduous Woods, including Beech—
 Upper limits in Edinburgh district 800 to 1000 feet (243 to 304 metres).
 Upper limits in North Perthshire 700 to 900 feet (213 to 274 metres).
 2. Oak Woods—
 Upper limits in North Perthshire 900 to 1000 feet (274 to 304 metres).

III. Sub-Alpine Region, 1000 to 2000 feet (304 to 608 metres).

A. Region of Coniferous and Birch-Trees.

1. Scots Pine Woods—
 Upper limits in Edinburgh district 1250 to 1500 feet (380 to 456 metres).
 Upper limits in North Perthshire 1500 to 1800 feet (456 to 547 metres).
 Isolated trees at 1900 feet (578 metres), (9).
2. Larch Woods—
 Upper limits in North Perthshire 1300 to 1800 feet (395 to 547 metres).
3. Birch Woods—
 Upper limits in North Perthshire 1500 to 2000 feet (456 to 608 metres).
 Isolated trees at 2300 feet (699 metres) (R.S.).

B. Region of Hill Pasture and Moorland.

a. Heather associations—

Erica cinerea and *E. Tetralix* (characteristic species) cease at an altitude of 2200 feet (669 metres), (9).

b. Pasture associations.

IV. Alpine Region, 2000 to 4000 feet (608 to 1216 metres).

[In Edinburgh district represented only by a few isolated species.]

a. Heather associations.—*Calluna* ceases at 3100 feet (942 metres), (9).

b. *Vaccinium Myrtillus* association.—Ceases 3600 feet (1094 metres), (R.S.).

c. Pasture associations.

d. Alpine plateau with mosses, lichens, etc.

e. Alpine crags.

One of the aspects of this survey which I intend to consider in detail in a future paper is the light which it throws on the relations between the vegetation of Britain and that of neighbouring European countries. With this end in view the regions and associations have been compared throughout with those described in the works of such authorities as Andersson, Blytt, Christ, Drude, Flahault, Hult, Warming, etc., and where possible have been designated by similar names.

It was with some degree of hesitation that I decided to publish this second sheet, since, owing to the nature of the country and the prevailing climatic conditions, a uniform accuracy of detail in the survey of such an extensive area cannot be obtained without much labour and a considerable expenditure of time. To reduce or remove any error that might have arisen from this cause, I have made out lists of questions concerning the more difficult areas, and have sent them to correspondents in the district capable of making the requisite observations. In this way I have obtained two or more reports on each doubtful area, and with these have checked my own notes. Some errors are undoubtedly still to be found, but I trust they are small and do not affect the main features of the survey.

It is necessary to note, that for the employment of this map in the field some little practice will be required to read the different aspects of the landscape. Thus, for example, a hill, which as seen from one part on it, may appear heather-clad, may be found when viewed as a whole, or when traversed and carefully examined, to be really of the grassy type. The character of a doubtful hill has usually to be judged, both by a series of classified lists made at different parts, and by the general aspect as seen from a neighbouring hill.

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A JOURNEY THROUGH SOMALILAND AND SOUTHERN ABYSSINIA TO THE SHANGALLA OR BERTA COUNTRY AND THE BLUE NILE, AND THROUGH THE SUDAN TO EGYPT.

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ABYSSINIA, the ancient Ethiopia, historically a land of many mysteries, which contains one of the sources of the Nile, the land of many glorious mountains and the seat of tremendous volcanic activity within geologically recent times, the highlands and Switzerland of Africa, had always had a great attraction for me; therefore, when I was offered an opportunity for visiting it, the offer was too tempting to refuse, and when it was also proposed that we should travel across the southern, less visited portion, from east to west, and return *via* the Sudan and Egypt, it could not be resisted.