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The beech and the beechforest in Poland.

By *Wladyslaw Szafer*, Kraków, Cracov.

Poland is of special importance for the geography of the beech and the beech forest, because through it passes the north eastern limit of the area of this species which runs in a straight line of about 1000 km from Pomerania to Bessarabia.

In analysing the character of this limiting line of the beech in Poland and in looking for the actual causes which condition it, we may characterise the horizontal area of the beech in the following way:

Horizontal area.

The beech as a species of plant of sub-atlantic type needing considerable moisture, shuns in Poland, areas with dry and continental climate. In the north-western part it clings distinctly to the moist areas of the Baltic lake district: leaving it, it makes a wide circle avoiding the areas of western Poland where the rainfall is less than 550 mm. Further east, the limit of this tree is distinctly connected in its course through Central Poland with the northern edge of the Central Polish Plateau and does not descend into the area of the great Mazovian valleys in the midst of which lies Warsaw. To the east of the Vistula the beech occupies only hilly situations and as a rule does not descend below the isohypsa of 300 m. Here the local waterdivides and chains of hills have the greatest influence on the course of its eastern limit. The hills with a longitudinal (i. e. north-south) direction, which stop rain-clouds coming mainly with the western winds become the limit line of the beech. This can be noticed especially in the chain of Roztocze, along the line north of Lwów, in the chain of Miodobory in Podolia and on the steppe part of Pokucie. Along these lines the amount of rainfall drops suddenly and on the eastern side of these hills the rainfall is about 100 mm less.

In the eastern part of the area of the beech in Poland, next to moisture there appears the temperature as another climatic factor influencing the beech. In this continental part of the country where steppe and forest intermix, there are often spring frosts and these, together with the sudden lowering of night temperature in the summer have a great influence. They are also responsible to a great extent for the character of its geographical distribution. The beech possesses here an area separated into islands which cling to the high hills where the frosts (especially in summertime) are rarer and where, at the same time, the air is more moist. Among the isolated islands occupied by forests with beeches, there are steppe areas which to-day have almost completely been taken over by agriculture — the soil being typically «czarnoziem».

Beechless areas.

Inside the area of the horizontal distribution of the beech in Poland there are quite numerous areas where the beech does not appear. These are river alluvia, the areas of warm loess in the southern part of the Malopolska Plateau, and the great territories of swamps situated on the upper course of the river Dniestr. The beech avoids also dry or sandy soils.

Vertical distribution.

The altitudinal distribution of the beech in the Polish Carpathians is noteworthy especially for the reason that here at a height of 500 to 1150 m. the beech finds the optimal conditions of existence, forming a distinct zone of beech forest. The lower limit, passing at a height of about 500 m, does not form however an absolute limit, because there often appear beech forests below it: they do not form there, however, compact areas, and they give place to mixed forests with *Carpinus betulus* as a predominating species.

As a species the beech in the Polish Carpathians reaches much higher. So e. g. in Babia Góra where the upper limit of the beech forest lies at a height of 1150 m, the beech reaches up to 1230 m, in the Tatras we find the beech at the height of 1251 m; in the Polish part of the Eastern Carpathians at a height of 1320 m and so on.

Exposure.

The exposure is an important factor for the distribution of the beech, but only beyond its mountain zone. In the Carpathians it is not connected with slopes of any special steepness and as a rule it appears on every exposure. In the lower mountain zone and on the plain the southern exposure is less favourable for the beech than the northern exposure. On the plain the beech distinctly prefers the damper western slopes to the more dry eastern ones. In the river canyons of continental Podolia it is closely connected with northern exposure and it does not appear at all on the slopes of southern exposure.

Winds.

The wind influences the beech and the beechforest in the mountains, especially in isolated ranges and in passes with strong wind currents always blowing in the same direction. In such places the beech forest is distinctly lower, the trees often bent and bearing the characteristic wind-injuries. The passes and ranges of the boundary chain of the Middle Carpathians, which are especially exposed to winds, may possess beeches quite dwarfed and bent earth-wards to one side — or they may become quite devoid of forest under the influence of strong winds.

In the lowland the winds also possess a great importance for the beech. In the north-west part of Poland the influence is that of the reigning west winds, on the east (Podolia, Volhynia) also that of the dry eastern winds which blow here with great strength, especially in the autumn and have an unfavourable influence not only on the rather susceptible beech, but even have a deteriorating effect on the oak (*Quercus pedunculata*) a tree much sturdier than the beech.

Temperature.

I should like to add here to my previous remarks about temperature the fact, that spring frosts and the considerable oscillations of day and night temperature in summer have a great influence on the beech — particularly in continental Podolia. The young trees freeze here very often and a normal regeneration can take place only under

the protection of old trees. Specimens of «border» beeches growing separately acquire in these conditions a special character: their trunks are low and the crowns strikingly thick, the cause of this, lying in the fact that in the place of the frequently freezing young top sprouting branches, the side branches develop more abundantly.

The low winter temperatures influence the beech only when the cold is abnormally great. The winter of '28/29 was particularly instructive in this matter. In the Carpathian valleys, where the minimal temperatures reached locally from -40 to -46 C., the beeches suffered very much and in places froze out entirely. In higher situations in the mountains and on elevations situated on the plain the beech suffered very little or not at all. As a result the limiting lines of the beech in Poland did not undergo any changes.

Soil.

As far as the soil on which the beech grows is concerned, it should be remarked, as regards the Carpathians, that the beech grows here on Flysh sandstones with a varied chemical composition, particularly in the content of Ca CO_3 ; it grows however on every other soil, provided it is not too barren or dry. In the Tatras the beech is especially connected with a lime soil and it does not grow at all on soils lacking in lime i. e. on granites and on quartzites. Beside the Carpathians it grows on various soils, and it always prefers soils abounding in lime, although it appears also on quartz (Holy Cross Mountains).

Acidity of the soil.

The acidity of the soil in beech forests, changeable in its profile in accordance with the character of the soil, shows for the most part values from 6—5.4 p H in the surface layer; only in the facies of the edge of the forest where the wind has a destructive effect on the soil by continually blowing off the humus, the soil shows sometimes a strong acidity and the typical phenomenon of leaching (podsol). The highest acidity proved in such cases amounted to p H 3.7 (Złoty Potok).

Grazing.

Grazing and gathering of the humus impoverishes the soil, changes its physical characteristics disadvantageously and changes its

chemical reaction, introducing to the beech forest foreign elements e. g. *Vaccinium myrtillus*, *Lycopodium*, *Pirola*, *Calluna* and others. Sometimes nitrophilous plants appear in places where the dung had accumulated in the soil, as e. g. *Rumex alpinus* in the Carpathians.

Fires.

After fires the grasses form often a transitory stage of the regeneration of the herbaceous layer e. g. *Anthoxanum odoratum*.

Relation of beech to fir.

The beech being a heavy-seeded tree, is a sociable tree and has a tendency to form beech forests — and it forms them whenever it does not meet with the competition of other species of trees.

Pure beech forests (*Fagus* in about 100 %) appear often in the Carpathians in the vertical zone from 500 m to 1120 m (on the east much higher) and beyond the Carpathians i. e. on the Plateau of Małopolska, Roztocze and Opole.

Both in the Carpathian beech zone and in the central areas of plain beech forest there appear, next to pure beech forests, forests where an important role is played by the Silver fir (*Abies alba*). The degree of intermixture of these two species of trees varies. These mixed forests lead to pure Silver fir forests. Since man, inhabiting the locality for a long time, had been systematically destroying the beech by using its wood for fuel, it is difficult to judge to-day in how far this factor influenced the formation of pure Silver fir-forests in those places, where the beech grew originally mixed with Silver firs. At any rate we should stress that from a sociological point of view the Silver fir forests (*Abietetum*) do not present a different forest association, and that in connection with *Fagetum* they play the role of introducing into it some components typical for spruce forest (*Piceetum*). *Abietetum* which is not a different association is consequently a natural link connecting *Fagetum* and *Piceetum* in all territories where originally the Silver fir appears together with the beech.

Relation of beech to spruce.

The spruce (*Picea excelsa*) is a natural constituent of beech forests in the Carpathian zone and in some places in the lowland;

but it does not appear often, and without the intervention of man it never expels the beech. In the Carpathians the spruce begins to play a more important role, but only at a height of (1050) 1080—1120 (1150) m and in this transition zone it begins to become a serious competitor of the beech. In spite of this competition the beech as a species reaches in the Carpathians much higher — but at these higher altitudes it does not form pure beech forests any more. In some Carpathian ranges only, lying south of the main range, where there is no spruce, the beech reaches a much higher altitude in the shape of pure beech forest and may even form here the upper timberline. So e. g. matters stand locally in Swidowiec, situated already in the territory of Czechoslovakia, where the beech forms the upper forest line at a height of 1250—1320 m.

Relation of beech to other trees in the Carpathians.

Of other trees growing together with the beech in the Carpathians the following ought to be mentioned:

Taxus baccata, *Acer pseudoplatanus*, *Ulmus montana*, *Sorbus aucuparia* and *Sorbus aria*.

The yew (*Taxus baccata*) rarely plays a conspicuous role in the Carpathian beech forests, because it has for the most part been exterminated by man.

Acer pseudoplatanus grows everywhere with the beech, but it is only interspersed.

Ulmus montana is rarer than *Acer pseudoplatanus* and in the western Carpathians it reaches only to an altitude of about 900 m.

Sorbus aucuparia appears seldom in beech forests, and mainly in lower situations. It grows more frequently near the upper forest line and the zone of *Pinus montana*.

Sorbus aria occurs rarely in the zone of beech growing on lime soils.

In the lower Carpathian zone (below 500 m) *Carpinus betulus* becomes a rival of the beech, partly also *Tilia ulmifolia* and *Acer platanoides*.

Relation of beech to other trees in the lowland.

In the lowland the relation of the beech to the other species of trees is analogous as far as the Silver fir, the yew, the spruce, *Acer pseudoplatanus*, *Ulmus montana* and *Sorbus aucuparia* are concerned. In relation to *Carpinus betulus*, however, it should be noticed that, to the east particularly (Podolia, Opole) *Carpinus betulus* has often a predominance over the beech and pushes it out successfully. In relation to the beech, *Carpinus Betulus* behaves here like the spruce in higher mountain situations. Apart from *Carpinus betulus* the following trees enter into close competitive relation with the beech: *Quercus* (especially in Opole), *Acer campestre*, *Acer platanoides*, and also the pine (*Pinus silvestris*) — but we shall not go into this problem more closely.

Shrubs.

The beech forest in its typical shape does not possess the stratum of shrubs. Shrubs of various height are present but they do not form a distinct and independent stratum. Among shrubs growing in the beech forests in Poland are the following: *Sambucus racemosa*, *Daphne mezereum*, *Rubus hirtus*, *Rubus idaeus*, *Ribes alpinum*, *Lonicera nigra* (in the Carpathians), *Sambucus nigra* (chiefly on the plain), *Viburnum opulus* (on the plain), *Evonymus verrucosa*, *Evonymus europaea* and *Hedera helix* (climber). In the beech forests thinned by man and in the facies of beech forests on rocks, there grow other species also, which however we shall not enumerate.

Ground vegetation.

The ground vegetation is composed of herbaceous plants partly evergreen, and forming the typical carpet of the beech forest. As a rule beech forests do not possess a stratum of mosses — not in their optimal facies at any rate. Mosses are usually richer in forests growing on stony soil and appear in spots near tree trunks and on the trees themselves. Of the frequently met mosses I shall mention: *Catarinea undulata*, *Polytrichum formosum*, *Plagiochilla asplenioides*, *Plagioteceium* sp, *Mnium* sp. etc.

The character of *Fagetum*.

The most important sociological feature of beech forests as an association is the possession of distinct characteristic species. Their list for beech forests in Poland is the following.

1. Characteristic species more or less common for the whole area of *Fagetum*.

a. Characteristic species of the 1-st degree:

Asperula odorata.

Veronica montana.

Dentaria bulbifera.

Corydalis cava.

Allium ursinum.

b) Characteristic species of the 2d degree:

Anemone ranunculoides.

Carex pilosa.

Festuca silvatica.

Galanthus nivalis.

Impatiens noli tangere.

Mercurialis perennis.

2. Characteristic species growing in some areas of beech forests.

a) Characteristic species of the 1-st degree:

Arum maculatum.

Dentaria enneaphyllos.

Digitalis purpurea.

Epipactis microphylla.

Festuca montana.

Gagea spathacea.

b) Characteristic species of the 2d degree:

Aposeris foetida.

Epipactis sessilifolia.

Galium rotundifolium.

Galium silvaticum.

Glechoma hirsuta.

Hacquetia epipactis.

Helleborus purpurascens.

Lactuca quercina.

Lysimachia nemorum.

Scopolia carniolica.

Symphytum cordatum.

Scilla bifolia.

Apart from these species an important role in the beech forests is played by other species common for *Fagetum* and other sociologically related forest associations, which we shall not mention here.

Geographical variants.

Considering floristic differences we may distinguish in Poland the following geographical variants (races) of beech forests ¹⁾

1. Area of beech forests of the West Carpathian type :

These beech forests are either pure or intermixed with Silver firs, and possess *Galium rotundifolium* as a species which differentiates them from others.

2. Area of beech forests of East-carpathian type :

Often intermixed with Silver firs they possess the following species which differentiate them from others: *Symphytum cordatum* and *Aposeris foetida*. *Scilla bifolia* appears specially frequently here.

3. Area of beech forests of Silesian type :

Species differentiating this area are: *Hacquetia epipactis*, *Digitalis purpurea*, *Epipactis microphylla* and *Dentaria enneaphyllos* (partially).

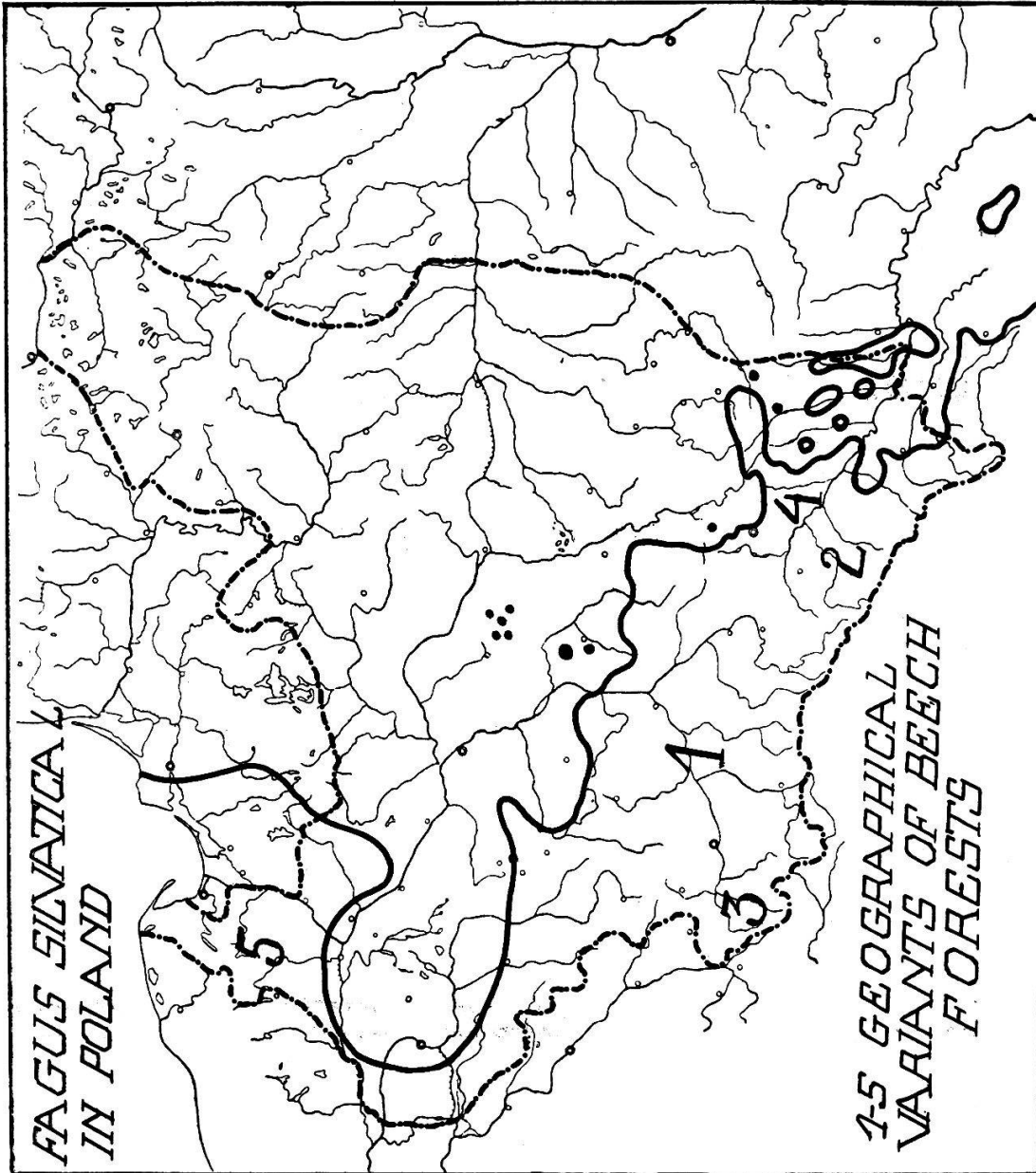
4. Area of beech forests of Opole-Podolia type :

This area is characterised, apart from the lack of Silver firs, spruces and yew trees by the following species: *Scopolia carniolica*, *Glechoma hirsuta*, *Helleborus purpurascens*, *Lactuca quercina* and *Epipactis sessilifolia*.

5. Area of Pomeranian beech forests :

The lack of Silver firs, spruces and many species of mountain plants such as: *Dentaria glandulosa*, *Senecio nemorensis*, *Euphorbia amygdaloides*, *Galium rotundifolium*, *Salvia glutinosa* and *Sambucus racemosa* are distinct negative features of this type of beech forests.

¹⁾ The map p. 177.



The influence of the oceanic climate is manifested by the presence of *Gagea spathacea*, *Galium hercynicum* and *Galium silvaticum*.

The above variants or geographical races of beech forests are not separated distinctly from one another — on the contrary, they are connected by transitions, the origin of which is due mainly to historical factors.

Sub-associations, facies and sub-facies.

On account of the changeability of edaphic and climatic conditions and also on account of the degree of the intermixing of the beech with other species of trees, we can differentiate, inside the beech association, lower sociological units i. e. subassociations and facies, which however have not been studied sufficiently as yet, over the whole area of Polish beech forests.

Carpathian sub-associations.

In the Western Carpathians where sociological research has been more satisfactory, we can differentiate (according to B. Pawłowski), beside the typical association, the following two subassociations:

1. Subassociation *Fagetum abietosum* developed in the zone from 600—1250 m with an optimum below 900 m (800—900 m) with a predominance of the Silver fir and a constant though usually inconsiderable admixture of spruce. Characteristic species for *Fagetum* appear here, but less abundantly than in the typical association. There appear also species connected rather with the spruce, such as *Homogyne alpina*, and *Lycopodium selago*.

2. Sub-association *Fagetum submontanum* occupying the lower zone from 600—300 m and differing from the foregoing by the presence of many herbaceous species which do not grow in higher situations and by the presence of *Carpinus betulus* and *Acer campestre*.

Further research will enable us to differentiate still other sub-associations which perhaps will partly coincide with the above mentioned geographical variants of beech forests in Poland.

Facies.

In connection with the kind and moisture of the soil and other local factors we can differentiate inside area of a given *Fagetum* its more or less numerous facies:

The optimal one is:

a) Facies *Asperula-Dentaria*, developing on the most favourable beech soils with a reaction of the surface layer from 6—5.5 pH. This type of beech forest is very frequently met with in the Carpathian zone corresponding to the climax of *Fagetum* and also in many optimal settlements of the beech on the plain (e. g. in the environs of Kartuzy in Pomerania, the range of Kraków—Wieluń Jura, Holy Cross Mountains, Roztocze and Opole).

b) Facies with *Allium ursinum* developing on moist soils on the plain as well as in the mountains.

c) Marginal facies in *Fagetum* show different forms; according to the locality they possess a soil with a reaction nearing the value of pH 4, often showing the phenomenon of the leaching. Frequently there are present floristic components foreign to *Fagetum* e. g. members of the family *Ericaceae* and some mosses which may form here the stratum covering the soil.

d) Rocky facies with shallow rocky soil, with an acidity depending on the sub-soil, usually abounding with shrubs in the undergrowth.

Subfacies.

Among the little known facies, which perhaps it will prove better to consider as sub-facies, there are areas of *Fagetum* with the following species dominant: *Impatiens noli tangere*, *Mercurialis perennis*, *Corydalis cava*, *Oxalis acetosella*, *Aposeris foetida*, *Carex pilosa*, *Senecio nemorensis*, *Geranium Robertianum* and others.

Different associations of *Cryptogamous* plants live on the trunks of the beech trees. Their dependence from the *Fagetum* as an association creating for them favourable conditions of existence, has not sufficiently been explained as yet. In order however to stress the fact that such a dependence exists, I want to mention, that according to J. Motyka (1929) there live in the western Carpathians two different associations of lichens on the bark of beeches: the first living on the smooth trunks is composed of *Pyrenula nitida*, *Graphis*

scripta for plur., *Opegrapha herpetica* and others; the second one in the upper parts of trees with the following characteristic species: *Lobaria pulmonaria*, *L. linita*, *Sticta silvatica*, *Parmelia cetrarioides*, *Usnea ceratina*, *U. longissima* and many others.

Relation of *Fagetum* to kindred associations.

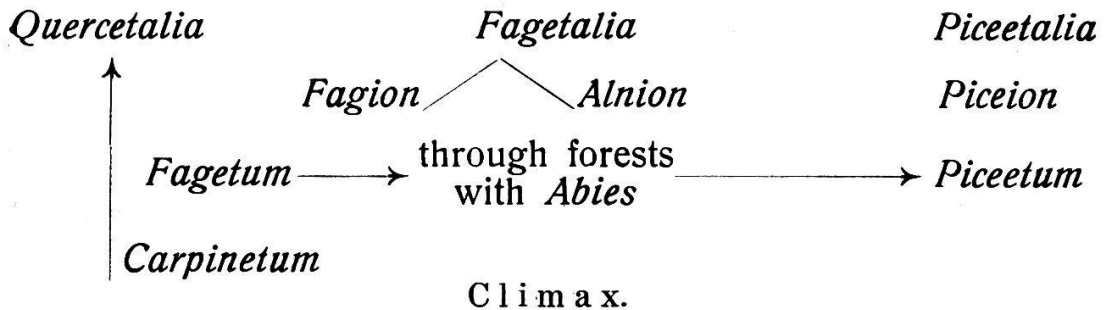
The relation of *Fagetum* to kindred associations may be expressed as follows:

The *Fagetum* shows a distinct floristic relation to the *Alneta* on one hand, the *Piceeta* on the other hand and also with mixed forests where *Carpinus* predominates. With the *Alneta* they are connected by their twin facies with *Allium ursinum*, also by sub-facies with *Impatiens noli tangere* and finally by the presence of a considerable number of connecting species such as e. g. *Dentaria glandulosa* (passing from beech forests into *Alneta*) and *Dryopteris cristata* (passing from *Alneta* to beech forests).

With the *Piceeta* the beech forests connect closely in places where the Silver fir appears, as to which it has been previously stated that *Abies* introduces to *Fagetum* floristic components of *Piceetum*. *Abietetata* although they do not create in the sociological sense a separate association, are a natural link connecting beech forests with *Piceeta*.

Carpineta are closely connected with beech forests in the lower mountain zone in the Carpathians (below 600 m), also in many places in the lowlands, especially in Opole, Podolia and Pomerania. They possess among their vegetation many species common with the beech forests.

From the above considerations results the following picture showing the position of beech forests in the system related associations:



From the point of view of succession the *Fagetum* is a climatic association (climax) in the zone of the Carpathians from 600—

1250 m (in the East it reaches higher), also in some parts of the Plateau of Małopolska, Pomerania and Roztocze. In Opole and Podolia it is an association retreating before *Carpinetum*; in isolated islands in Podolia on the other hand it is an example of a relict association.

Historical successions and relicts.

The beech as a species appeared in Poland after the diluvial epoch in the atlantic period. It found here already forests of the order *Piceetalia*, *Quercetalia* and *Alneta*, probably also *Carpineta*. In gradually superseding these forests, *Fagetum* acquired part of their flora and made it its property; some species on the other hand the beech brought with it as its closer companions. It may be taken that the species characteristic of beech forests whose geographical areas are identical or very similar to the beech areas (e. g. *Veronica montana*) belong especially to this category.

On account of considerable floristic differences between beech forests belonging to various geographical races we must hold that the beech forest did not come to Poland from one place and by one route. Also it did not immigrate everywhere at the same period of postglacial time. This supposition finds confirmation in the pollen analyses of peat bogs in Poland, which show quite considerable differences in this matter. The youngest are the beech forests in Pomerania, because here they developed richly at the end of the sub-atlantic period. Elsewhere in Poland the beech forests are considerably older i. e. early sub-atlantic or even atlantic. The sub-atlantic period was an optimal period for the distribution of beech forests both in the horizontal and the vertical directions. In this period the beech reached in the Carpathians about two hundred meters higher than it reaches to-day and in the lowland it extended north east, travelling chiefly along water divides up to the Białowieża primeval forest, to western Polesia, western Volhynia and Podolia. The disconnected islands of beech, which we meet to-day beyond the limit of its geographical area in Eastern Poland are therefore relicts from the sub-atlantic period.

The beech in Poland is therefore at present retreating to the South and West: and this is one of the proofs that the contemporary climate is becoming dryer and more continental.