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The beech-forests of Sweden.

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The exact distribution of the Swedish beech-forests has so far been little known. With due permission from the Royal Swedish Air Force I have had the opportunity of mapping from the air the beech-forests of South Sweden during 1927 to 1930.

By its light verdure during several weeks in the spring the beech forest may be easily distinguished at a great distance. A reliable map of the distribution of beech-forest may at this time be quickly sketched during reconnaissance flights. During no other time of the year is such exact work possible. Therefore, although the mapping has extended over a considerable period, it has really occupied very little actual time (about 30 hours). The Swedish ordnance maps on the scale of 1 : 100,000 were used as foundation maps. The precision of the mapping has been tested by comparison with accurate maps made on the ground and found quite satisfactory. The flying height was 1500 to 2000 m. The mapped area is about 15,000 square miles.

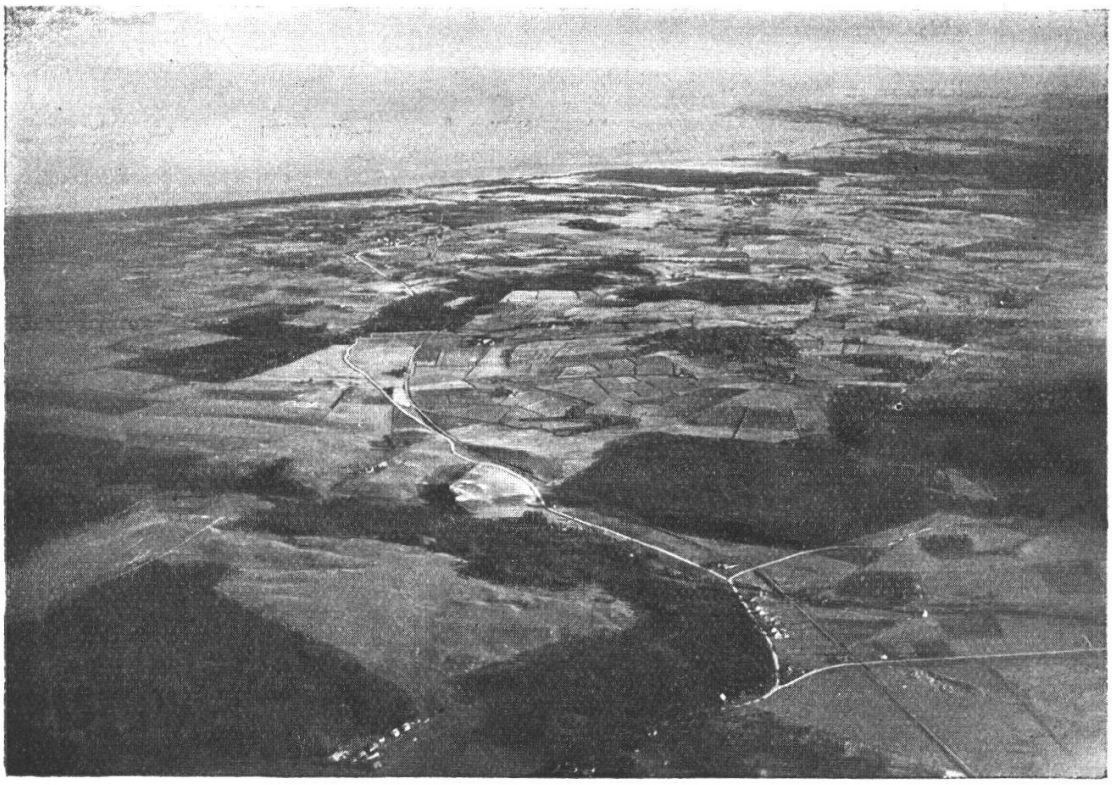
The distribution of the beech-forest of Sweden is limited to the southern part of the country. Its northern limit rises considerably in passing from east to west across the country. In the east it extends to about 58° N. while in the west it passes the Norwegian frontier and extends nearly to 60° N.

The beech forest area is divided into three parts:

1. The southern beech area. This is the north-western part of the great European beech-forest region. The northern limit is determined by the spontaneous occurence of the spruce.

2. The beech-spruce area. While the beech in the southern beech-forest area is broadly speaking the dominant tree, its extension in the beech-spruce area is strictly limited. The spruce here has colonised the greater part of the very acid soil. The beech forest occurs mainly on slopes and lake-shores.

3. The outpost area of the beech. This is the broad zone nearest to the northern limit of the beech within which it occurs only in scattered spots with a very uneven spread all over the area. Here the beech seems to propagate unsatisfactorily and to lack the power of occupying new ground. This has prevented the beech from becoming dominant in the numerous oak forests which have been preserved. A number of the present beech stands can be proved not to be spontaneous but have been derived from plantations.

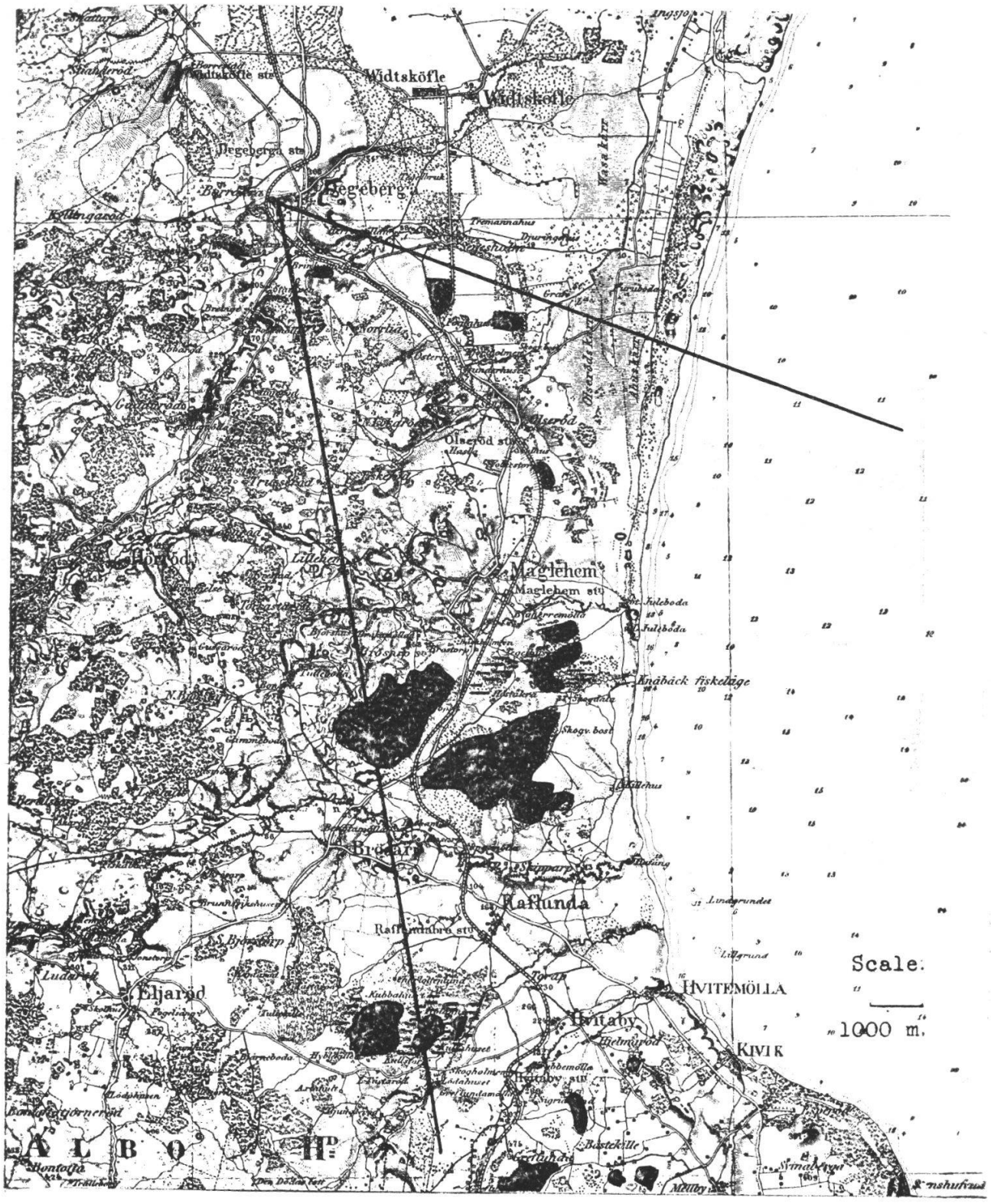


1. Aerial view from the south eastern part of the Southern Beech Area (Degeberga-region, Skåne). The champaign is founded by deforestation during the fifteenth and sixteenth century.

   The road and the railway in the middle of the picture goes down to the village Olseröd.

   In the foreground the beech and spruce-woods close to Degeberga, in the background the beech-woods between Maglehem and Raflunda.

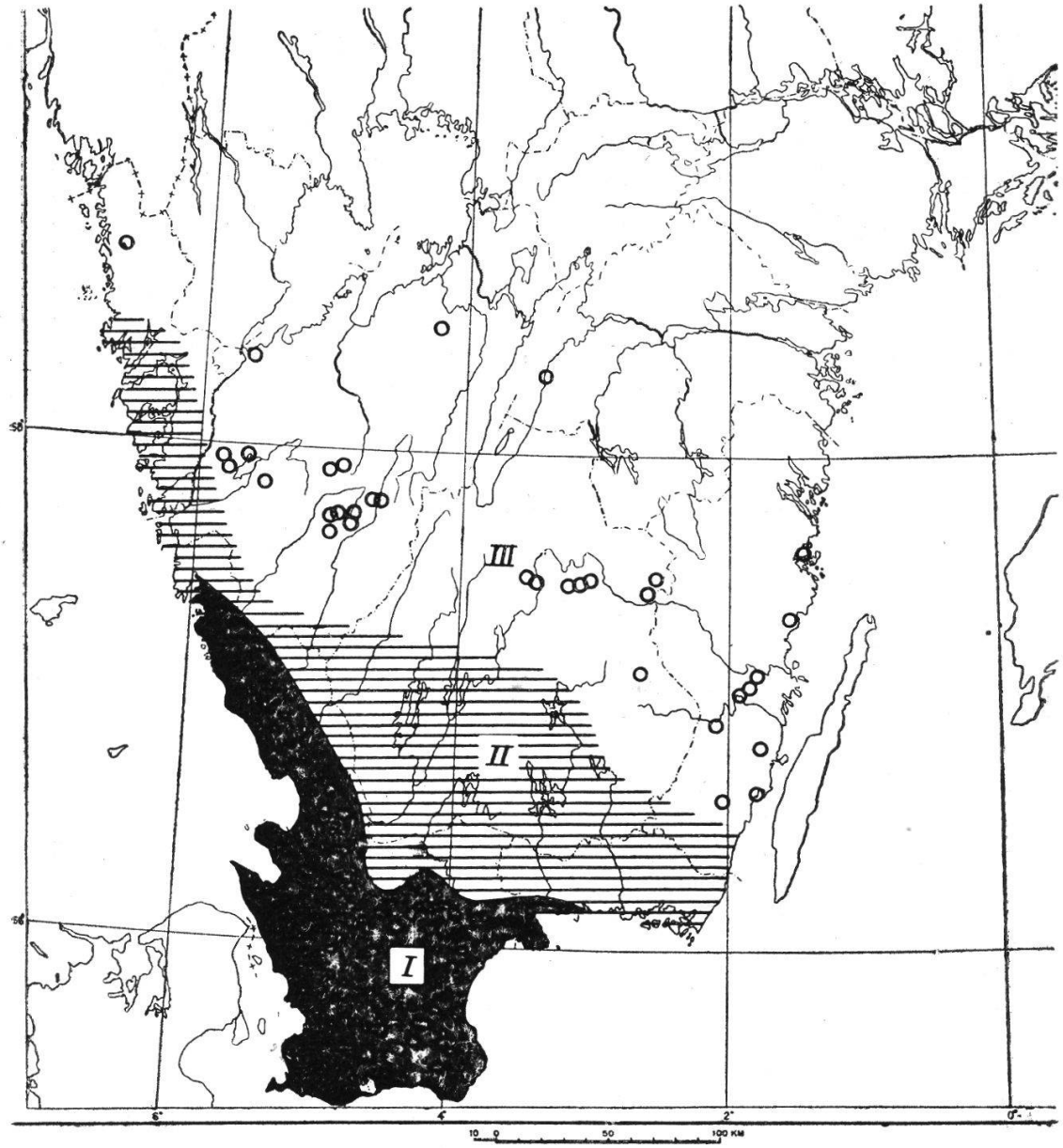
The climatic conditions which have proved to be of decisive importance for the natural spread of the beech in South Sweden are duration of winter, summer temperature, and rainfall.



2. Map of the above photographed area. The occurrence of Beech is specially marked.

The length of the winter, i. e. the time of arrival of spring, is of very great importance for the flowering and fruiting of beech.

Lack of sufficient heat in the height of summer reduces the amount of flowering of the beech and can thereby be considered to have a certain influence on its north-western limit.

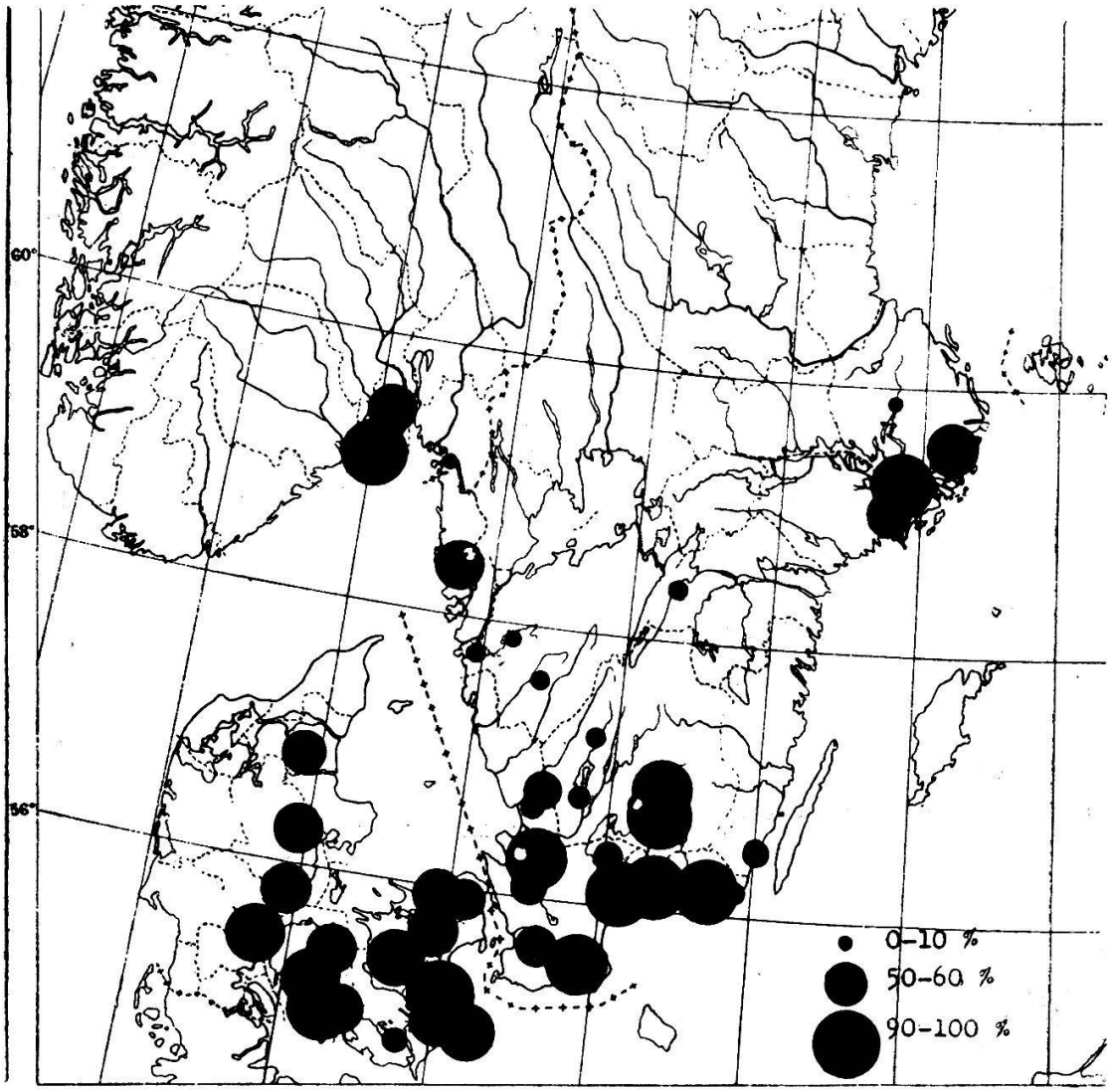


3. Map showing the distribution of Beech in South Sweden. I. The Southern Beech Area. II. The Beech-spruce Area. III. Outpost Area of the Beech (o present sites).

Too little rainfall is probably the reason why the beech in East Sweden has not spread effectively. On the Island of Öland, where a

spontaneous beech forest does not exist, the average rainfall is less than 500 mm (20 in.).

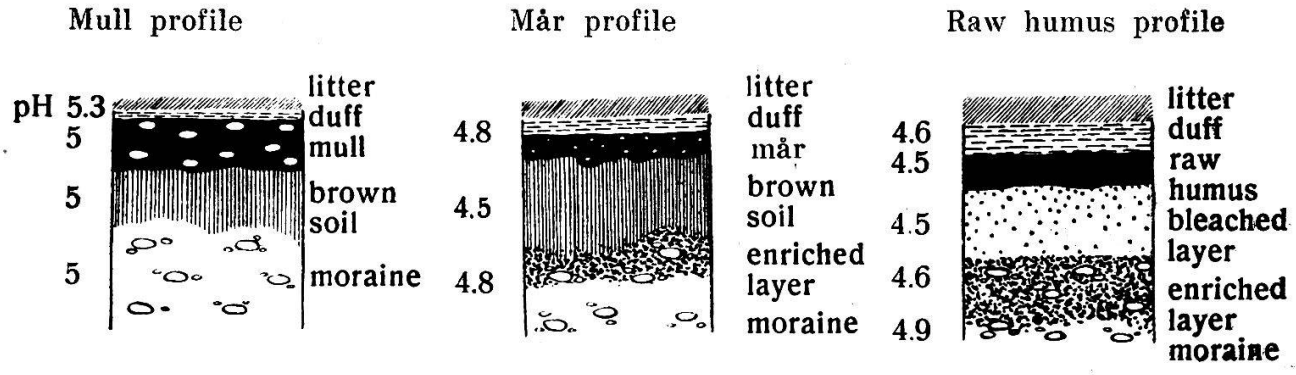
The soil profile in the Swedish beech forests may be a mull profile, a raw humus profile, or a mår profile, intermediate between these two.

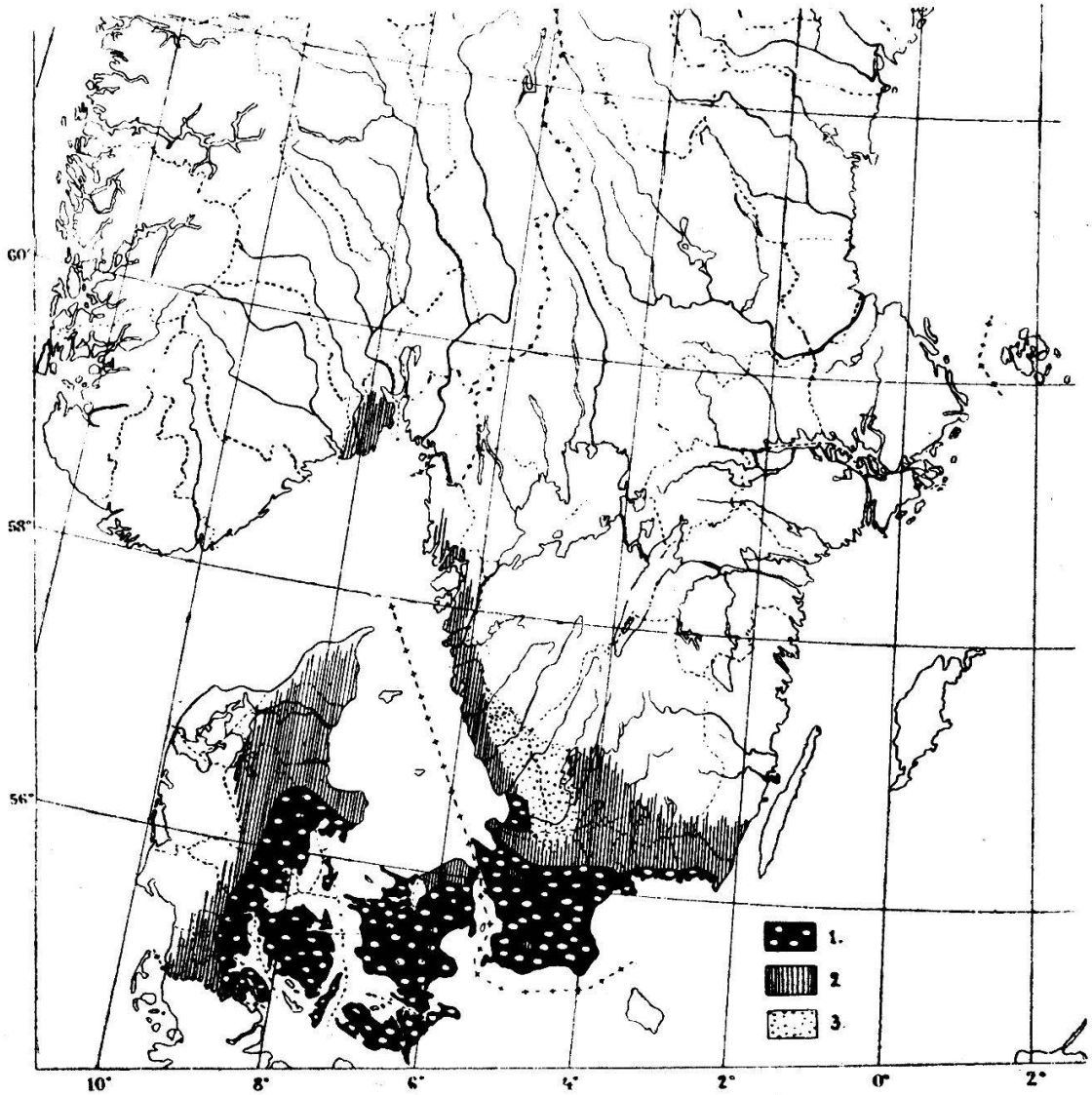


4. Map showing the percentage of effectively ripened beech-nuts in relation to the total number of developed nuts in Scandinavian Beech-forests in the year 1930.

The lack of ripened fruits in several places in the north is due to low temperatures in the spring.

The mull profile has a litter of undecomposed leaves of varying depth but seldom more than 5 cm (2 in.). The duff or mouldering layer is extremely thin. The mull layer (i. e. the upper





5. The main distribution of different soil profiles and their common composition in Scandinavian beech-forests.
1. Mull soils. 2. Mår soils mixed with raw humus and mull soils.
3. Raw humus soils.

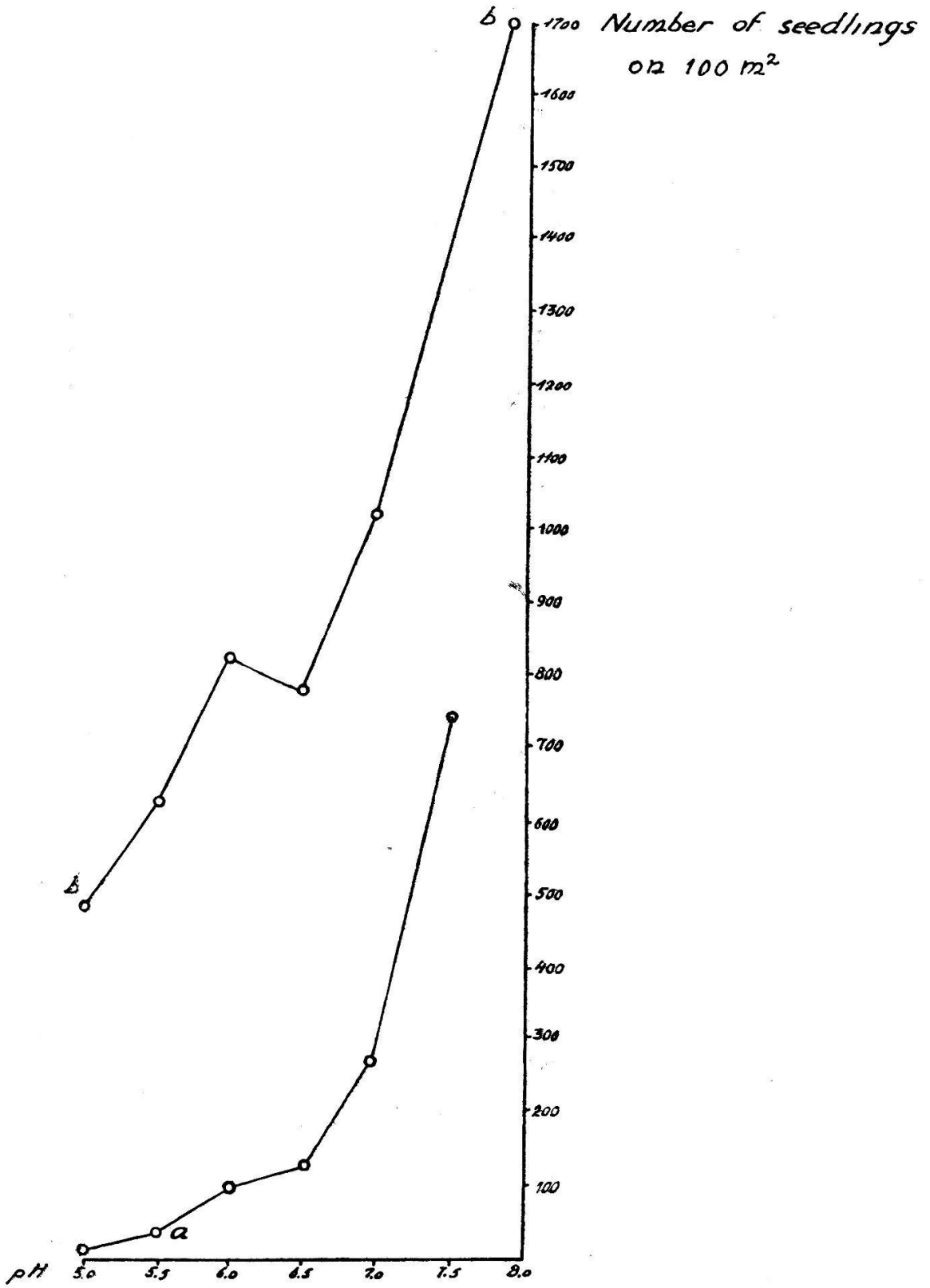
mineral horizon strongly mixed with humus) is generally strongly nitrifying. Under this occurs a brown soil layer which is generally of a more acid character than the mull layer.

The intermediate mår type is rather like the mull profile, but the litter and the duff layers are considerably deeper, the latter often up to 6 to 7 cm (2.5 to 3 in.). The duff layer is underlain by a layer whose appearance is intermediate between raw humus and mull, and this again by a generally deep brown soil layer. The ammonification in the mår layer is strong, the nitrification a good deal weaker than in the mull layer.

The litter of the raw humus profile is of varying depth. The duff or decomposition layer, which seems to be analogous with the duff layer in the last profile, consists of a deep layer of slightly decomposed leaves, bud-scales and mast, woven together with fungus-hyphae. The humus layer is similar to the organic portion of the mull in the mull profile and consists of a black colloidal humus. Ammonification takes place in this horizon but is not as great as in the duff. The nitrification as a rule has stopped. Below this layer comes the bleached horizon.

As to the common distribution of these types within the area it can be generally said that on all moraines with a pH greater than 5.5 the profiles are typical mull profiles. When the acidity is greater than pH = 5.5 the characteristic soil profile will depend upon cultivation and climate. In the northern part of the area an intermediate profile results from a strong winter climate, and in the western parts typical raw humus podsol profiles appear in the beech forests owing to the extremely high annual rainfall. South of this area mull formation is found down to a pH of 4.5, due to the considerably milder climate and other causes.

The propagation of the beech-forest. In a number of quadrats (10 m on a side) the number of 2—15-year-old beech seedlings, the light intensity and the production of nitrate were determined. It was apparent that the reproduction of the beech on mull soils is inversely proportional to the acidity of the humus layer. On the calcareous soils the re-growth of the beech seems to reach the maximum for the area, while on the soils lacking in lime (pH 4.5—5.0) it reproduces itself only with great difficulty. When the pH is less than 5.0 not even abundant nitrification can cause an annual growth



6. The regeneration of beech on mull soils. Curves showing the correlation between the acidity of soil and the frequency of 2—15 year-old beech-seedlings.

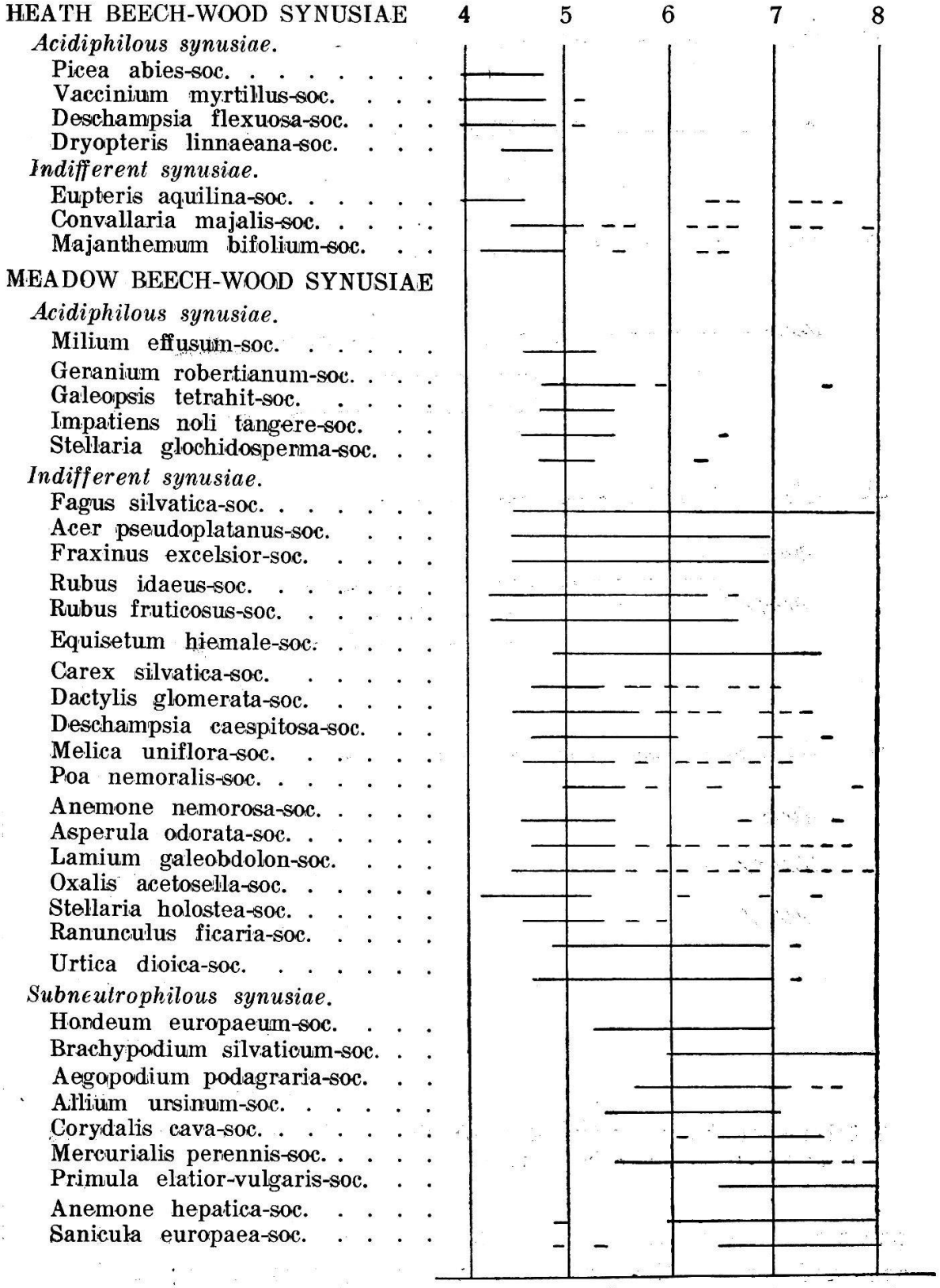
worth mentioning. When the pH is higher, however, a rich nitrification is accompanied by a greater number of plants. The curves given in this paper illustrate the variation in amount of reproduction corresponding to the various pH values in well-closed stands with 4—9 per cent light and under shelterwood stands with ground cultivation and up to 15 per cent light.

The sunysiae of the beech-forest. The list of synusiae of the beech-forest in Sweden (Fig. 5) attemps to illustrate the connection between the production of the field-layer synusiae and the pH values of the sites. The terminology of the synusiae is according to the new system of Du Rietz. This classification is based upon the connection between the distribution of the different synusiae in relation to the degree of acidity. The synusiae more closely associated with acid soils have a large extension within the area, whereas the others are rare and limited to beech-forests within the farming area of South Skåne. As a rule the Swedish beech forests lack a shrub layer. Only in a few forests strongly affected by the Atlantic climate *Rubus fruticosus* (coll.) is met with.

As to the question whether the beech forest in Sweden ought to be regarded as a natural unit the following may be said. The beech forest may be considered as the only consociation of one rather distinct association. It constitutes a natural unit well separated from all the other forest communities of Sweden. In this unit an admixture of other trees is extremely rare. The difference between the development of the field layer of the raw humus beech-forest and the mull beech-forest is striking as is seen from the lists. This same difference, a luxuriant field layer on the mull and a paucity of field-layer vegetation in the raw humus type, is found in all Swedish forests. Most of the species forming the field layer have a narrow acidity tolerance, while that of beech is wide. It follows that the field-layer spectrum changes as the acidity of the surface soil changes.

According to what has just been said about the reproduction of the beech, the succession on soils differing in nutrient content must be very various.

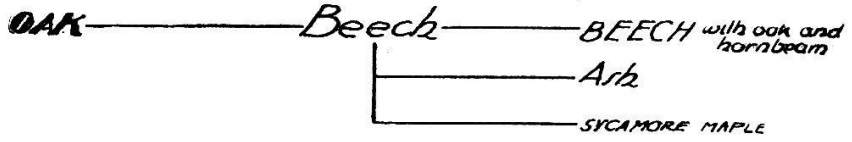
On neutral and subneutral soils in Sweden beech has always succeeded in immediately producing pure stands, generally at the ex-



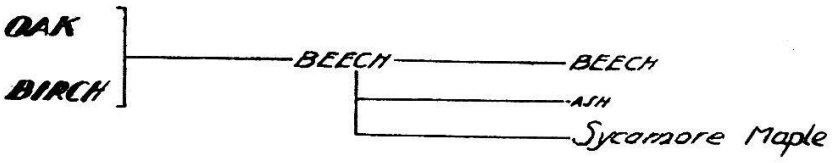
7. The synusiae of the field layer in the middle-aged and old types of South Swedish beech-forests and their relation to soil reaction. Main types.

1 On sub-neutral and alkaline mull soils.

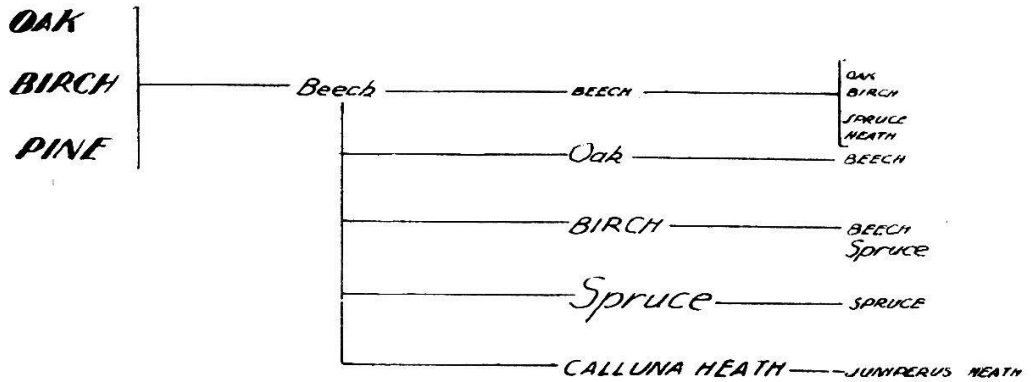
2. On acid mull soils on clay moraine



3. On acid mull soils on stony moraine



4 On brown soils and raw humus soils



8. Scheme of the succession of beech, the development of beech-forests from other types and their subsequent change.

pense of the oak forests. The beech forest regenerates well on these soils and seems to be capable of indefinitely perpetuating itself.

On acid soils on loam there is even nowadays a colonisation of beech in the oak forest. However, this does not mean that the beech

forest has not until now had the opportunity of colonising these forests. Rather it would appear that the colonisation effort met with such great competition that the effective penetration of the oak forests could not take place. When our modern culture removed the hazel-thicket of the forest the ground was dried up as a result of exposure to the wind. Additional drying resulted from the breaking up of the previously existing continuous forest cover, because soil of the isolated remnants is exposed to more and drier wind. In these forests the development towards beech-forest is more rapid, as the oak-forest in its changed condition seems very open to penetration by beech.

On the acid mull soils which have been formed on stony moraine the beech seems to have succeded oak and birch-forests. It reproduces itself with difficulty, the best reproduction being found where a certain percentage of loam is present in the moraine. These forests if let alone show a strong tendency to transform themselves into forests of the introduced sycamore *(Acer pseudoplatanus)*.

On soils of mår type and raw humus soils within the beech-spruce area the beech has principally succeeded pine, birch and oak forests. Not always do two generations of beech appear in succession. The beech-forest is often succeeded by birch, spruce-beech and oak forest, but when influenced by culture followed by spruce forest and heath. Thus heath areas appeared in West Sweden through devastation of beech-forests mainly during the sixteenth to eightteenth century. On account of the strong exposure to the wind and the rather bad soil it seems economically difficult nowadays to regenerate these heath areas.

Broadly speaking, up till now the spruce and heath areas have increased at the expense of the beech forest. Thus for the present it does not pay to cultivate beech-forests on the raw humus and mår soils. It can be surmised that the beech will in the future more and more quickly lose ground within the Swedish beech-spruce area — that is, outside the mull soil region.