Det Kgl. Danske Videnskabernes Selskab.

Biologiske Meddelelser. I, 13.

THE GROWTH-FORMS OF SOME PLANT-FORMATIONS OF SOUTHERN NORWAY

BY

M. VAHL

WITH ONE MAP

KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1919

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In continuation of my former investigations of the vegetation of the woods and bogs of Småland[1], in the summer of 1915, I carried out research, according to the statistical method of RAUNKIÆR[2], in the surroundings of Kragerö in Norway, particularly in the communes of Skaatö and Bamle. Comparing this region with my earlier sphere of work in Småland, the difference in the formation of the ground is first conspicuous. While Småland is a hilly country, where the knolls do not rise more than 30—40 m. above the level of the lakes and rivers, the ground here in this, according to Norwegian conditions, low coastland of Skagerak, is far more uneven. The valleys are deeper carved, and very often steep slopes are seen with considerable talus at their foot. The soil within the examined territory is rather varying too. The base consists chiefly of gneiss, yet frequently interrupted by micaschist, which is very easy-weathering and forms plenty of loose soil. Near the coast as well on the continent as on the skerries, the gneiss is very frequently interrupted by quartzite. The quartzite hills easily strike the eye by their white-grey surface, which is bare, without rock waste, and only

[1] Les types biologiques dans quelques formations végétales de la Scandinavie.' (Académie des sciences et lettres de Danemark. Ertrait de bull. 1911).

The vegetation of the Notö, Botanisk Tidsskrift XXXII, 1911.

The growth-forms of some plant-formations of Swedish Lapland Dansk bot. Arkiv, 1913.

Livsformerne i nogle svenske Moser. Mindeskrift for Japetus Steenstrup, Kbhvn. 1913.

[2] RAUNKIÆR, Types biologiques pour la géographie botanique Acad. des sc. et l. de Danemark. Extrait de bull. 1905.

Formationsundersøgelser og Formationsstatistik. Bot. Tidsskrift XXX 1909.

scantily covered with scattered small trees. A geologic map-sketch of these parts has been published by Werenskiold[1].

The climate too is somewhat different from that of Småland. Winter is milder, summer rather cooler. The time of vegetation is of a somewhat longer duration, autumn being here warmer than in Småland.

The outer small skerries are generally bare, clean-washed by the sea, and almost without vegetation. Wood, however, is found in the isle of Jomfruland, in direct proximity of the sea. Jomfruland is a longish island, situated right at the open Skagerak. It is the top of a submarine terminal-moraine. The soil is morainic gravel, and no solid rock is found. On the inner skerries as well as on the continent nearly all is uncultivated land clad with wood. Excepting the places where the surface consists of quartzite, there are only small hill-tops, destitute of glacial drift or weathered rock, and therefore poor in vegetation. Woodless bogs do not take up much space in this region either. The forest consists for the most part of spruce, among which scattered broad leaved trees yet hold a more prominent place than in the forests of Småland, In many places, however, the spruce forest is interrupted by broad leaved forest in which coniferous trees hold quite a secondary place.

As in earlier pamphlets I have used as my base for the statistics of vegetation 50 squares of 0·1 m^2 [2]. Where, in the following no local designation is stated, the locality is the neighbourhood of the little lake Bakkevandet in the commune of Bamle.

Hill-tops. We shall look first at the vegetation which is found on the inhospitable, more or less naked hill-tops, from

[1] Fra Bamle. Festskrift til Prof. Amund Helland. Kristiania 1916.

[2] In my pamphlet „Les types biologiques etc. p. 330" is erroneously written "1 décimètre carré" it ought to be 0,1 m^2, and I take the opportunity of correcting the fault.

which wind and rain carry away all the detritus that is not retained by the scanty vegetation or in the fissures of the rock. On the grey rocks we find crustaceous lichens. Here and there, especially in places where the ground is smoother, and in small cavities, bigger lichens and mosses are found. In the crevices of the rock isolated specimens of different species of vascular plant make their appearance. *Calluna vulgaris*, *Aira flexuosa*, *Festuca ovina*, *Silene rupestris* are among the most frequent. Nearly all the individuals belong to species the shoots of which have not the faculty of protruding through the soil. I have given these plants the designation of epigeic[1] as distinct from the diageic sorts, whose shoots have the faculty of protruding through the soil. *Agrostis alba* is generally found in the somewhat larger crevices, where some soil has gathered. This sort is a transition form between the epigeic and the diageic species, having often short subterranean runners. On loose and moist ground I have often seen runners of 5—10 cm.

In mountain crevices, however, it most frequently proves epigeic. Typically diageic species e. g. *Convallaria majalis*, *Calamagrostis epigejos* and *Rumex acetosella* are found here and there in such large fissures or in little earthfilled hollows. The greater part of the species are strongly xeromorphous, as the mountain fissures are not capable of holding much water, and on sunny days the surrounding rocks will become very hot. In large and deep crevices with more loose soil species may yet occur the xeromorphous character of which is only slight. Öttli[2] has pointed out, with regard to Switzerland, the great individual difference of the mountain crevices as a habitat for the plants.

Calluna is the plant which has the greatest importance for the gathering and fastening of detritus. Often it is seen

[1] Les types biologiques p. 323.
[2] Beiträge zur Ökologi der Felsflora. Zürich 1905.

growing in long rows in the mountain fissures. In spreading from there its branches over the rock to both sides, these plants form a defence of organic and inorganic detritus, and a crust of raw-humus is formed in which the branches of the heather take root, and which forms a soil for other plants, especially mosses and *Vaccinium vitis idæa*. Often you can lift these, hardly more than 1 cm. thick, flakes of raw-humus up from the rock, on which they lie quite loose, only here and there anchored by heath-root running down into a fissure in the rock.

Table I *A*—*C*[1] gives examples of very poorly covered hill tops. In not a few of the squares where plants are noted, these, however, were only represented by a single little individual, so that the vegetation is much poorer than the number of bald squares will suggest. A statistic record with smaller squares would mark out more strongly the poverty of individuals.

The locality *A* is the poorest. Here crustaceous lichens were found, but only very little moss. There was a pronounced difference between the narrow crevices with *Calluna*, and the large earthfilled ones with *Agrostis alba*, which here had subterranean runners. *B* is likewise very poor in mosses. In a little earthfilled cavity *Rumex acetosella* was found. *C* is richer in patches of small mosses. Also here *Agrostis* is found, in other crevices than *Calluna*.

For *D* and *E* of the same table trees and shrubs have made their appearance in some crevices. The trees are all of small growth. In *D* only 17 of the 50 squares were overshadowed by trees or bushes. The moss-vegetation was here somewhat richer, and the mosses formed large patches. In the raw-humus formed by the mosses *Vaccinium vitis idæa* was found in abundance. The stratum of raw-humus lay rather loose on the rock and Vaccinium did not root in the fissures.

[1] The point-totals stated under the tables, as well as points of diageic and epigeic species, only have reference to the under-vegetation.

Table I.

	A	*B*	*C*	*D*	*E*	*F*
Microphanerophytes	—	—	—	**12**	**36**	—
Picea excelsa	—	—	—	1	—	—
Pinus silvestris	—	—	—	2	12	—
Populus tremula	—	—	—	9	14	—
Quercus sessiliflora	—	—	—	—	10	—
Nanophanerophytes	**3**	—	—	**9**	—	—
Juniperus communis	3	—	—	9	—	—
Chamæphytes	**10**	**15**	**3**	**82**	**37**	**127**
Aira flexuosa	—	—	—	9	7	46
Calluna vulgaris	10	15	3	46	27	—
Linnæa borealis	—	—	—	—	—	35
Vaccinium myrtillus	—	—	—	—	—	10
— vitis idæa	—	—	—	27	—	35
Veronica officinalis	—	—	—	—	3	1
Hemicryptophytes	**9**	**10**	**36**	**1**	**22**	**2**
Agrostis alba	8	—	22	—	11	—
— vulgaris	—	1	—	—	—	—
Hieracium floribundum	—	3	—	—	—	—
Hypericum perforatum	—	—	—	—	2	—
Luzula pilosa	—	—	—	1	—	2
Potentilla tormentilla	—	1	—	—	—	—
Rumex acetosella	—	1	—	—	—	—
Sedum maximum	—	—	—	—	4	—
Silene rupestris	1	4	14	—	3	—
Viscaria viscosa	—	—	—	—	2	—
Geophytes	—	—	—	—	**8**	—
Convallaria majalis	—	—	—	—	7	—
Calamagrostis epigejos	—	—	—	—	1	—
Therophytes	**3**	—	—	**8**	—	**20**
Melampyrum pratense	3	—	—	8	—	20
Points	**22**	**25**	**30**	**112**	**103**	**149**
Without vascular plants in the under-vegetat.	**30**	**28**	**21**	**3**	**5**	—
Diageic	8	1	—	27	8	45
Epigeic	11	24	39	56	59	84

In *E* 35 squares were overshadowed so that there is already a beginning of an open forest, but the moss-vegetation was poor; and the bottom vegetation therefore the same as on the treeless tops.

F shows a quite particular locality, an almost plane rock sloping to the north with a declivity of about 35°. It lay in rather deep shade from tall spruce growing partly above

partly beneath the slope, but it was itself totally destitute of trees, obviously for want of crevices in which trees might take root. It was densely covered with moss, which has formed a layer of raw-humus, lying loosely, and which can easily be removed. In the raw-humus *Aira flexuosa*, *Linæa borealis* and *Vaccinium vitis idæa* are characteristic plants; indeed the shady, humid locality will even allow of an abundance of *Vaccinium myrtillus*. In some places, where the raw-humus forms a very thin layer, the Vaccinia thrive badly, and part of the individuals have died.

On the hill-tops, poor in plants, we thus find a vegetation bearing in the very poorest places the stamp of chance, according to the individual qualities of each single crevice. As a rule, however, chamaephytes dominate in the crevices. In

Table II.

	A	*B*
Mesophanerophytes	**33**	**57**
Picea excelsa	14	50
Pinus silvestris	19	7
Nanophanerophytes	**4**	**2**
Juniperus communis	4	2
Without trees or shrubs	**25**	—
Chamæphytes	**171**	**195**
Aira flexuosa	43	25
Calluna vulgaris	23	49
Linnæa borealis	24	21
Vaccinium myrtillus	31	50
— vitis idæa	50	50
Hemicryptophytes	**4**	**5**
Orobus tuberosus	3	—
Pirola media	1	—
Trientalis europæa	—	5
Geophytes	**15**	—
Majanthemum bifolium	12	—
Pteridium aquilinum	3	—
Therophytes	**6**	—
Melampyrum pratense	6	—
Points	**196**	**200**
Diageic	100	105
Epigeic	90	95

Table III.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Mesophanerophytes	**40**	**51**	**54**	**71**	—	**26**	**34**	**43**	—
Picea excelsa	34	40	—	50	—	13	20	—	—
Pinus silvestris	6	—	29	7	—	13	4	17	—
Betula verrucosa	—	11	—	14	—	—	8	—	—
Populus tremula	—	—	—	—	—	—	2	7	—
Quercus pedunculata	—	—	13	—	—	—	—	19	—
— sessiliflora	—	—	12	—	—	—	—	—	—
Without trees or shrubs	**13**	**6**	**10**	—	**50**	**29**	**23**	**8**	—
Chamæphytes	**105**	**139**	**90**	**118**	**138**	**137**	**151**	**121**	**165**
Aira flexuosa	2	—	6	9	—	17	6	—	17
Calluna vulgaris	5	—	—	4	25	27	45	50	50
Empetrum nigrum	—	—	—	—	5	—	—	—	—
Linnæa borealis	4	49	—	5	8	3	—	—	—
Lycopodium annotinum	—	13	—	—	—	—	—	—	—
Pirola secunda	—	2	—	—	—	—	—	—	—
Vaccinium myrtillus	48	27	43	50	50	50	50	27	48
— vitis idæa	46	48	41	50	50	40	50	44	50
Hemicryptophytes	—	**10**	**19**	—	**6**	—	**3**	**5**	—
Hieracium vulgatum	—	—	—	—	—	—	—	1	—
Orobus niger	—	—	5	—	—	—	—	—	—
— tuberosus	—	—	13	—	—	—	—	4	—
Oxalis acetosella	—	3	—	—	—	—	—	—	—
Trientalis europæa	—	7	—	—	6	—	3	—	—
Viola silvatica	—	—	1	—	—	—	—	—	—
Geophytes	—	**8**	**3**	**22**	**36**	—	**4**	**3**	**2**
Calamagrostis epigejos	—	—	—	—	—	—	—	3	—
Convallaria majalis	—	—	2	—	—	—	—	—	—
Majanthemum bifolium	—	—	—	22	36	—	4	—	2
Melica nutans	—	—	1	—	—	—	—	—	—
Phegopteris dryopteris	—	8	—	—	—	—	—	—	—
Therophytes	—	—	—	—	—	**11**	**15**	**2**	**7**
Melampyrum pratense	—	—	—	—	—	11	15	2	7
Points	**105**	**157**	**112**	**140**	**180**	**148**	**173**	**131**	**174**
Diageic	94	95	101	122	142	90	107	78	100
Epigeic	11	62	11	18	38	47	51	51	67

places covered with a thick layer of raw-humus, too, epigeic chamaephytes preponderate, but with the growing thickness of the raw-humus the diageic species increase in frequency.

Table II shows instances of hill-tops covered with raw-humus, where epigeic and diageic species balance. Both are

from the commune of Skaatö. In the rock, in the locality *A*, larger crevices fit for the growth of trees are evidently scarce. The cover of mosses is here poor while in *B* it is rich. The deeper shade in *B* favours the growth of *Vaccinium myrtillus*.

In the localities mentioned in table III the development is further advanced, so that diageic species prevail more or less. The forest, however, is still open. In the localities *B* and *C* the rock is covered with a layer of gravel. *C* as well as *H* are remarkable for an abundance of oaks. Both are situated on the southern edge of a greater range of hills. In both these places the moss-vegetation was rather poor and consisted of small species. In the other places it was abundant. *D.* and *E* are from the commune of Skaalö. *D* shows the composition of the vegetation under the trees, *E.* in the intervals between them. As usual the epigeic species are somewhat more frequent in the less shady intervals. In *I* it is only the compound of the bottom-vegetation that is summed up. The upper stratum consisted of scattered individuals of *Picea*, *Sorbus aucuparia*, *Salix cinerea* and *Juniperus*. The flora of these, more richly covered hill-tops, is already very nearly the same as in the continuous forests.

Coniferous forest with an under-vegetation of xeromorphous diageic chamaephytes is the type of wood which has the greatest extension in these regions. In the coniferous forest, however, scattered broad leaved trees very often occur, especially birch and popolus tremula, but oak is not uncommon either. In the bottom an abundant moss-vegetation is found, and among the vascular plants *Vaccinium vitis idæa* and *Vaccinium myrtillus* are characteristic plants. Table IV affords examples of this type of forest. The greater part of the localities are from rather level ground. *A* and *C* from rather even slopes. In *D.* the slope was steep but still the place was rather moist and the moss-vegetation abundant. The forest is here very fine and vigorous. The locality *C* had a hard raw-humus, and the

Table IV.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Mesophanerophytes	**50**	**56**	**63**	**54**	**65**	**57**	**61**	**50**
Picea excelsa	50	36	43	44	50	36	36	50
Pinus silvestris	—	20	20	—	—	—	5	—
Betula pubescens	—	—	—	10	—	—	—	—
— verrucosa	—	—	—	—	—	—	17	—
Populus tremula	—	—	—	—	15	—	—	—
Quercus pedunculata	—	—	—	—	—	21	3	—
Microphanerophytes	—	—	—	—	—	**7**	**8**	—
Juniperus communis	—	—	—	—	—	—	8	—
Sorbus aucuparia	—	—	—	—	—	7	—	—
Chamæphytes	**155**	**132**	**149**	**117**	**127**	**128**	**156**	**165**
Aira flexuosa	44	16	—	17	20	41	48	43
Calluna vulgaris	—	—	48	—	10	—	3	—
Linnæa borealis	7	17	8	1	—	6	5	23
Lycopodium annotinum	—	1	—	—	—	—	—	5
Pirola secunda	4	—	—	—	—	3	—	—
Vaccinium myrtillus	50	50	43	50	47	46	50	50
— vitis idæa	50	50	50	49	50	29	50	44
Veronica chamædrys	—	—	—	—	—	3	—	—
Hemicryptophytes	**1**	—	—	—	**5**	**25**	**34**	**37**
Carex pallescens	—	—	—	—	—	1	—	—
Fragaria vesca	—	—	—	—	—	2	—	—
Luzula pilosa	—	—	—	—	1	5	10	1
Orobus tuberosus	—	—	—	—	—	4	—	—
Oxalis acetosella	—	—	—	—	—	10	1	10
Potentilla tormentilla	—	—	—	—	—	—	3	—
Rubus saxatilis	—	—	—	—	4	—	—	14
Trientalis europæa	1	—	—	—	—	3	20	12
Geophytes	**10**	**21**	**3**	**1**	—	**54**	**45**	**76**
Anemone nemorosa	—	—	—	—	—	11	—	15
Majanthemum bifolium	10	21	—	1	—	40	43	34
Melica nutans	—	—	—	—	—	3	—	—
Phegopteris dryopteris	—	—	—	—	—	—	—	27
Pteridium aquilinum	—	—	3	—	—	—	2	—
Therophytes	**6**	**43**	—	**14**	**35**	**22**	**1**	—
Melampyrum pratense	6	3	—	—	11	22	—	—
— silvaticum	—	40	—	14	24	—	1	—
Points	**172**	**196**	**152**	**132**	**167**	**229**	**236**	**278**
Diageic	115	121	96	100	97	152	166	192
Epigeic	51	32	56	18	40	55	69	86

moss-vegetation was poor. In spite of a rather deep shade, an abundance of heather was found. The other localities had a luxuriant moss-carpet.

In the localities *A*—*E* the chamaephytes strongly preponderate in the under-vegetation. Perennial herbs only are very scarce. The greater part of the specimens are xeromorphous, this applies least to *D* where the mesomorphous *Vaccinium myrtillus* numbers about half the points of the under-vegetation. Here in this particularly vigorous and shady spruce forest the total of individuals of the under-vegetation, too, is small and it already forms a transition to the next type.

In the localities referred to in *F*—*H*, a great minority of perennial herbs occur along with the dominating chamaephytes. These localities are however considered as belonging to the forest with chamaephytes predominant in the under-vegetation as the number of points of the chamaephytes is more than 1·5 times the aggregate number of points of hemicryptophytes and geophytes. Beside the xeromorphous species, well marked mesomorphous ones, as *Oxalis acetosella*, *Anemone nemorosa*, *Melica nutans* and *Phegopteris dryopteris* make their appearance. As it will be seen from the tables, the great majority of points is formed by species with erratic rhizomes and subterranean runners, which easily make their way in the loose raw-humus formed by the mosses.

This type of forest is particularly found on level ground and rather even slopes. It is also frequent on steeper slopes and talus, facing north, and moist because of the slight insolation. In much the greatest number of places *Majanthemum bifolium* is found in a great number of individuals, and often more or less other diageic herbs, which in this region are far more numerous than in the forests of Småland. Where the forest is old and vigorous it generally belongs to the next type:

Coniferous forests with thick moss-carpet and few vascular plants among the under-vegetation, of which instances are shown in table V. *B* and *E* are from level ground, *A* and *C* from slopes, *D* from a talus inclining to the north. The big blocks of rock

Table V.

	A	*B*	*C*	*D*	*E*
Mesophanerophytes	**50**	**50**	**66**	**50**	**86**
Picea excelsa	50	50	50	50	43
Pinus silvestris	—	—	16	—	—
Betula pubescens	—	—	—	—	29
Populus tremula	—	—	—	—	3
Quercus pedunculata	—	—	—	—	9
Sorbus aucuparia	—	—	—	—	2
Chamæphytes	**101**	**95**	**35**	**21**	**43**
Aira flexuosa	10	12	—	4	—
Linnæa borealis	20	19	—	—	—
Lycopodium annotinum	4	2	—	—	—
Vaccinium myrtillus	21	32	21	7	43
— vitis idæa	46	30	14	10	—
Hemicryptophytes	**2**	**1**	—	**2**	**3**
Lastræa dilatata	—	—	—	2	—
Poa nemoralis	—	—	—	—	3
Rubus saxatilis	—	1	—	—	—
Trientalis europæa	2	—	—	—	—
Geophytes	**7**	**6**	—	**10**	**3**
Majanthemum bifolium	3	7	—	10	—
Phegopteris dryopteris	4	6	—	—	—
Pteridium aquilinum	—	—	—	—	3
Without vascular plants in the under-vegetation	4	5	20	27	6
Points	**110**	**102**	**35**	**33**	**49**
Diageic	76	68	35	27	46
Epigeic	34	34	—	6	3

were here covered with thick moss. In *E* the ground was even. The spruce-forest is widely mingled with broad leaved trees, and the ground therefore covered with withered foliage, which has the effect that the moss-carpet is less vigorous than in the other places. — As in the hill-tops the poverty of individuals is less obvious when as large squares as 1 m² are used. As a rule only few individuals are found within each square. The considerable felling in the forests makes this type of wood less frequent than it would be, if the forest was allowed to grow old.

Coniferous forests with an under-vegetation of diageic herbs. Table VI *B*—*E* gives examples of this type of forest. *B* has still, for the greater part, a soil of raw-humus, but in spots mould is

Table VI.

	A	*B*	*C*	*D*	*E*	*F*
Mesophanerophytes	**66**	**50**	**50**	**68**	**60**	**50**
Picea excelsa	46	50	50	50	50	50
Alnus incana	—	—	—	—	10	—
Betula verrucosa	—	—	—	10	—	—
Quercus pedunculata	6	—	—	—	—	—
Populus tremula	14	—	—	—	—	—
Sorbus aucuparia	—	—	—	8	—	—
Nanophanerophytes	**17**	**2**	—	—	—	—
Juniperus communis	17	2	—	—	—	—
Chamæphytes	**165**	**95**	**86**	**58**	**8**	**20**
Aira flexuosa	49	1	37	23	8	1
Calluna vulgaris	26	—	—	—	—	—
Linnæa borealis	40	8	40	29	—	4
Lycopodium annotinum	—	—	—	—	—	8
Pirola secunda	—	—	3	6	—	—
Vaccinium myrtillus	3	39	2	—	—	7
— vitis idæa	45	47	2	—	—	—
Veronica chamædrys	2	—	2	—	—	—
Hemicryptophytes	**76**	**96**	**168**	**71**	**89**	**40**
Agrostis vulgaris	7	—	—	—	—	—
Anthoxanthum odoratum	2	—	—	—	—	—
Carex pallescens	3	4	1	2	1	—
Fragaria vesca	—	—	—	—	1	—
Hepatica triloba	—	1	27	7	—	—
Hieracium vulgatum	—	—	—	3	—	—
Lastræa dilatata	—	—	—	—	3	3
— filix mas	—	—	—	1	—	7
Luzula pilosa	34	40	15	—	1	—
Orobus tuberosus	12	—	21	—	—	—
Oxalis acetosella	—	28	36	40	48	20
Pirola media	—	9	—	—	—	—
Poa nemoralis	—	3	—	—	—	—
Potentilla tormentilla	1	7	8	—	—	—
Rubus saxatilis	—	1	—	—	—	—
Solidago virga aurea	16	—	—	10	7	—
Succisa pratensis	1	—	—	—	—	—
Trientalis europæa	—	—	22	—	3	3
Viola silvatica	—	3	38	8	25	7
Geophytes	**79**	**55**	**180**	**92**	**101**	**55**
Anemone nemorosa	6	4	42	17	20	9
Convallaria majalis	32	—	—	—	—	—
Majanthemum bifolium	33	45	43	50	2	21
Melica nutans	2	—	43	3	20	4
Phegopteris dryopteris	—	6	45	11	45	17
— polypodioides	—	—	—	2	14	4

Table VI. (Continued)

	A	*B*	*C*	*D*	*E*	*F*
Platanthera bifolia	1	—	—	—	—	—
Pteridium aquilinum	5	—	7	9	—	—
Therophytes	**30**	**17**	**43**	**5**	—	—
Melampyrum pratense	30	17	—	—	—	—
— silvaticum	—	—	43	5	—	—
Without vascular plants in the under-vegetat.	—	—	—	—	—	**13**
Points	**350**	**263**	**477**	**226**	**198**	**115**
Diageic	139	178	266	148	159	85
Epigeic	179	68	168	73	39	30

found. The moss-carpet is thick. Among the herbaceous species, such characteristic raw-humus plants as *Luzula pilosa* and *Majanthemum bifolium* dominate, while *Oxalis acetosella* is the only typical mould-plant that occurs in great number. Beside the herbs, Vaccinia, too, are very frequent. In the other localities the soil is mould, which in places, where broad leaved trees are found, is covered with withered leaves. For the rest we see on the ground withered spruce-needles, and mosses forming, however, no continuous carpet, and wanting in large areas. *C* and *D* are from the commune of Skaatö. *E* is from a slope facing north in the commune of Bamle.

Coniferous forest with an under-vegetation of diageic herbs, *herbous coniferous forest* is found particularly on slopes facing north.

In this region it forms two main-facies. On mild raw-humus *Majanthemum* is the typical plant. On mould some characteristic mould plants are further added, especially *Oxalis acetosella*, *Anemone nemorosa*, *Melica nutans* and *Phegopteris dryopteris*. Oecologically the characteristics of the two facies are, that on raw-humus the more or less pronounced xeromorphous elements hold almost as important a place as the mesomorphous ones, while on mould the mesomorphous species decidedly dominate.

The locality *A* of table VI is an almost level plane of rock covered with a thin stratum of raw-humus, and with low,

poor and not very shady trees. In the under-vegetation the chamaephytes are somewhat more numerous than the perennial herbs. The epigeic species are a little more numerous than the diageic ones, as is generally the case where the layer of earth is very thin. Among chamaephytes as well as herbs the xeromorphous elements dominate. Such a type of wood is very uncommon, as in such places a number of fissures in the ground, sufficient for the trees to grow dense enough to form a continuous cover, is generally not found.

Column *F* of the same table, gives an example of a type of wood, rare too in this region, namely a spruce forest poor in mosses, with an under-vegetation poor in individuals. It is from a place a little to the east of Kragerö. The soil is typic mould covered with dead spruce needles. Along with *Majanthemum*, typical mould plants dominate, especially *Oxalis acetosella* and *Phegopteris dryopteris*.

Broad leaved forest with an under-vegetation of diageic chamaephytes. Broad leaved forest is found in abundance in southern Norway. Broad leaved trees are common as a secondary element of the coniferous forest. Often several broad leaved trees combine in forming a small spot of broad leaved forest in the coniferous forest. But, beyond the immediate surroundings of the coast, large continuous broad leaved forests are only found on talus and other slopes declining to the south. On such slopes the soil is widely varying from spot to spot. The bare rock appears in many places. In other places it is covered with a thin stratum of raw-humus or gravel, and between the stones cavities are found filled with earth, on which, according to circumstances, mould or raw-humus may be formed. Mould is most frequent in the broad leaved forest, but greater or smaller spots of raw-humus is found everywhere. A soil of raw-humus will be found to the greatest extent in even or gently sloping places where the drainage is less easy than in other places. On raw-humus the

under-vegetation consists mainly of diageic chamaephytes. As table VII will show, a great number of intermingled species of trees are found in the broad leaved forest. Beside the species specified in table X *Fraxinus excelsior*, *Quercus sessiliflora* and *Alnus incana* are common. In one place a certain species may preponderate, in another place another one, but greater pure stocks, as in cultivated forests, are not found. Coniferous trees are found interspersed as a secondary element of the forest. The locality *A* is from a spot of mixed wood in the spruce forest. The slope is steep, the moss-vegetation rich with a few cushions of Sphagnum. The under-vegetation is poor, mainly consisting of Vaccinia. *B*—*D* are all from level ground. *B* from the commune of Bamle. *C* from Valberg east of Kragerö. *D* is from Gumö among the skerries of Kragerö. Everywhere, the ground is covered with withered foliage, which cannot, however, totally stifle the moss-vegetation. *E* is from a flat rock in a talus, the stone is richly covered with moss that has formed a layer of raw-humus which, however, is quite thin. The thinness of the layer of earth, with which the rock is covered, manifests itself in the composition of the vegetation with its relatively great number of epigeic plants. *Poa nemoralis* is particularly characteristic for such thinly covered places. *F* and *G* are from rather gently sloping places with southern exposure.

The under-vegetation is quite the same as that which is found in spruce forest on raw-humus. The chamaephytes are in most places in very great majority and among these it is the two species of *Vaccinium* that characterize the vegetation. The xeromorphous and mesomorphous elements are nearly in balance, except in particularly shady places, such as D and G, where the under-vegetation is markedly mesomorphous.

Broad leaved forest with a substratum of mesomorphous diagetic herbs is the typical form for broad leaved forest

Table VII.

	A	*B*	*C*	*D*	*E*	*F*	*G*
Mesophanerophytes	**93**	**84**	**79**	**115**	**67**	**62**	**71**
Picea excelsa	41	27	14	12	7	—	—
Pinus silvestris	—	13	5	—	—	—	—
Acer platanoides	—	—	—	3	—	—	18
Alnus glutinosa	—	—	3	—	—	—	—
Betula pubescens	8	—	—	—	—	—	—
— verrucosa	—	—	17	50	—	—	—
Populus tremula	24	3	—	—	50	—	8
Quercus pedunculata	9	27	25	50	—	34	35
Sorbus aucuparia	11	14	15	—	9	5	3
Tilia parvifolia	—	—	—	—	10	23	7
Microphanerophytes	—	**4**	—	**23**	—	**15**	—
Juniperus communis	—	4	—	—	—	15	—
Lonicera periclymenum	—	—	—	23	—	—	—
Chamæphytes	**97**	**117**	**102**	**54**	**87**	**134**	**52**
Aira flexuosa	2	25	1	—	—	46	—
Linnæa borealis	—	5	—	—	—	—	—
Pirola secunda	—	—	1	—	—	—	—
Vaccinium myrtillus	45	46	50	50	39	43	49
— vitis idæa	50	41	50	4	48	45	3
Hemicryptophytes	**4**	—	**7**	**11**	**48**	**18**	**9**
Carex pallescens	—	—	—	4	15	7	3
Fragaria vesca	3	—	—	—	4	—	—
Luzula pilosa	—	—	—	1	13	4	3
Orobus tuberosus	—	—	—	6	—	—	—
Oxalis acetosella	—	—	—	—	—	5	—
Poa nemoralis	—	—	—	—	12	—	3
Polypodium vulgare	—	—	—	—	1	—	—
Rubus saxatilis	—	—	—	—	—	1	—
Trientalis europæa	1	—	6	—	—	—	—
Viola silvatica	—	—	1	—	3	1	—
Geophytes	**10**	—	**21**	**12**	**4**	**49**	**1**
Convallaria majalis	—	—	4	—	—	19	1
Majanthemum bifolium	9	—	15	—	—	18	—
Melica nutans	—	—	—	3	4	—	—
Phegopteris dryopteris	—	—	—	8	—	12	—
Pteridium aquilinum	1	—	2	1	—	—	—
Therophytes	**3**	**4**	**38**	**7**	**16**	**14**	—
Melampyrum pratense	3	4	38	7	16	10	—
— silvaticum	—	—	—	—	—	4	—
Points	**114**	**121**	**168**	**84**	**155**	**215**	**62**
Diageic	106	87	128	72	91	142	53
Epigeic	5	30	2	5	48	59	9

on mould. It is most frequently found on slopes inclining to the south; yet, in close proximity to the coast, it is not strictly bound to any particular exposure. The soil is covered with withered leaves. On large stretches the soil is totally devoid of moss, in places a small quantity of moss is found. The tables VIII and IX afford examples. The growth of trees is ordinarily very mixed, and only in few places small pure associations of a single species of tree are found.

Table VIII.

	A	*B*	*C*	*D*	*E*	*F*	*G*
Mesophanerophytes	**70**	**83**	**94**	**62**	—	**49**	**57**
Picea excelsa	—	46	5	16	—	—	—
Pinus silvestris	13	—	—	7	—	—	—
Betula verrucosa	7	17	—	35	—	18	—
Populus tremula	10	15	8	—	—	—	—
Quercus pedunculata	27	—	—	—	—	—	28
— sessiliflora	43	—	32	—	—	—	29
Sorbus aucuparia	—	5	7	4	—	31	—
Tilia parvifolia	—	—	42	—	—	—	—
Microphanerophytes	—	**20**	—	**12**	**50**	**15**	—
Corylus avellana	—	20	—	8	50	15	—
Salix cinerea	—	—	—	4	—	—	—
Nanophanerophytes	—	—	**4**	**2**	—	—	—
Juniperus communis	—	—	4	—	—	—	—
Ribes grossularia	—	—	—	2	—	—	—
Chamæphytes	**82**	**134**	**51**	**89**	**112**	**53**	**63**
Aira flexuosa	4	41	—	15	—	3	—
Linnæa borealis	—	20	—	—	—	—	—
Pirola secunda	—	3	—	10	10	—	—
Vaccinium myrtillus	16	35	2	40	48	50	40
— vitis idæa	50	35	49	17	50	—	13
Veronica chamædrys	12	—	—	4	4	—	10
— officinalis	—	—	—	3	—	—	—
Hemicryptophytes	**71**	**91**	**38**	**112**	**67**	**35**	**44**
Agrostis vulgaris	3	—	—	—	—	—	—
Carex pallescens	6	—	20	10	10	1	4
Fragaria vesca	11	3	2	1	9	—	—
Hieracium vulgatum	2	—	1	1	—	—	—
Hepatica triloba	—	—	—	—	—	—	1
Lastræa filix mas	—	4	—	—	—	—	—
Luzula pilosa	17	17	8	—	3	—	4
Orobus niger	—	—	—	—	—	—	3
— tuberosus	27	—	—	—	—	—	16

Table VIII. (Continued)

	A	*B*	*C*	*D*	*E*	*F*	*G*
Pirola media	—	—	—	10	—	—	—
Poa nemoralis	—	—	1	10	—	1	10
Potentilla tormentilla	—	—	—	10	—	—	—
Oxalis acetosella	—	50	—	36	29	26	—
Ranunculus repens	—	—	—	3	—	—	—
Rubus saxatilis	—	5	—	—	—	—	—
Sedum maximum	—	1	—	—	—	—	—
Solidago virga aurea	—	—	—	13	—	7	—
Stellaria graminea	—	—	—	—	—	—	3
Trientalis europæa	—	1	3	4	16	—	—
Vicia silvatica	—	—	—	—	—	—	3
Viola silvatica	5	10	3	14	—	—	—
Geophytes	**8**	**111**	**32**	**44**	**67**	**47**	**52**
Anemone nemorosa	4	24	—	3	—	—	—
Convallaria majalis	—	—	30	—	4	—	12
Majanthemum bifolium	—	27	—	14	33	—	—
Melica nutans	—	—	2	12	—	47	37
Phegopteris dryopteris	—	47	—	10	23	—	3
— polypodioides	—	13	—	5	—	—	—
Pteridium aquilinum	4	—	—	—	7	—	—
Therophytes	**10**	**7**	**8**	—	—	**1**	**3**
Melampyrum pratense	10	7	8	—	—	1	3
Points	**171**	**343**	**129**	**245**	**246**	**136**	**162**
Diageic	101	235	86	161	220	124	127
Epigeic	60	101	35	84	26	12	32

Table IX.

	A	*B*	*C*	*D*	*E*	*F*	*G*
Mesophanerophytes	**72**	**70**	**57**	**55**	**89**	—	**48**
Picea excelsa	—	—	12	—	32	—	—
Alnus glutinosa	—	—	—	—	50	—	—
Betula pubescens	—	—	—	—	7	—	—
— verrucosa	27	10	—	—	—	—	—
Fraxinus excelsior	10	10	10	—	—	—	29
Populus tremula	—	—	—	—	—	—	11
Quercus pedunculata	—	50	—	35	—	—	—
Sorbus aria	—	—	28	—	—	—	—
— aucuparia	14	—	7	—	—	—	8
Tilia parvifolia	21	—	—	20	—	—	—
Microphanerophytes	**7**	**3**	—	—	—	**50**	**62**
Corylus avellana	7	3	—	—	—	50	50
Rhamnus frangula	—	—	—	—	—	—	12
Nanophanerophytes	—	—	**8**	—	—	—	**4**
Viburnum opulus	—	—	8	—	—	—	4

Table IX. (Continued)

	A	*B*	*C*	*D*	*E*	*F*	*G*
Chamæphytes	**36**	**69**	—	**6**	**1**	**7**	**3**
Aira flexuosa	6	9	—	—	—	—	—
Vaccinium myrtillus	16	40	—	2	—	2	—
— vitis idæa	6	20	—	4	—	—	—
Veronica chamædrys	—	—	—	—	1	—	3
— officinalis	3	—	—	—	—	2	—
Pirola secunda	5	—	—	—	—	3	—
Hemicryptophytes	**57**	**105**	**46**	**47**	**69**	**64**	**77**
Ægopodium podagraria	—	—	3	—	—	—	—
Asperula odorata	—	—	—	—	—	19	—
Campanula rotundifolia	1	—	—	—	—	—	—
Carex pallescens	8	5	3	6	4	8	—
Chamænerium angustifolium	3	—	—	—	—	—	—
Fragaria vesca	12	4	20	—	—	—	7
Hepatica triloba	—	13	13	2	11	—	11
Hieracium vulgatum	—	—	—	2	—	—	—
Lactuca muralis	—	—	—	—	—	1	—
Lastræa filix mas	1	—	—	—	—	—	1
— dilatata	3	—	—	—	—	—	—
Luzula pilosa	1	4	—	1	1	5	—
Orobus niger	—	—	—	2	—	—	—
— tuberosus	—	—	—	20	2	—	6
Pirola minor	1	—	—	—	—	—	—
Poa nemoralis	7	—	—	—	1	3	—
Oxalis acetosella	17	21	—	—	50	22	21
Rubus idæus	—	—	2	—	—	2	5
— saxatilis	—	—	—	2	—	—	—
Sedum maximum	—	—	—	1	—	—	—
Spiræa ulmaria	—	—	5	—	—	—	10
Solidago virga aurea	3	8	—	6	—	—	6
Trientalis europæa	—	6	—	—	—	4	—
Viola silvatica	—	44	—	5	—	—	10
Geophytes	**43**	**100**	**50**	**50**	**52**	**68**	**63**
Anemone nemorosa	—	3	—	—	14	2	20
Convallaria majalis	—	—	12	47	—	3	—
Majanthemum bifolium	—	32	—	—	—	18	3
Mellca nutans	43	45	38	3	20	4	21
Phegopteris dryopteris	—	20	—	—	—	41	3
— polypodioides	—	—	—	—	11	—	14
Pteridium aquilinum	—	—	—	—	7	—	2
Therophytes	—	**4**	—	**14**	**16**	—	**4**
Melampyrum pratense	—	—	—	14	16	—	4
— silvaticum	—	4	—	—	—	—	—
Points	**136**	**278**	**96**	**117**	**138**	**139**	**147**
Diageic	97	187	60	76	104	120	105
Epigeic	35	87	36	27	18	19	38

Table VIII and *A*—*B* of table IX give instances of places where chamaephytes are still prominent in the physiognomy of the under-vegetation. Table VIII *A* show them in a small majority over the herbs. In *C*—*G* the points of the herbs are about 1.5 times as many as those of the chamaephytes, in VIII *B* (mixed forest) likewise, while the herbs are in great majority in IX *A*—*B*. In the other localities mentioned in table IX only single, scattered individuals of chamaephytes appear.

All the localities of table VIII are taken from south slopes in the commune of Bamle; with the exception of *D*, which is from a north-slope in the commune of Skaatö, near the coast. Of the localities in table IX *A*—*B* are from north-slopes in the commune of Skaatö, *C* is from a cleft fronting north at Valberg by Kragerö; the others from south-slopes in the commune of Bamle.

When in many places Chamaephytes and herbs occur in equal number, this is due to a constant alternation of small spots with mould and with raw-humus, where the raw-humus is decomposing in some places, and is re-formed in other places; where mould prevails hardly any chamaephytes are found, they are generally represented only by a few individuals of *Veronica officinalis* and *Chamædrys*. The greater part of the herbs are markedly mesomorphous. Where the shade is not too strong the number of species as well as of specimens is great. The great majority of the species have erratic rhizomes and subterranean runners.

With regard to the greater part of species it is easy to decide whether they are diageic or epigeic, as we find subterranean shoots protruding through the soil, or short vertical rhizomes. In some specimens, however, we find oblique or almost horizontal subterranean shoots, as to which it is difficult to decide whether they are growing through the soil or have come down by the earthing activity of the earth worm

or by the contraction of the roots. This is particularly the case where one has no opportunity of observing the germination of the species in question and its conditions through the seasons. I have placed *Spiræa ulmaria* among the diageic, *Solidago virga aurea* among the epigeic sorts; but have some doubt whether this is right. WARMING[1] mentions them as plants with perpendicular or oblique rhizomes, but on the loose forest-mould all the samples I have dug up, have had horizontal rhizomes, lying at some depth under the surface. Besides the above mentioned pamphlet by WARMING his pamphlet on subterranean runners[2] too, has been very useful to me for the determination of certain doubtful cases. As it will be seen from the tables, these doubtful species do not occur in a number or abundance of individuals great enough to exercise any influence on the picture of the vegetation given by the statistics.

Now and then tall ferns and a few other tall herbs occur in so great a quantity that they form an all but close middle story of tall perennial herbs. This will most frequently be found in shady clefts with deep mould, often on talus, between the stones of which organic detritus has gathered. Of tall perennials I have in such places found *Struthiopteris germanica* and *Lastræa felix mas* preponderating, and besides *Athyrium filix foemina*, *Lastræa dilatata*, *Valeriana sambucifolia*, *Urtica dioeca* and *Milium effusum*. Table X shows three examples of this facies, all from the commune of Bamle. *A* and *B* are from a talus in a shady cleft. The big ferns grow in mould-filled hollows between the blocks of rock, partly over-shading these. In many places the naked stones appear but in large areas they are covered with a layer of mould, in which lower herbs can grow. The squares in *B* that show no under-vegeta-

[1] Om Skudbygning, Overvintring og Foryngelse. Naturhistorisk Forenings Festskrift. Kbh. 1891.

[2] Om Jordudløbere. Mémoires de l'ac. r. des sciences et lettres de Danemark. 1918.

Table X.

	A	*B*	*C*
Mesophanerophytes	**50**	**52**	—
Picea excelsa	26	—	—
Betula verrucosa	—	3	—
Cerasus padus	24	37	—
Sorbus aucuparia	—	12	—
Microphanerophytes	—	**12**	**50**
Corylus avellana	—	12	50
Without vascular plants in the under-vegetation	—	**4**	—
Chamæphytes	—	**5**	—
Lycopodium annotinum	—	5	—
Hemicryptophytes	**99**	**82**	**111**
Actæa spicata	—	2	—
Adoxa moschatellina	3	—	—
Asperula odorata	—	—	47
Athyrium filix foemina	—	—	4
Circæa intermedia	7	—	—
Hepatica triloba	—	—	27
Oxalis acetosella	50	43	6
Rubus saxatilis	—	1	—
Lastræa dilatata	3	10	—
— filix mas	7	23	2
Struthiopteris germanica	23	—	24
Valeriana sambucifolia	3	—	—
Viola silvatica	—	—	1
Urtica dioica	3	3	—
Geophytes	**37**	**61**	**50**
Anemone nemorosa	2	—	4
Equisetum arvense	1	—	—
Milium effusum	—	8	12
Paris quadrifolia	—	2	25
Phegopteris dryopteris	9	33	—
— polypodioides	25	18	9
Points	**136**	**148**	**161**
Diageic	126	109	127
Epigeic	10	39	34

tion, are due to naked stones. *C* is from a south-facing talus in a cleft.

Broad leaved forest with an under-vegetation of epigeic chamaephytes or herbs is characteristic of stony ground with a very thin stratum of loose soil, most frequently of essentially inorganic origin, and is found in smaller areas where the solid rock or big blocks of stone are only covered with a thin layer of loose soil. On a thin stratum of raw-humus

Table XI.

	A	*B*	*C*	*D*	*E*	*F*
Mesophanerophytes	**81**	**78**	**66**	**68**	**76**	**83**
Picea excelsa	—	12	26	—	14	—
Pinus silvestris	5	4	—	—	—	—
Acer platanoides	6	—	—	4	—	—
Betula verrucosa	33	—	—	—	17	—
Fraxinus excelsior	4	—	—	2	29	—
Populus tremula	—	11	10	4	7	—
Quercus pedunculata	6	39	—	31	3	50
— sessiliflora	—	—	—	—	—	10
Sorbus aucuparia	27	—	30	4	3	—
Tilia parvifolia	—	12	—	21	3	23
Microphanerophytes	—	—	—	—	**9**	—
Corylus avellana	—	—	—	—	9	—
Chamæphytes	**47**	**40**	**33**	**8**	**2**	—
Aira flexuosa	47	5	25	—	—	—
Pirola secunda	—	—	1	—	—	—
Sedum album	—	—	—	—	1	—
Vaccinium myrtillus	—	17	2	—	—	—
— vitis idæa	—	18	5	—	—	—
Veronica officinalis	—	—	—	6	1	—
— chamædrys	—	—	—	2	—	—
Hemicryptophytes	**21**	**47**	**57**	**72**	**101**	**61**
Actæa spicata	—	—	—	—	1	—
Asplenium trichomanes	2	—	2	—	—	—
Calamagrostis arundinacea	—	—	—	—	16	—
Campanula rotundifolia	—	—	—	—	3	—
Carex pallescens	5	3	—	10	13	—
Clinopodium vulgare	—	—	—	2	—	—
Fragaria vesca	—	—	23	—	7	—
Hepatica triloba	—	—	—	—	9	34
Hieracium vulgatum	—	6	—	1	2	—
Lastræa filix mas	3	—	—	3	8	—
Luzula pilosa	3	9	—	—	—	—
Origanum vulgare	—	—	—	—	3	—
Orobus niger	—	3	—	8	—	—
— tuberosus	—	3	—	—	3	7
Oxalis acetosella	2	—	8	—	8	—
Poa nemoralis	3	19	—	37	23	19
Polypodium vulgare	3	—	3	—	1	—
Rubus idæus	—	—	—	—	1	—
— saxatilis	—	—	6	—	—	—
Sedum maximum	—	—	—	3	—	—
Solidago virga aurea	—	—	1	6	1	—
Stellaria media	—	—	—	1	—	—
Viola silvatica	—	4	14	1	2	1

Table XI. (Continued)

	A	*B*	*C*	*D*	*E*	*F*
Geophytes	—	**4**	**17**	**7**	—	**6**
Melica nutans	—	4	10	7	—	6
Phegopteris dryopteris	—	—	7	—	—	—
Therophytes	—	**17**	—	**3**	—	**3**
Melampyrum pratense	—	17	—	—	—	3
— silvaticum	—	—	—	3	—	—
Without vascular plants in the under-vegetat.	—	**13**	—	—	—	**10**
Points	**68**	**108**	**107**	**90**	**103**	**70**
Diageic	2	42	33	20	16	13
Epigeic	66	49	74	67	87	54

Aira flexuosa may prevail, but only rarely, as *Vaccinium vitis idæa* does not demand any particularly thick stratum of raw-humus. Table XI *A* shows an example of such a place in the commune of Skaatö. It is very much like the locality of table I *F*. In *B* Vaccinia are found, but the herbs are in small majority. Mould and raw-humus alternate in spots. Big stones appear in the table as squares without under-vegetation. In the following examples herbs are in decided majority. In *C* the soil is mouldering raw-humus; the rest have mould. In the flat easily drying soil the decomposition of organic detritus goes on quickly, and often, in such places, the soil is poor in humus. *C*, *D* and *R* are from Valberg near Kragerö, *F* from the commune of Bamle. The plant typical for this facies of forest is *Poa nemoralis* which is seldom wanting. Some few species as *Asplenium trichomanes* and *Polypodium vulgare* grew in the fissures of the stones. **Broad leaved forest with a substratum poor in individuals.** As mentioned above, the broad leaved forest is rich in species of trees, and only seldom a single species of tree preponderates for larger stretches; but often, however, some individuals of the same species grow together so that small pure associations of a few hundred m^2 may be formed. From what has been said it will likewise appear that with regard to the under-vegetation we distinguish, from an ecological and floristic point of view, three main types, found on raw-humus, deep

mould and shallow mould, but that none of these are to be found with a particular species of trees except in so far that raw-humus does not equally agree with the different species of trees. Birch and aspen are very common on raw-humus, which also agrees well with the oak. Hazel and lime occur on raw-humus, but evidently prefer mould. The locality *E* of table VIII was from a pure growth of hazel with alternating mould and raw-humus; IX *F* and X *C* were from pure growths of hazel on mould.

A more considerable difference arises from the unequal shading power of the trees.

This appears less in the absolute absence of light-affecting species under the most umbrageous trees, than in the fact that they are few, stunted and without bloom; and finally the under-vegetation in very shady places is on the whole poor in individuals. The intensity of the shade depends partly on the greater or smaller intervals between the trees, and their vigour, partly on the sorts of the trees. Birch and aspen are but slightly shading; the lime is the tree that gives most shade; and a rich interspersion of lime in a growth will always involve an under-vegetation very poor in individuals. In such forests the cover of withered foliage on the bottom is far more prominent than the few scattered plants, which, however, do not at all always belong to the decidedly shade-affecting species.

In table XII examples are shown of this type of forest. *A* is a pure growth of oak on a very steep slope. *B* is from a growth of oak with some spruce and a middle story of hazel. Also here the slope is rather steep. In the last three examples lime is more or less dominating, in *E* the lime is all but sovereign. In such places the bottom always lacks nearly every trace of an under-vegetation.

Where the under-vegetation is not too poor it is obvious that the usual mesomorphous diageic species of the mould-soil preponderate; but the poorer the vegetation becomes,

Table XII.

	A	*B*	*C*	*D*	*E*
Mesophanerophytes	**52**	**48**	**74**	**90**	**53**
Picea excelsa	—	11	12	13	—
Pinus silvestris	2	—	—	—	—
Acer platanoides	—	—	4	—	—
Betula pubescens	—	—	11	—	—
Fraxinus excelsior	—	—	10	6	—
Populus tremula	—	—	—	14	3
Tilia intermedia	—	—	28	31	50
Quercus pedunculata	50	37	—	26	—
— sessiliflora	—	—	9	—	—
Microphanerophytes	—	**43**	**10**	**9**	**13**
Corylus avellana	—	43	10	9	13
Without vascular plants in the under-vegetation	**7**	**13**	**17**	**23**	**47**
Chamæphytes	**19**	**1**	**8**	**9**	—
Vaccinium myrtillus	13	1	2	—	—
— vitis idæa	6	—	6	9	—
Hemicryptophytes	**31**	**18**	**39**	**10**	**3**
Carex pallescens	—	1	7	3	—
Luzula pilosa	2	1	—	1	1
Orobus niger	—	—	—	1	—
— tuberosus	22	—	1	—	—
Oxalis acetosella	—	9	13	—	—
Poa nemoralis	—	—	3	—	1
Hepatica triloba	—	—	8	—	—
Solidago virga aurea	2	—	3	—	—
Stellaria media	—	—	—	3	—
Trientalis europæa	—	7	—	—	—
Vicia sepium	—	—	—	1	—
Viola silvatica	5	—	4	1	—
Geophytes	**28**	**29**	**17**	**19**	—
Anemone nemorosa	—	10	4	—	—
Convallaria majalis	28	6	—	2	—
Majanthemum bifolium	—	13	—	—	—
Melica nutans	—	—	13	12	—
Pteridium aquilinum	—	—	—	5	—
Therophytes	**24**	—	—	**17**	**1**
Melampyrum pratense	—	—	—	17	1
— silvaticum	24	—	—	—	—
Points	**102**	**48**	**64**	**55**	**3**
Diageic	69	46	39	29	—
Epigeic	9	2	25	9	2

the more it bears the stamp of chance as in the locality *F*.

The quartzite-area. In all places mentioned above the ground consists of gneiss and mica schist, exceptionally of

granite; and it has not been possible to find any difference in the vegetation of these three kinds of rock. Near the shores we find, as mentioned above, considerable areas where the substratum consists of quartzite and where the vegetation is very scarce. Everywhere the quartzite-hills are discernible at a great distance by their light colour. In the few fissures grow small scattered samples of birch, pine and spruce. The rock between the trees is as a rule quite devoid of loose soil and only covered with crustaceous lichens. In but few places some raw-humus has gathered, formed by lichens and mosses, and in this raw-humus different plants may grow; while in ravines and larger cavities greater quantities of gravel is found, affording a soil for a richer vegetation.

Table XIII *A*—*C* shows examples of the vegetation under some small groups of trees on hills of quartzite. The naked rock is prominent. The points stated in the tables give a somewhat exaggerated representation of the number of individuals, as in many squares only one or a few individuals were found. Epigeic xeromorphous chamaephytes dominate everywhere among the vascular plants of the subtratum.

In *D*—*F* the vegetation is shown in flat cavities in the quartzite-hills. The ground is here quite covered with raw-humus. Plenty of moss is found among which at *D* and *F* some Sphagnum. In all places chamaephytes preponderate. At *D* epigeic and diageic species are equally frequent, in the two other places the diageic species are in great majority. At *F* no trees were found, probably for want of fissures in the rock.

In some ravines and hollows so much detritus has gathered that a continuous wood can be found, and here the under-vegetation is of quite the same composition as in other soil. Yet such woods take up very small areas in the quartzite area Instances of such woods are shown in table XIV. *A* is a spruce forest with an under-vegetation of diageic chamaephytes. *B* is a mixed-wood with preponderance of broad leaved trees.

Table XIII.

	A	*B*	*C*	*D*	*E*	*F*
Microphanerophytes	**31**	**30**	**42**	**16**	**30**	—
Picea excelsa	—	—	9	—	—	—
Pinus silvestris	27	30	30	16	20	—
Betula verrucosa	4	—	3	—	10	—
Nanophanerophytes	—	—	—	—	—	**3**
Juniperus communis	—	—	—	—	—	3
Without trees or shrubs	**23**	**20**	**8**	**34**	**20**	**47**
Chamæphytes	**17**	**36**	**51**	**196**	**117**	**169**
Aira flexuosa	3	13	12	3	1	23
Calluna vulgaris	14	23	36	50	40	27
Empetrum nigrum	—	—	—	48	—	—
Linnæa borealis	—	—	—	—	—	31
Lycopodium clavatum	—	—	—	—	—	2
Vaccinium myrtillus	—	—	—	45	36	37
— vitis idæa	—	—	3	50	40	49
Hemicryptophytes	**1**	—	—	**4**	—	**17**
Polypodium vulgare	**1**	—	—	—	—	—
Trientalis europæa	—	—	—	4	—	17
Geophytes	—	—	—	**1**	**4**	**62**
Majanthemum bifolium	—	—	—	—	4	48
Pteridium aquilinum	—	—	—	1	—	14
Therophytes	—	—	—	—	—	**3**
Melampyrum pratense	—	—	—	—	—	3
Without vascular plants in the under-vegetation	**32**	**16**	**9**	—	—	—
Points	**18**	**36**	**51**	**201**	**121**	**261**
Diageic	—	—	3	100	80	175
Epigeic	18	36	48	101	41	83

Also here diageic chamaephytes are the chief component of the under-vegetation. *C* and *D* are both from spruce forest with some broad leaved trees as a secondary element. In *C* herbs and chamaephytes are about equally numerous, while *D* is an example of the most luxuriant form of spruce forest, the herbous forest. In all the four localities the number of species was not smaller than usually on other ground.

It will thus be seen that the quartzite area houses quite the same plant-formations as the other kinds of rock, only with a difference of frequency. On quartzite, naked rock with scattered trees prevails, while such a vegetation on other kinds of rock is only found on small hill-tops. The formation of raw-

Table XIV.

	A	*B*	*C*	*D*
Mesophanerophytes	**50**	**125**	**66**	**61**
Picea exelsa	50	10	45	40
Pinus silvestris	—	38	—	—
Betula pubescens	—	29	—	21
— verrucosa	—	—	11	—
Quercus pedunculata	—	39	—	—
Sorbus aucuparia	—	9	—	—
Microphanerophytes	—	**4**	—	—
Rhamnus frangula	—	4	—	—
Chamæphytes	**124**	**112**	**79**	**21**
Aira flexuosa	15	25	4	—
Calluna vulgaris	—	9	—	—
Linnæa borealis	29	—	—	—
Pirola secunda	—	—	25	—
Vaccinium myrtillus	50	47	50	13
— vitis idæa	30	31	—	8
Hemicryptophytes	**7**	**3**	**11**	**91**
Carex pallescens	—	—	—	4
Hieracium vulgatum	—	—	—	1
Luzula pilosa	—	—	1	—
Oxalis acetosella	—	—	6	48
Rubus idæus	—	—	—	6
Solidago virga aurea	—	3	—	10
Trientalis europæa	7	—	4	9
Viola silvatica	—	—	—	13
Geophytes	**13**	**49**	**58**	**68**
Anemone nemorosa	—	—	—	10
Convallaria majalis	—	49	—	—
Majanthemum bifolium	—	—	50	10
Melica nutans	—	—	—	9
Phegopteris dryopteris	—	—	—	32
— polypodioides	—	—	—	4
Pteridium aquilinum	13	—	8	3
Therophytes	—	**30**	**3**	—
Melampyrum pratense	—	30	3	—
Points	**144**	**194**	**151**	**180**
Diageic	100	130	143	162
Epigeic	44	34	5	18

humus, and the growth, first of epigeic and then of diageic chamaephytes, goes on, however, quite in the same way and including the same species. On gneiss and mica schist, wood is the dominating formation, on quartzite it is quite secondary,

but represents the same main types as on the other kinds of rock. We are therefore led to infer that these differences, physiognomically so striking, between the vegetations of the quartzite and other kinds of rock, are only due to the great power

Table XV.

	A	*B*	*C*	*D*	*E*	*F*	*G*
Microphanerophytes	—	**33**	—	—	—	—	—
Picea exselsa	—	3	—	—	—	—	—
Betula pubescens	—	3	—	—	—	—	—
Alnus glutinosa	—	10	—	—	—	—	—
Nanophanerophytes	**41**	**4**	—	**21**	—	—	**50**
Myrica gale	—	1	—	21	—	—	50
Vaccinium uliginosum	41	3	—	—	—	—	—
Chamaephytes	**122**	**21**	**24**	**33**	**26**	**11**	**34**
Aira flexuosa	20	—	—	—	—	—	—
Andromeda polifolia	4	—	—	30	—	—	31
Calluna vulgaris	5	4	—	—	—	1	—
Comarum palustre	—	—	—	—	26	—	—
Linnæa borealis	1	—	—	—	—	—	—
Lycopodium annotinum	8	13	—	—	—	—	—
Oxycoccus palustris	5	24	—	3—	—	10	3
Vaccinium myrtillus	29	—	—	—	—	—	—
— vitis idæa	50	4	—	—	—	—	—
Hemicryptophytes	**102**	**102**	**4**	**105**	**3**	**19**	**6**
Carex echinata	—	8	—	3	—	—	—
Cornus suecica	50	50	—	—	—	—	—
Drosera rotundifolia	—	—	—	4	—	15	3
Eriophorum vaginatum	—	—	1	—	—	—	3
Menyanthes trifoliata	—	—	—	—	3	—	—
Mollinia coerulea	—	15	—	—	—	—	—
Potentilla tormentilla	—	16	—	—	—	—	—
Rhyncospora alba	—	—	—	3	—	4	—
Rubus chamaemorus	48	—	—	45	—	—	—
Scirpus cæspitosus	—	—	—	50	—	—	—
Trientalis europæa	4	13	—	—	—	—	—
Geophytes	**29**	**66**	**50**	**44**	**93**	**93**	**92**
Carex Goodenoughii	—	27	—	—	50	50	50
— pauciflora	—	—	—	—	—	22	—
— panicea	—	19	—	—	—	—	—
÷ rostrata	—	—	50	44	43	21	42
Majanthemum bifolium	27	—	—	—	—	—	—
Phegopteris dryopteris	2	—	—	—	—	—	—
Points	**394**	**193**	**78**	**203**	**141**	**123**	**182**
Diageic	255	137	50	140	115	93	173
Epigeic	39	56	28	60	26	30	9

Table XVI

	A	*B*	*C*	*D*	*E*	*F*	*G*
Nanophanerophytes	47	7	—	10	28	—	7
Betula pubescens	—	7	—	—	—	—	—
Myria gale	—	—	—	10	28	—	—
Vaccinium uliginosum	47	—	—	—	—	—	7
Chamaephytes	**101**	**15**	**89**	**117**	**90**	**119**	**106**
Andromeda polifolia	46	—	—	17	47	19	—
Calluna vulgaris	11	—	39	50	—	50	50
Oxycoccus palustris	44	8	50	50	43	50	50
Vaccinium vitis idæa	—	7	—	—	—	—	6
Hemicryptophytes	**157**	**100**	**114**	**147**	**95**	**140**	**72**
Drosera rotundifolia	9	50	14	48	44	50	—
Eriophorum vaginatum	—	—	—	—	45	—	22
Menyanthes trifoliata	44	—	—	—	—	—	—
Molinia coerulea	48	—	—	—	—	—	—
Rhyncospora alba	—	—	—	—	6	—	—
Rubus chamaemorus	3	—	50	49	—	50	50
Scirpus caespitosus	50	50	50	50	—	40	—
Viola palustris	3	—	—	—	—	—	—
Geophytes	—	**53**	**19**	—	**1**	—	—
Carex rostrata	—	34	19	—	1	—	—
Scheuchzeria palustris	—	19	—	—	—	—	—
Points	**305**	**168**	**222**	**274**	**214**	**259**	**185**
Diageic	143	60	69	76	76	69	63
Epigeic	162	108	153	198	138	190	122

of resistance of the quartzite against crumbling and weathering, and not to the chemical differences.

Bogs[1] are found every where in the hollows but as a rule they take up only small areas. In table XV examples are shown of the border zones of different bogs. *A* is from a copse of *Myrica* surrounding the bog. A particularly luxuriant carpet of *Hypna* is found, but only few *Sphagna*. The under-vegetation consists mainly of the diageic chamaephytes of the wood combined with the diageic species of the bog-border. In *B* scattered trees are still found, while the bottom is much moister, and plenty of *Sphagna* are found. The vegetation proves a diageic cryptophytium as in the following examples. These represent the wet

[1] Concerning the growth-forms in the different zones of bogs of southern Sweden, I refer to my above quoted pamphlet. The growth-forms of some Swedish bogs.

border-zone of the bog with submerse *Sphagna*. *Carex rostrata* is the typical vascular plant and on somewhat less wet ground *Carex Goodenoughii*. *Myrica gale* may form low shrubs.

Table XVI represents the next zone, where the submerse *Sphagna* are replaced by species that rear themselves above the surface of the water. With regard to the vascular plants, this belt is characterized by the epigeic caespitose hemicryptophytes, of which, in this region, *Scirpus caespitosus* is the most frequent, while *Eriophorum vaginatum* and *Molinia coerulea* rarely dominate. *B* and *C* still represent a rather wet level, where the diageic herbs of the border-zone have not yet disappeared. *A*, too, is very wet, *Menyanthus trifoliata* is still frequent. Here is found copse of *Vaccinium uliginosum*, which in such wet places is less frequent. *Oxycoccus* and *Calluna* are found here too. On the higher level, represented by *D*—*F*, the chamaephytes are almost as numerous as the herbs until, in *G*, they surpass these in points.

At the interior border of this zone of epigeic chamaephytium the marginal forest usually follows without or with dropping *Sphagna* and an under-vegetation af diageic chamaephytium. Within the latter extends the central area of the bog with *Sphagna*. The vascular plants here form an epigeic chamaephytium with *Calluna* as the characteristic plant. In the small bogs of this region, these belts were not distinctly developed. In table XVII *A*—*C* show examples of the area of the bogs with a growth of scattered trees. *Sphagna* are here dropping, while the vigorous *Hypna* form a loose raw-humus in which a diageic *Vaccinia* together with *Rubus chamaemorus* are typical plants. *Myrica gale* and *Vaccineum uliginosum* are found in nearly all squares.

The columns *D*—*F* show holes with a retrograde process of development. The decomposition of the peat is here stronger than the formation of peat, so that holes are formed, often with bare black peat at the bottom, in other places regenerating.

Table XVII.

	A	*B*	*C*	*D*	*E*	*F*	*G*
Microphanerophytes	**19**	**16**	**37**	—	—	—	—
Betula pubescens	15	6	—	—	—	—	—
Pinus silvestris	**4**	10	37	—	—	—	—
Nanophanerophytes	**95**	**46**	**47**		—	—	**23**	**4**
Myrica gale	45	9	—	—	—	23	4
Vaccinuum uliginosum	50	37	47	—	—	—	—
Chanaephytes	**163**	**158**	**125**	**48**	**3**	**7**	**50**
Andromeda polifolia	36	28	—	48	—	7	50
Calluna vulgaris	45	47	50	—	—	—	—
Empetrum nigrum	5	—	—	—	—	—	—
Lycopodium annotinum	—	1	—	—	—	—	—
Oxycoccus palustris	10	20	—	—	3	—	—
Vaccinium myrtillus	17	33	30	—	—	—	—
— vitis idæa	50	29	45	—	—	—	—
Hemicryptophytes	**56**	**26**	**57**	**75**	**17**	—	**3**
Drosera rotundifolia	—	—	—	50	3	—	—
Eriophorum vaginatum	6	3	7	12	—	—	3
Rhyncospora alba	—	—	—	13	14	—	—
Rubus chamaemorus	50	23	50	—	—	—	—
Geophytes	—	3	—	**11**	**100**	**70**	**100**
Carex Goodenoughii	—	3	—	—	—	—	—
— panicea	—	—	—	—	—	13	50
— rostrata	—	—	—	—	50	7	—
Eriophorum angustifolium	—	—	—	11	—	—	—
Scheuchzeria palustris	—	—	—	—	50	50	50
Points	**314**	**233**	**229**	**134**	**120**	**100**	**157**
Diageic	248	162	229	134	120	100	157
Epigeic	66	71	57	75	20	—	3

Table XVIII.

Chamaephytes	**6**
Calluna vulgaris	6
Hemicryptophytes	**125**
Agrostis canina	21
Calamagrostis arundinacea	3
Carex Oederi	3
Galium palustre	7
Juncus supinus	1
Lythrum salicaria	37
Molinia coerulea	46
Potentilla tormentilla	8
Veronica scutellata	5

Rhyncospora alba is characteristic of the bare spots. Column *G* shows the edge of a bog round a little lake. There was a quaking-bog of *Sphagna* which could hardly bear a man. Finally table XVIII shows the vegetations of a little flat island in Bakkevandet. The bottom consists of gneiss and fine gravel which at the flood of the sea is washed over. Many germinating plants of *Calluna* were found, but no older specimens. The bottom was scantily overgrown. The species of plants were, not counting a single exception, epigeic ones of the same sorts as are common on gravelly sea-shores in the neighbourhood.

In what has been said parallels have been drawn between the forests of the communes of Bamle and Skaatö and the forests of Småland. The most striking fact is the far greater extension of the broad leaved forest here than in Småland. In this respect this region is like the northern part of Blekinge, where, from the region of broad leaved forest near the coast, we approach the region of coniferous forest of Småland.

The predominance of coniferous forest in the northern part of the woodland-regions of the continent, and the predominance of broad leaved forest farther south, wherever forest-cultivation has not altered the conditions, proves the underlying of a climatic cause. This also becomes apparent through the fact that the broad leaved forests in the territories of transsition are confined to slopes declining to the south. Besides we find edaphic causes for the proportion of broad leaved forest and coniferous forest, namely the small power of competition of most broad leaved trees growing on a soil of raw-humus. In the territory of transition the broad leaved forest therefore prefers slopes with easy drainage, while flat areas, where the difficult drainage favours the formation of raw-humus,

are given up to the coniferous forest. Birch and aspen differ from the great majority of other broad leaved trees in so far that they thrive well on raw-humus and besides go much farther north than these.

Already GRISEBACH[1] has pointed out the shortened time of vegetation as the most important climatic reason for the northern limit of the species of trees. For it is quite obvious that the limits of vegetation only exceptionally follow simple meteorologic curves, such as the mean temperature for warmest month, the summer months, or the like. If we want to show the northwards decreasing duration of the period of vegetation we at once meet with the difficulty of determining what on the whole is to be understood by the period of vegetation. Indeed, the life of a plant is an ensemble of many physiologic processes, each of these processes prepares the other. At the outset we therefore must renounce the idea of arriving at more than an approximative statement of the climatic conditions that determine the limits of vegetation.

SUPAN[2] was the first to construct maps of the duration of certain periods of heat. His maps comprise all Europe and show the duration of the time during which the daily mean temperature is above 0°, 10° and 20°. While the curves for 0° only prove parallel to the limits of certain oceanic species which will stand only light frost of short duration, the curves for 10° are parallel to several important limits of vegetation. Thus the northern limit of the evergreen Mediterranean-vegetation is found between the 7 months and 8 months curves for a day-temperature above 10°.

It is obvious that the parallelism would be greater if a temperature of a little below 10° was chosen. The limit between preponderating broad leaved forest and preponderating coni-

[1] Die Vegetation der Erde I. Kap. 2. Leipzig 1872.

[2] Die mittlere Dauer der Haupt-Wärmeperioden in Europa. (Peterman's Mitt. 1887).

ferous forest in northern Europe is between the curves for 4 months and 5 months, and the northern limit of the oak is at a little north of the curve for 4 months.

It seems very natural that the very duration of the period of vegetation should be a most important climatic factor in the determination of the limit between preponderating broad leaved and coniferous forests. No doubt the different broad leaved trees have different powers of changing their time of foliation according to the conditions of temperature; thus we see that in different regions the foliation of the different species goes on in varying order. Thus *Alseulus Hippocastanum*, which in Denmark is among the earliest budding trees, in Madeira[1] is one of the latest, and its foliation takes place there but little earlier than here. *Quercus pedunculata* which in Denmark comes out very late, in Madeira has its foliation as early as in January, exceptionally even in December. At its polar limit, however, any species of tree must have its foliation at the lowest temperature possible, which, as Grisebach has shown, is higher than that which reigns during the time when the defoliation sets in. This, no doubt, is useful for the tree, as the young leaves are less exposed to the hurt by late frost; but it is uneconomical, as the tree is bereby prevented from utilizing the warm days of spring for its assimilation of carbon dioxide. It therefore seems probable that, in that respect, the ever-green coniferous trees have an advantage over the majority of the deciduous species of trees. Besides, a long period of heat favours the destruction of the residual products of the plant, as the heat both directly favours the action of the bacteria, and furthers the evaporation, so that the earth is better ventilated.

The greater part of the Scandinavian peninsula has a strongly marked podsol-climate. In the woods we find almost everywhere raw humus with underlying podsol and hard-pan.

[1] Menezes Contributions à l'étude de la phénologie de Funchal. Bull. de l'ac. internationale de géographie botanique 1905, 1908, 1912.

In southern Sweden, on the contrary mould prevails, and the mould insensibly passes into the underlying brown-soil. In Sweden the podsol soil holds a constantly more important place the more we advance to the north[1]. In particular it impedes the assimilation of nitrogen of most broad leaved trees; containing generally only ammonium-salts, and lacking in nitrates.[2]

Although the duration of the vegetation is an important factor in many species of plants, it must not be overlooked, however, that it can never be indifferent whether the temperature within this period is higher or lower. In his work on the limit of the hazel in Scandinavia SAMUELSSON[3] has used for time of vegetation the time with the day-temperature above 0°, and, along the limit of the hazel, he, of course, has found this period varying, as the warmth of a period of vegetation compensates its shorter duration. In an interesting way he has cleared up the proportion between the temperature of the period of vegetation and its duration.

As to the deciduous trees it seems beforehand probable that the duration of the time during which they have green leaves is a main-factor in their extension. As, for a great number of species, the visible phenomena of foliation set in about the time when the daily mean-temperature reaches 8°, I have constructed a map of southern Scandinavia with curves for the duration of the time when the mean-temperature of the 24 hours surpasses 8°.

I have calculated the course of the curves according to the existing temperature-tables. With regard to Sweden we possess such tables by H. E. HAMBERG[4], reduced to a period of

[1] G. ANDERSSON & HESSELMAN, Mittelschwedische Böden. Stockholm 1910.

[2] HESSELMAN, Studier öfver Salpeterbildninger i naturlige Jordmåner. Meddelanden från Statens Skogforsöksanstalt. 1917.

[3] Über den Rückgang der Hazelgrenze und andere pflanzengeographische Grenzlinien i Skandinavien. Bull. of the geol. Inst. of Upsala 1915.

[4] Lufttemperaturen i Sverige. Bihang til Met. Iagtt. i Sverige 1907.

years (1859—1900). They comprise 257 stations, 204 of which are within the territory of my investigations. From Norway we have means by Mohn[1] from 78 stations, 54 of which south of Tronhjem. These are reduced to a period of 48 years (1841—90). The smaller number of stations in Norway makes the curves of the map far less exact than in Sweden. Finally I have included the islands of Aaland according to Johanson[2]. From Denmark no published temperature-tables are extant, but manuscript material has kindly been lent for my use by the Danish Meteorological Institute.

The temperature curves in spring and autumn being almost rectilinear at the times when the day-temperature is about 8°, I have calculated the dates for 8° by linear interpolation.

From the map it appears that the limit for preponderation of broad leaved forest very nearly coinsides with a period of 155 days with a mean temperature above 8°. At the western coast of Norway it begins about the mouth of Sognefjord, cutting off the outer skerries and peninsulas. For want of a sufficient number of stations, however, its course cannot be quite exactly determined. It thereafter runs close inside the shore along the Skagerak to turn into the sea south of Larvik. In Sweden it begins again north of Strömstad, cutting off the coast region of Bohuslän and Halland. Excepting the north-eastern corner, Skåne is situated south of this curve, and finally it runs close inside the shore of Blekinge and the southern part of Kalmar Län. At the western coast of Sweden and at the coast of Blekinge the curves are very close to each other so that towards the inland the duration of the period of vegetation quickly decreases. This fact explains the rather distinct limit between the broad leaved forests of the coast regions and the coniferous

[1] Klimatabeller for Norge I. Videnskabsselsk. Skrifter. Kristiania 1895.

[2] Temperatur- und Niederschlagsverhältnisse für 8 finnische Orte. Met. Jahrb. für Finland 1901—02. Helsingfors 1908. —

forests of the inland. Finally, Öland is almost quite inside the curve for 155 days. In the southern part of Öland broad leaved forest prevails, in the northern part coniferous forest. The places of observation of temperature in the northern part of Öland, however, are all near the coast, and the high level of the island suffices to place the northern part of its interior north of the curve. The map also clearly shows, how the Baltic, which during the months of spring is still filled up with drift-ice and melting-water, has a considerably shortening influence on the period of vegetation. Near the rest of the coasts, on the contrary, the period of vegetation is longer than in the inland.

The region of Kragerö is between the curves for 150 and 155 days, like northern Blekinge, where the vegetation has a similar character.

North of the limit of the belt of broad leaved forest scattered broad leaved trees are found in the coniferous forest and a few broad leaved forests. The broad leaved forests prefer slopes with easy drainage, where the soil is less disposed to become sour, the farther we arrive north, the more they prefer south facing slopes, and also places where the soil is rich in lime, accordingly a soil that favours a formation of neutral mould.

North of the great Swedish lakes the more pretentious broad leaved trees are mostly found in the so-called „*leaf-meadows*" (löfängar) where areas of meadow alternate with small broad leaved forests on a soil of mould. SERNANDER[1] demonstrates that a soil abounding in lime favours this type of vegetation. HESSELMAN[2] shows that in Uppland it parti-

[1] Die Einwanderung der Fichte in Scandinavien. Engler's bot. Jahrb. 1892. Växtvärlden. Uppland, Skildring af land och folk. Uppsala 1901.

[2] Zur Kenntnis des Pflanzenlebens schwedischer Laubwiesen. Mitt. aus dem blt. Inst. Stockholm, Jena 1904.

cularly occurs on limy morainic gravel. Palmgren[1], too, points out the abundance of lime in the soil as a condition for the occurrence of the leaf-meadow in the islands of Åland. On a soil which favours the formation of mould the broad leaved forest is consequently, even so far north, capable of successful competition with the coniferous forest.

If in southern Norway broad leaved forest particularly occurs on strongly sloping ground, this is to be ascribed to the easier drainage. In promoting the evaporation of the water the southern exposure, ordinarily found in the broad leaved forest, has, too, a favourable influence on the formation of neutral mould.

The map includes curves up to 130 days with a daily mean-temperature above 8°. The highland of Småland with its more northern character of vegetation appears limited by the curves for 145 days. The curve for 135 days is very close to the northern limit of oak and hazel, while lime, elm, alder and maple go a little farther north.

The widely preponderating type of spruce forest is the one in which the under-vegetation is formed by diagcic chamaephytes. The next in frequency is the spruce forest where the under-vegetation is poor in vascular plants. The Swedish plant-geographers take these two main-types together under the designation of "*spruce forest rich in mosses*". Far less extended is the spruce forest with an under-vegetation of diageic herbs, the Swedish plant-geographers' "*herbous spruce-forest*". The latter is the type of the spruce forest in places where it is growing on mould or on a transition-form between mould and raw-humus.

In the spruce forest rich in mosses a greater or smaller number of herbs are found, although they stand back compared with the chamaephytes, in the herbous spruce forest, rever-

[1] Studier öfver Löfängsområdena paa Åland. Acta pro fauna et flora fennica 1915.

sedly. The advantage of the statistic description of the vegetation in the particular places of growing is obvious. It makes it much easier for another person to understand how the plant-associations have been limited and to compare the habitats of the same type of vegetation in different places.

In the surroundings of Kragerø the herbous spruce forest is common, and in the under-vegetation of the spruce forest rich in mosses a great number of herbs are often comprised; particularly common is *Majanthemum*. In the Danish cultivated spruce forests the herbous type is common too, where, on the whole, the conditions of light permit an under-vegetation. RAUNKIÆR[1] has described it as the oxalis-facies of the spruce forest. In the highland of Småland the herbous spruce forest is not common, and I never succeeded in finding it anywhere. Only in a cultivated pine forest I have found an under-vegetation of diageic herbs[2]; on the other hand I have found it in Blekinge and in Bohuslän in the transitional area between the belts of broad leaved and coniferous forests. In Norway I have found it frequent in the silurian territory near the fiord of Kristiania. I have also seen it even high up in the mountain in the territories of metamorphosed silurian rocks that are found in the folded range of Scandinavia for instance in Østre Slidre not far below the limit of the forest; and everywhere in this limy territory I have found the spruce forest rich in mosses far richer in herbs than are the spruce forests of Småland, Dalarne and elsewhere in Sweden, not counting the southern and western coast regions. A. NILSSON[3] has described the herbous spruce forest of Omberg where, in course of a little more than a century it has supplanted the

[1] Formationsundersøgelse og Formationsstatistik. Botanisk Tidsskrift 1909.

[2] Les types biologiques dans quelques formations végétales de la Scandinavie. Bull. de l'acad. royale des sc. et lettres de Danemark 1911.

[3] Om örtrika barskogar. Tidskrift for skogshushållning 1896.

oak forest. In Värmland[1] spruce forest with or without intermixture of broad leaved trees (mainly birches) makes 94,2 per cent of the woodland territory. Of this only 3,7 per cent belong to the herbous type, which is mainly found where the underground consists of Hyperite or lime stone. G. ANDERSSON and HESSELMAN[2] state that the herbous spruce forest in Hamra Kronopark in Dalarne is found on steep slopes where the water-circulation is quick. According to HESSELMAN[3] strongly marked mould is found on the limy bowlder clay of Gotland and on limy sand as well. On limy bowlder-clay in Södermanland he has found a similar soil covered with herbous spruce forest. In the silurian territories of Jämteland matters are quite different. The herbous spruce forest is confined to slopes where, in the most favourable places, podsol is wanting so that the substratum of mould insensibly passes into the underlying mineral earth. On level ground, on the contrary, the lime is washed out of the upper stratum of soil. Under a layer of typical raw-humus podsol is found, which may be of a considerable extent and under which is hard-pan. The vegetation of the substratum of the spruce forest does not differ from that which is found in the lime-wanting regions of Norrland. The same differences of vegetation reappear if we compare localities on archaic lime of middle Sweden with such localities in the northern part of the country. He draws the conclusion that the cause must be sought in the climatic difference between middle and northern Sweden. The northern part of the country has a more strongly marked podsol-climate than the middle part, as the shorter summer and lower temperature favour the formation of podsol.

In the herbous pine-forest growing on the limy soil of

[1] Värmlands läns skogar. Betänkande avgivet av kommissionen for försökstaxering av skogarne i Värmland län. Stockholm 1914.

[2] Vegation och flora i Hamra kronopark. Skogsvårdsföreningens tidskrift 1907.

[3] Studier over Salpeterbildningen i naturliga Jordmåner.

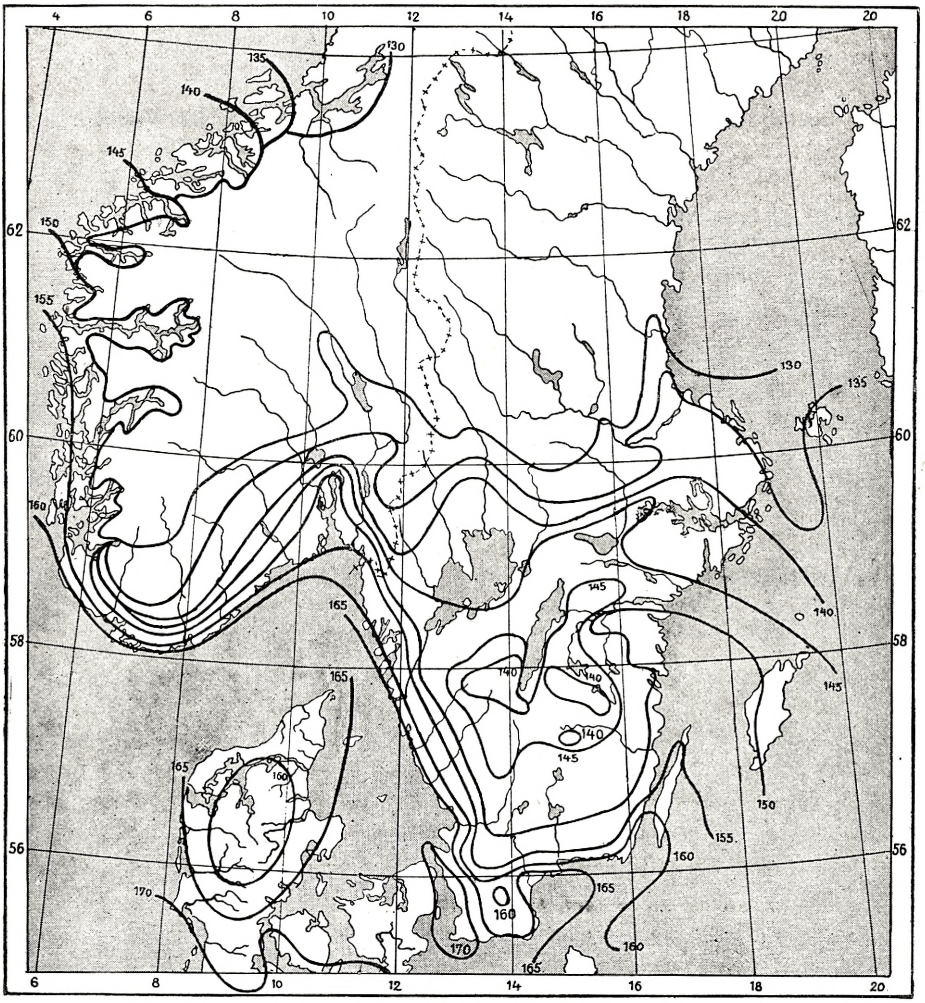
Gotland[1] a great number of epigeic herbs are found in the under-vegetation, as well on glacial drift as in localities with a thin layer of weathered rock. From the description it seems to appear that the epigeic species often preponderate over the diageic ones, if this is not ordinarily the case. The determination of the causes of this fact might require further investigations.

If the herbous spruce forest has so great an extension in the environs of Kragerö, the rugged character of the country for a great deal accounts for it. But if, in this region, it also appears on a ground so poor in lime as quartzite gravel, and if the diageic herbs hold so importent a place in the woods rich in chamaephytes on flat ground, this, no doubt, is due to a climatic cause, namely the long period of vegetation and the relatively warm summer, which favour the destruction of the organic residual products and thereby makes the formation of raw-humus less vigorous than in the parts of the Scandinavian peninsula, where summer is shorter.

[1] SERNANDER, Studier över den gotländske Vegetationens Utvecklingshistoria. Uppsala 1894.

HESSELMAN, Vegetationen og Skogsväxten paa Gotlands hällmarker. Skogvårdsforeningens tidskrift 1908.

Færdig fra Trykkeriet d. 24. Oktober 1919.



Map showing the duration of summer in southern Scandinavia.

The curves indicate the number of days on which the daily mean temperature exceeds 8°.

BIOLOGISKE

MEDDELELSER

UDGIVNE AF

DET KGL. DANSKE VIDENSKABERNES SELSKAB

I. BIND

MED 13 TAVLER

KØBENHAVN

HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL

BIANCO LUNOS BOGTRYKKERI

1917—19

INDHOLD

DET KGL. DANSKE VIDENSKABERNES SELSKABS SKRIFTER

NATURVIDENSKABELIG OG MATHEMATISK AFDELING

8DE RÆKKE

BIOLOGISKE MEDDELELSER

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DET KGL. DANSKE VIDENSKABERNES SELSKAB

1. BIND (Kr. 13,85):