Palaeovegetation Change in Eastern Scandinavia during the last 15,000 Years

Palaeovegetation Change in Eastern Scandinavia during the Last 15,000 Years[1)]

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Abstract

An explanation of the palaeovegetation change in Eastern Scandinavia during the last 15,000 years makes clear on the basis of a lot of paper and book by some botanists, geologists, bioecologists, and palaeobotanists, especially Fries, Berglund, and Påhlsson etc. Namely, in the explanation, the last 15,000 years are divided chronologically and palaeobotanically into five sections such as the Late Glacial, Preboreal and Boreal, Atlantic, Subboreal, and Subatlantic, and explained in detail concerning every period from the view points of palaeovegetation and palaeoclimate changes (Fries, 1965).

Finally, the human influence on the natural vegetation, and the palaeovegetation development (Påhlsson, 1977) in the southern part of Sweden are introduced respectively in this paper.

Introduction

In the early part of the 20th century, palynological investigation was considered to be only one of local biostratigraphic studies. However, the pollen-statistical method introduced by the great Lennart von Post turned out to be an extremely valuable complement to the investigations based on fossil macroplants and macroanimals. And, the investigation in the palaeontology during the last 15,000 years soon became more and more dependent on pollen analysis. However, the outline of the history on vegetation and climate during the late Quaternary in this region has been drawn on the basis of studies of macrofossils and macrostratigraphy (Fries, 1965). Interglacial deposits were discovered from Jämtland, Ångermanland, and Hälsingland in central Sweden (Lundqvist, G. 1964). The occurrence of an arctic flora composed of *Dryas*, *Betula nana*, *Salix polaris*, and *S. reticulata* from southernmost

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Sweden shortly after the retreat of the ice sheet was reported in 1871 by A. G. Nathorst. A period of warmer climatic condition than that of the present day was discovered, although there was some controversy concerning its character and duration (Andersson, G. 1909, 1910 ; Sernander, 1910). The course of immigration of the main forest trees became known through early studies on stratigraphy in Denmark to southernmost Sweden (Steenstrup, 1941). The results of these studies in the early stage on the history of vegetation and climate in Eastern Scandinavia were summarized by G. Andersson (1896, 1906, 1909, 1910) and Sernander (1895, 1899-1900, 1916).

In this paper, the present writer expresses an introduction on the palaeovegetational change in Eastern Scandinavia during the last about 15,000 years mainly from the view point of palynological investigation, on the basis of some publications by not only the scientists above -mentioned but also by later scientists such as M. Fries and B. Berglund, and comments on the change.

The introduction and comment of the palaeovegetation change described in this paper were surveyed during a stay at the Kvartärgeologiska Avderningen, Uppsala Universitet in Uppsala, Sweden under the Japan and Sweden Joint Project: "Reconstruction and Comparison of the Lost Earth Environment in Japan and Sweden during the Holocene" supported by the Japan Society for the Promotion of Science for two years 1978 to 1979, and also by the Royal Swedish Academy of Sciences in 1985. The present writer is greatly indebted to Prof. Lars-könig Königsson, Dr. I. Påhlsson and members of Kvartärgeologiska Avderningen, Uppsala Universitet, and also Dr. M. Fries, members of the Japan Society for the Promotion of Science and the Royal Swedish Academy of Sciences for their kindness.

1. The Late Clacial

For an account of the knowledge of the history on vegetation in the Late Glacial and Postglacial: Holocene in Eastern Scandinavia, it is necessary to consider several investigations in Sweden, Denmark and Norway etc. As southern Sweden was not yet separated from the Continent, for an understanding of the Late Glacial landscape of the southern Scadinavia, modern Danish studies are especially instructive (Iversen, 1954 ; Krog, 1954). The Late Glacial of Scania and other parts of the southern Scandinavia has been illustrated by T. Nilsson (1935), followed by later pollen-analytical studies (Mohrén, 1942 ; Erdtman, 1946, 1949 ; Donner, 1951 ; Fries, 1951 ; Terasmäe, 1951 ; Magnusson,1962; Berglund, 1963b).

The Scanian course of vegetational and climatic development follows the tripartite scheme[1)] known in Denmark since the famous studies of the biostratigraphy on the Late Glacial layers at Alleröd on Sjaelland (Hartz and Milthers, 1901).

1) : *Older Dryas* period : up to about 12,200 years B.P. ; with a climate and vegetation of slight arctic character ; *Alleröd* period : about 12,200 to 11,000 years B. P. ; subarctic probably even cool-temperate ; *Younger Dryas* period : about 11,000 to 10,000 years B. P.

2) : *Bölling* period was found in the *Older Dryas* period in Denmark and stated to have been of more subarctic than arctic character.

In the zone systems of pollen-stratigraphy, these three main periods of the Late Clacial are designated in chronological order as follows: I, II, and III (Danish system, K. Jessen, 1935, 1938) or DR 1, DR 2, AL, and DR 3 (Scanian system, T. Nilsson, 1961, 1964a).

The famous Bölling oscillation has not yet been recognized in Sweden, the only part of Sweden that began to appear from the ice sheet at this early period.

The climatically ameliorational condition within the Alleröd period is characterized in Skånia by an increase of the *Betula* pollen proportion and a corresponding decrease of the non-arboreal pollen proportion, and also by the occurrence of pollen of some temperate plants such as *Typha latifolia*, which nowadays does not reach much north of the *Quercus* border except locally in the southern areas of Finland and along the Bothnian coasts.

To what extent the climatically ameliorational condition brought a vegetational change towards temperate conditions also to the ice-free area as far north as the Central Swedish Moraines is not known yet. However, a colder climate and a flora of more arctic or subarctic feature than in Scania was reported (Mohrén, 1942). Recent investigations of the deglaciation in southern east Scandinavia have shown that this partly more raised area was periodically rich in extensive ice-dammed lakes during parts of the Alleröd period (Lundqvist, G. 1961), and by

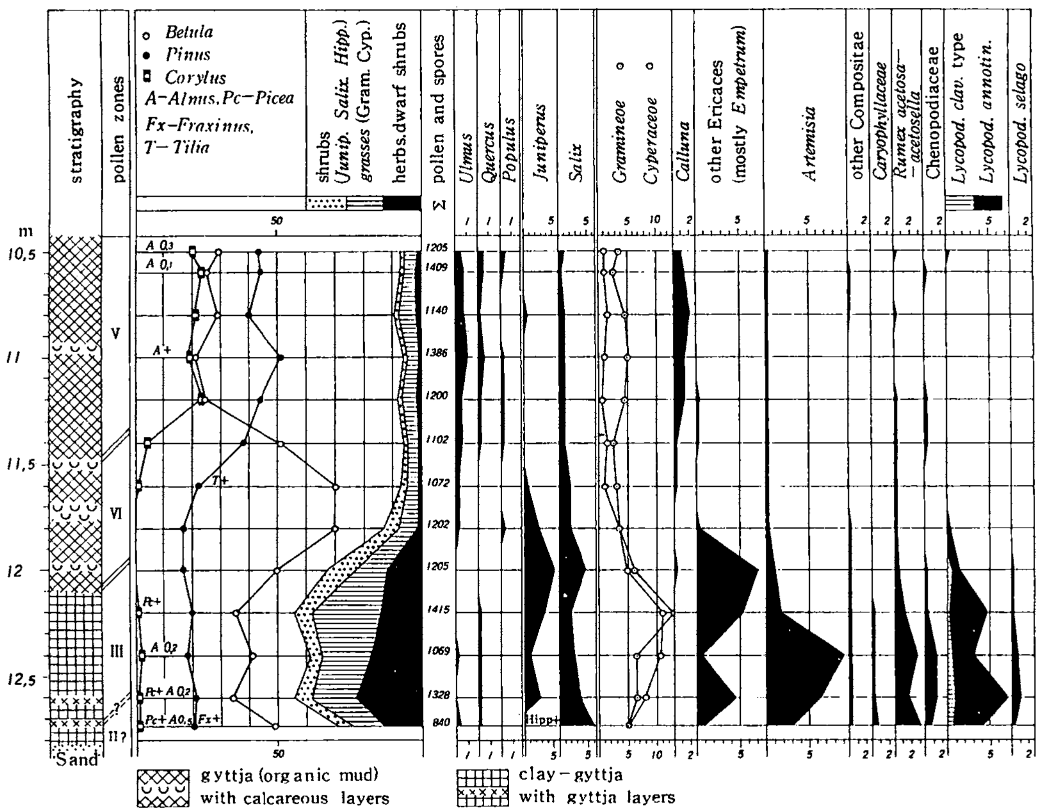

Fig. 1. A pollen diagram of the bottom sediments of the bog Åkhultsmyren (225 ms.m.), Aneboda and Moheda parishes in the center of the South-Swedish province of Småland (After Fries, M., 1965).

this reason they probably had a lowering influence on the summer temperature in their surroundings.

Pollen analytical investigations in Denmark and southern Sweden have shown that there was not only an arctic and partly subarctic vegetation, but also a continental or steppe one during the Late Glacial. Pollen grains of *Artemisia* spp., *Centaurea cyanus*, *Helianthemum* spp., *Delpinium consolida*, Chenopodiaceae, *Ephedra* and others have been found in the Late Glacial of the southern Scandinavia (Erdtman, 1946, 1949 ; Iversen 1947, 1951, 1954 ; Terasmäe 1951 ; Magnusson 1962).

Although the landscape of eastern Scandinavia is not yet so clearly discernible as that in Denmark (Iversen, 1947, 1954), it is obvious that the landscape was open. Only locally, especially during the Alleröd period in the southeastern part of Scandinavia, there were distributed low *Betula* groves and scrub of *Salix*, *Juniperus*, and *Hippophaë*. The *Betula* was confined to edaphically and climatically favourable places such as areas along streams and rivulets, in ravines and on wind-protected south slopes. Low *Pinus* were scattered here and there during the later part of the Late Glacial (Iversen, 1954). And also, low shrubs and dwarf shrubs such as *Juniperus*, *Betula nana*, *Dryas* and *Empetrum*, herbs, grasses and *Lycopodium* spp. formed the field-layer communities.

In Eastern Scandinavia, the fossil plants belonging to the arctic or tundra type are restricted to the southern fourth of the district, that is, mainly south of the Central-Swedish Moraines formed in the Younger Dryas period. The lacking of fossils between this area and the Scandes, where Scandinavian mountains exist and many plants of the Late Glacial tundra are growing now, is considered more evidence for a different origin of arctic-alpine type plants in the mountain flora than that for immigration from the southern area.

On the basis of the present distribution of the western arctic and high mountain species which are found in the Alps, biogeographers regard some restricted areas in the Norwegian west and north coasts, where these species and other arctic and alpine species have survived the latest glaciation (Fries, 1965). However, many geologic data have been presented that are regarded incompatible with the theory of glacial relict. The origin of the mountain flora of the Scandinavian mountains is still under discussion.

2. Preboreal and Boreal periods : the early stage of the Postglacial

The most weight change of vegetation on land during the Preboreal and Boreal periods after the retreat of the Scandinavian ice sheet may be the invasion of forest. The tundra just before the Preboreal was rapidly occupied by trees and grasses to form fresh communities. In various areas, the land was little by little covered by raw humus or peat in moist places. The edaphic environment became more and more unfavourable for plants, which require open mineral soil and much light. This rapid change of condition initiated about 10,000 years ago in Skåne (T. Nilsson, 1964a), and defines the beginning of the Holocene (Fuji, *et al.*, 1980). The palaeoclimatic change from the arctic-subarctic condition in the Younger Dryas to the temperate one during the early Preboreal, although that change was limited only near the ice-border and the lakes dammed up by the ice sheet (Fries, 1965).

The radical retreat of the ice sheet from the Central-Swedish Moraines northward during the Preboreal period indicates a remarkable climatic amelioration. On the basis of this climatic change, the forest is considered to have followed close to the margin of the retreating ice sheet, and prevented the arctic-subarctic plants of the Late Clacial from moving northwards. However, this assumption, although plausible in itself, is not yet supported by any valid palaeontological evidence such as pollen analysis and/or detailed studies of the Preboreal deposits in the area between the Central-Swedish Moraines and the mountains.

In the pioneer forest of the Preboreal period, *Betula* was the predominant tree. Many pollen analyses indicate the existence of pure *Betula* forests during the middle part of the Preboreal period (pollen zone IV in the Danish system). Although the identification as to species of *Betula* pollen on the basis of size measurements is difficult or sometimes doubtful, it is most likely that *Betula pubescens* sens. lat. formed the pioneer *Betula* forest. Minor constituents in this forest were *Populus tremula* and later on *Pinus silvestris*. The *Betula* forest perhaps offered resistance to the immigration of *Pinus silvestris*.

In the early Preboreal period, the amount of non-arboreal pollen is still significant. Treeless patches obviously with bare mineral soil enabled some of the heliophilous herbs, dwarf shrubs, and grassess in the Late Glacial to thrive in the new environmental condition.

The map of Fig. 2 is intended to show the ice sheet margin at about 9,500 years ago based on the varved clay chronology and the corresponding forest situation (Frie, 1965). In the north of Skåne, the *Betula* forest from the Preboreal period prevailed still, although the landscape had just changed to the Boreal situation.

The next forest-forming tree was *Pinus silvestris*, which came obviously from the south and southeast, but may have had another later path of invasion from the northeast into Lappland of Scandinavia. At almost the same time, *Corylus svellana* appeared. It immigrated perhaps from the fertile soils of southerneast Scandinavia ; especially, in the southwestern part of Sweden it formed large woods. Evidently they were almost pure, only locally mixed with *Ulmus*, a type of wood which has no natural equivalent in Sweden at the present. *Pinus* certainly was the predominant tree on poor or very dry soils. However, in the north of the *Corylus*-thriving area of central and north Sweden, *Betula* forests were formed. This *Corylus-Pinus-Betula* dominnt period (pollen zone V in the Danish system) or the Oldest Boreal period lasted about 1,000 years in the south. According to radiocarbon datings (T. Nilsson, 1964a), it began as early as about 10,000 years B.P. in Skåne. It seems plausible to assume a northward retardation owing to the northward immigration of *Corylus*. In the absence of radiocarbon dating referable to the beginning of the *Corylus* pollen curve (pollen zone border IV/V in the Danish zone system) farther to the north, it is difficult to estimate the magnitude of this retardation. Anyhow, there was a delay of probably a few hundred years in the province of Dalsland and still more in the area north of the Vänern-Mälaren depression (Fries, 1965).

Table 1 : Schematic table showing the changes of vegetation, environment of Baltic Sea and the pollen zones since the Late Glacial age in Sweden.

Kilimatsked	Zon Jesson	Zon Nilsson	Vegetationsutvecklingens huvudpunkter	Östersjöns stadier	Arkeologi	Kronologi	B.P.
					Historisktid	1950	0
Subatlantis-ktid	IX	SA 2 SA 1	Fortsatt klimarförämring Gran invandrar fran öster, bok fran söder	L i m a e a-havet	Järnalder	1000 A.D	1000
					Bronsalder	Kr.f. B.C.	2000
Subborealtid	VIII	SB 2 SB 1 SB 1	Pc* Kallare, Potglaciala värmetiden slut. Trädgränsen i fiällen sjunker.	---- ---------	Neolitisktid	1000 2000	3000 4000
Atlantisk	VII	AT 2 AT 1	U* Postglaciala värmetidens-max. Ekblandskogen (QM) har sin största utbredning. QM och hassel (C) i Norrlands kustland. Högre tradgräns, järnek, mistel och murgröna	Littorina havet	Mesolitisk-tid	3000 4000 5000	5000 6000 7000
Borealtid	VI	BO 2	T* Varmare, QM expanderar			6000	8000
	V	BO 1	A* Torrt, varmt	Ancylussjon		7000	9000
Preborealtid	IV	PB	C* Varmare, trädgräns norrut.	Yoldiahavet		8000	10000
Yngre Dryas	III	DR III	Kallare, Tundra	Baltiska issjön		9000	11000
Alleröd	II	AL	Klimatförbättring				
Äldre Dryas	Ic	DR II	Tundra			10000	12000
Bölling	Ib	Bö	Nagot mildare			11000	13000
Äldsta Dryas	Ia	DR I	Tundra			12000	14000

3. The Atlantic period : the middle stage of the Postglacial

The immigration of *Alnus glutinosa* about 8,800 to 8,600 years ago (T. Nilsson, 1964a) and even more thermophilous trees like *Ulmus glabra* and *U. scabra*, *Quercus robur*, *Tilia cordata*, *Fraxinus excelsior*, and *Acer platanoides* implied a considerable change of the vegetational landscape. The beginning of this process, with less *Tilia* and *Fraxinus* than later, is ften assigned to the Boreal and may be called the Younger Boreal period (pollen zone IV in the Danish system or BO 2 in the Scanian pollen zone system).

These thermophilous trees met possibly some resistance of the dense Boreal *Corylus* forest (B. Lindquist, 1938). They, therefore, were perhaps not able to keep pace with the rapid climatic amelioration. However, between 8,800 and 8,200 years ago the *Alnus* and the other broadleaved thermophilous trees occupied most of Skåne and with some retardation the rest of Southeastern Scandinavia.

The change of the forest composition as above-mentioned was the vegetational response to the beginning of a period of climatically favourable conditions as the Holocene warm period. It seems to have lasted about 8,500 years B.P. in the southern area, and about 8,800 years B.P. in Skåne (T. Nilsson, 1964a), but less in the northern area, and culminated about 6,500 years B.P. It may have taken more than one thousand years before the whole assembly of thermophilous trees got a permanent foothold in South-Central Sweden north of the Vänern-Mälalaren depression, which to a great extent still was below sea level. With the aid of radiocarbon datings of pollen analyzed lake sediment marking the isolation from the sea, S. Florin (1961, 1944) estimated the *Tilia* pollen curve to begin at about 7,500 years B.P. in Södermanland located south of the present Lake Mälaren.

The gradual opening of the English Channel and the submergence of the North Sea banks were probably of importance for giving the climate in southern Scandinavia a more humid character than that in the beginning of the Holocene. Comparatively high temperature and humidity were assumed to have been characteristic of the Atlantic period in early works by Blytt (1876a, 1876b, 1881). The Atlantic period is designated as zone VII in the Danish zone system and At 1-2 in the Scanian pollen zone system.

There are several observations indicating that during the warm period the thermophilous trees and their accompanying flora were more common and occurred farther to the north than they do today.

Fossils nuts and pollen grains of *Corylus avellana* found considerably farther to the north and northwest (E. Prttersson, 1956) made it possible to estimate the difference in summer temperature between the Holocene warm period and today. This difference has been estimated as 2.4℃ (Fries, 1965).

Trapa natans is one of a symbol of the Holocene warm period. It obviously spread rather rapidly to a great many lakes as far north as the Vänern-Mälaren depression and even somewhat north of this area (Fries, 1951). Its immigration to Southwestern Scandinavia seems to have coincided with the invasion of *Alnus glutinosa* at that time. It disappeared from most of the shallow lakes, where the nuts are now found in the bottom deposits, at the time of the climatic deterioration about 3,000 years ago, if not earlier because of the filling-in of the lakes by sediments.

Several finds of stems and stumps of *Pinus silvestris* above the present timberline in the mountains indicate a more favourable climate also in this area, even when the influence of the later land uplift is taken into consideration (G. Lundqvist, 1959b). Radiocarbon dating of the stumps coincide with the beginning and the middle part of the warm period (G. Lundqvist, 1959b). The lack of stumps dated to the later third of this period in the Southeastern Scandinavia shows that the climatic deterioration had a negative effect on the comparatively thermophilous vegetation earlier here than farther south.

On the basis of the pollen spectra hitherto published, it is hard to know more exactly to what extent Sweden during the warm period was covered by forests of the broadleaved thermophilous trees, and how far to the north they reached. The actual composition of the forests is difficult to imagine on the basis of pollen diagrams. Most of Skåne and a few other similar areas was occupied by these trees. In the rest of Southeastern Scandinavia (up to about 60° N in latitude) they probably covered over 50 per cent of the land. In the coastal areas of Norrland and locally in the inland they obviously formed scattered stands, as was also the case with *Corylus* at the same time. The present isolated occurrences of *Ulmus glabra* and *U. montana* not far from the mountains are certainly relics from the warm period and have originated from west of the mountain chain in coastal Norway (Andersson and Birger, 1912).

As to the composition of the deciduous forests it is customary in Europen pollen analysis to speak about mixed oak forest "Quercetum mixtum", constituted by *Ulmus*, *Quercus*, *Fraxinus*, *Tilia*, and *Acer*. To a certain extent it may be reasonable to do so. Judging from studies of deciduous forests at the present as Dalby Söderskog in Skåne, it is probable that there was a tendency towards stands of only one or two species, according to the age of the stands, conditions of light and soil, browsing by wild animals, fire etc.

The figures in Fig. 2 for the forest landscape during the optimum of the warm period, the Atlantic period is not complete without adding a few further comments. (a) The relatively high amount of *Alnus* pollen reflects the abundance of *Alnus* forests in fens and on badly drained clay plains. The *Alnus* woods formed a significant element of the landscape, in particular before the period of clearing by man. (b) In areas of dry or shallow soil, the pine certainly still played an important role. The pine woods naturally increased towards the north. (c) In Southeastern Scandinavia, the *Betula* was more restricted and probably grew more locally than before. However, the pollen diagrams from the northern two thirds of Sweden, show generally in their lower or middle part a dominance of *Betula* pollen, a regional phenomenon contemporaneous with the maximum of *Ulmus-Quercus-Fraxinus-Tilia* pollen in the Holocene warm period of Southeastern Scandinavia ("regional parallelism" by von Post, 1944). Before the immigration of *Picea*, *Betula* could obviously compete successfully with *Pinus* on moist or fertile soils of the north. *Betula* in question was here most likely predominantly *Betula pubescens*, which easily regenerates vegetatively from the stump or stem base.

In the primeval forests in the climatic optimum period, there was little chance for light-demanding plants to grow. They may have found refuge in temporary openings produced by wind or fire in pine forests, on permanently open soil along the shores of the sea, lakes, and streams, locally in ravines or bluffs, and in rocky areas. On the *alvar* of the Öland and Gotland, i.e. calcareous bedrock with no or only an extremely shallow soil layer, an open ground flora with elements of the Late Glacial managed to survive, even if this area was less open before the grazing of domestic animals began.

Not until man began to cut clearings in the forests in order to get pasture land for his cattle did the heliophilous flora of herbs, grasses, and dwarf-shrubs get renewed chances to expand. In the Subboreal and early Subatlantic periods, these open or partially open areas were confined to Southeast Scandinavia and certainly were very small, but in the later stage, they enlarged greatly, especially after the use of iron tools to cut trees, branches, and grasses.

It is perhaps more likely that many herbs and grasses immigrated or reimmigrated with incipient agriculture, additional species arriving mainly from the southeastern and southern areas to Eastern Scandinavia. At this early time, dispersal may have occurred to some extent through human activity, intentionally or accidentally.

In the period of undisturbed forest cover, a regional zonation of the forests and other vegetation types was established as shown in the map D in Fig. 2. However, these regions later changed their geographical position as a result of changes due to climate at the later stage but also because of the land uplift, a decrease in soil and freshwater fertility, and the invasion of

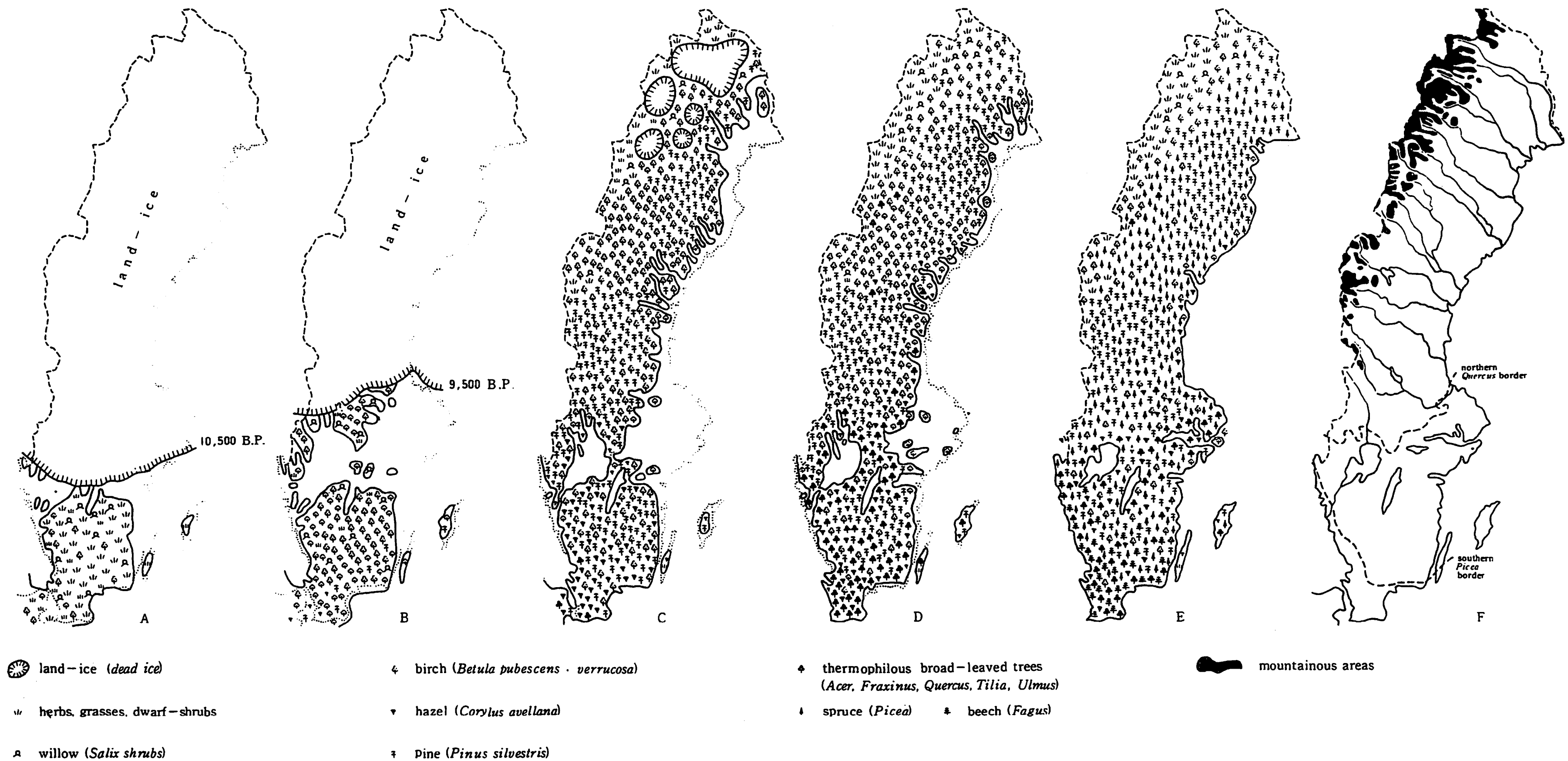

Fig. 2. Maps showing the composition of the main vegetation of Sweden during five Late-glacial and Post-glacial stages, viz. A : the end of Younger Dryas (pollen zone III) ; B : Preboreal (zone IV), in the southernmost part of the beginning of Boreal ; C : Boreal, older part (zone V) ; D : Atlantic, i.e. the climatic optimum (zone VII), and E : Subatlantic, the end of the Roman Iron Age, i.e. before the extensive clearings of the Late Iron Age (After Fries, M., 1965).

a few new tree species and the competition caused by them.

4. Subboreal period : the later part of the Postglacial

This period was the final part of the Holocene warm period, and forms a sort of transition between the preceding Atlantic and the following Subatlantic period. It is characterized by certain climatic and vegetational changes, which forebodes the Subatlantic situation. In the Danish pollen zone system, the Subboreal is designated as zone VII, in the Scanian system as SB 1-2.

The climatic deterioration that followed the warm period and influenced the vegetation was regarded by Sernander (1908,1910), and others as a single abrupt event, almost of catastrophic character, happening in the middle of the first millenium B.C. in Southeastern Scandinavia. According to G. Andersson (1909, 1910), this period assumed a gradual deterioration after the climatic optimum in the Atlantic period. It is most likely, however, that the change to a cooler and moister climate happened during a period of two or three thousand years, probably starting as early as about 5,000 years B.P. Judging from modern interpretation of detailed pollen diagrams, the vegetational change at about 5,000 years B.P. in Southeastern Scandinavia is a result of both climatic and cultural influences, which are difficult to separate. Discussion whether a special *Ulmus* decline in the pollen diagrams from the South and West Scandinavian regions, at about 5,000 yeras ago, was caused by climatic or cultural influence or both, has to be continued (Fries, 1965).

5. Subatlantic period : the last part of the Postglacial

The immigration of new forest trees as *Picea abies* from the northeast and *Fagus silvatica* and as *Carpinus betulas* from the south, gave the forests of Eastern Scandinavia a new face, coinciding with a southward displacement of the regions as a result of climatic deterioration as shown the map E in Fig. 2. Although the immigration started earlier, these events were completed in the middle of the first millenium B. C. in most areas of Eastern Scandinavia. So the forest regions of the present-day were established, that is, from south to north (disregarding the subalpine birch belt) : (a) deciduous tree forest region with *Fagus*, (b) conifer forest region together with thermophilous deciduous trees (partly except *Fagus silvatica)*, and (c) conifer forest region, mainly without thermophilous deciduous trees (Du Rietz, 1925c, 1964 ; Fries, 1965).

The chronology of the immigration of *Picea* is still rather uncertain, though it has been a subject of many studies since the last century such as Sernander's investigation : "*Die Einwanderung der Fiethte in Scandinavien*" in 1892. An absolute date, about 3,000 years ago, for the *Picea* invasion into a central coastal part of Northeasten Scandinavia was obtained through pollen-analytical investigations of geochronológically dated varves clay (Fromm, 1938). Some radiocarbon datings of the marked increse of the *Picea* pollen curve in the Northesatern Scandinavian sediments verify this date, other do not (G. Lundqvist, 1957, 1963b). Within rather limited regions, the dates differ considerably. This index level, however, shows a tendency to transgress in time towards earlier dates from Southeastern-Eastern Central

Scandinavia southwards (von Post, 1924 ; Fries, 1965 ; J. Lundqvist, 1957 ; G. Lundqvist, 1957). Certainly one should always be cautious when using the increase of the *Picea* pollen curve as an index. The invasion of *Picea* and its chronology ought to be the subject of further, more special studies by means of pollen analysis and determinations by rediocarbon.

In Northeastern Scandinavia, *Picea* invaded mainly into the *Betula* forests of the warm period. Wide areas of the Northeastern Scandinavian forests were fundamentally changed during a short time.

Some pollen diagrams from different parts of Sweden show remarkable occurrences of *Picea* pollen, even values of about 20% and more (G. Lundqvist, 1929 ; S. Florin, 1944), as early as in the late Atlantic and Subboreal periods (pollen zone VII and VIII respectively). All of them can hardly be interpreted as the result of transportation from great distance. There are also a few archaeological evidences of *Picea* before the Iron Age (S. Lindqvist, 1916). These early occurrences, perhaps infrequent and very restricted, may have been important for their rapid spread over most of Sweden, when the climate became more suitable for *Picea*.

The immigration of *Fagus* and *Carpinus*, which covered a comparatively small area of Southeastern Scandinavia, is known well (T. Nilsson, 1964a). However, it is still an unsolved problem whether or not these trees, which seem to have accompanied each other fairly well, ever reached as far north as the provinces around Lake Mälaren. Low but not extremely low amounts of *Fagus* and *Carpinus* in pollen diagram from this area may indicate that this was the case (Fries, 1965). Scattured pollen grains have been found even farther north. Anyhow, it is quite clear that the distribution of *Fagus* and *Carpinus* has been diminished during the last ten or fifteen hundred years, a process which to some degree may be a result of climatic change but is largely caused by human interference (B. Lindquist, 1931).

Judging from the circumstances mentioned-above, the last part of the Postglacial period, the Subatlantic period (pollen zone IX in the Danish system, and SA 1-2 in the Scanian system) is characterized pollen-analytically by the occurrence of *Picea, Fagus,* and *Carpinus* and other events, caused by a series of complicated climatic changes in a cooler and moister direction. Clearly, these changes that ended the Postglacial warm period interfered more seriously with the thermophilous flora in the northeastern areas of Scandinavia. We, therefore, may assume that the zone border VIII/XI transgresses in time from north to south.

6. The human influence

The influence of man on the vegetation was exceedingly small in preagricultural time. The following Neolithic and Bronze Ages cultures were restricted to certain areas in Southeastern Scandinavia, separated by wide tracts of untouched forests. This situation prevailed in fact far into the Iron Age, in some parts into the Medieval and even Modern Age.

It is still a matter of discussion to what extent the climatic deterioration that occurred about 2,500 years B.P., i. e. the transition between the Bronze and Iron Ages, influenced the settlement that was dependent on agriculture and animal husbandry (Stenberger, 1962 ; Fries, 1965). In this connection, it may be emphasized that there were other climatic changes, both earlier and later, though probably not so severe as this one. In certain regions, however, they may have had even more influence.

Several palynological investigations in Southeastern Scandinavia show that the landscape with vestiges of Neolithic and Bronze Age cultures was increasingly utilized by man during the Iron Age up to about 1,000 A.D. in Sweden, and still more during the Medieval and Modern Ages. In the districts with ancient agriculture and animal husbandry, the frequency of pollen from cereals, weeds, and pasture plants increase in the sediment or peat layers formed in these periods M-B. Florin, 1957b ; Fries, 1965 ; S. Florin, 1961 ; T. Nilsson, 1961, 1964a). Districts into which agriculture spread comparatively late have only rarely been investigated with a detailed pollen analysis-technique that takes the effects of culture fully into consideration.

Investigations about seeds, fruits, and comparable remains of prehistoric sites and agriculture are a rich source of information (Fries, 1965).

The method of palynology is generally not exact enough to analyze palaeovegetational development during the most recent centuries. Also, the method of radiocarbon-dating gives results too unsure for that time. Sources written that can be applicable to these investigations occur from the Medieval Age, though little is left from the early part.

Studies about the development of the vegetational landscape based on archival records, have been carried out for some areas of Southeastern Scandinavia and to a small extent the Central part of Eastern Scandinavia by G. Weimarck (1953), Sjörs (1954), and Fries (1965).

Some information about former vegetation, especially the distribution of forest or particular kinds of trees, may be obtained from old place names (B. Lindquist, 1931 ; Atlestam, 1942 ; Fries, 1958a).

The profound changes of the cultural landscape in the latest century have largely been brought about by a shift in aims and methods rural economy.

7. Summary in the Southern Sweden

The palaeovegetation development in the southern part of Eastern Scandinavia since about 15,000 years ago has been summarized as a following section (Fries, 1965 ; Påhlsson, 1977).

(1) Alleröd period : Zone II in the Danish pollen zone system

Rather high values of the arboreal pollen grains and consequently low values of the non arboreal pollen grains (NAP). *Betula* dominates over *Pinus* in the early stage of this period, and *Pinus* over *Betula* in the later stage. *Salix* and *Juglans* are common throughout the period. Among herbs, Gramineae, Chenopodiaceae, Cyperaceae, and *Artemisia* are predominant, being lower values towards the late stage (Påhlsson, 1977).

(2) Younger Dryas : Zone III

The values of NAP are high ; Gramineae, Cyperaceae, Chenopodiaceae, and *Artemisia* are predominant. The values of *Pinus* exceed those of *Betula*. The frequencies of *Salix* are still rather high, but lower than those in the Younger Dryas. *Juniperus* is predominant in the late stage of the period. The lower boundary of the Younger Dryas period has been settled at the distinct rise of the NAP curve (Påhlsson, 1977).

Table 2 : Chronosubdivision of the period since the Late Glacial age in Sweden, and main characteristics in every pollen zone.

Age	Chronozone	Pollen zone	Characteristics	Definition of boundary
Holocene (Postglacial)	Subatlantic	IX	immigration of *Picea*	yrs.B.P.
				2,500
	Subboreal	VIII	decrease of *Ulmus*	
				5,000
	Atlantic	VII	immigration of *Tilia*	
				8,000
	Late Boreal	VI	immigration of *Alnus*	
				8,500
	Early Boreal	V	immigration of *Corylus*	
				9,000
	Preboreal	IV (a, b, c)	decrease of NAP	
				10,000
Pleistocene (Late Glacial)	Younger Dryas	III	increase of NAP	
				11,000
	Alleröd	II		

(3) Preboreal period : Zone IV

The Preboreal period is divided into three subperiods as IVa, IVb, and IVc. Subperiod IVa is characterized by high values of *Pinus* and NAP. *Juniperus* is common, but *Hippophaë* is represented by scattered finds only. The values of Cyperaceae and *Artemisia* are rather high.

Subperiod IVb is characterized by high values of *Betula*, *Juniperus* and *Hippophaë*. *Empetrum* is common. The frequencies of NAP decrease gradually.

Subperiod IVc is characterized by a distinct increase of *Pinus*, and by decrease of *Betula*. The frequencies of NAP decrease still (Påhlsson, 1977).

The boundary between the Younger Dryas and Preboreal periods has been fixed at the time, when the NAP curve, especially the *Artemisia* curve, distinctly decreases and, therefore, the AP (arboreal pollen grains) values increase.

(4) Early Boreal period : Zone V

Pinus increases, and reaches a culmination in the middle stage of this period, after which the curve decreases towards the late stage. *Betula* decreases generally throughout the period. *Salix* and *Juniperus* decline towards a minimum in the middle stage of the period ; the curves display new maxima around the late stage limit. The curve of *Populus* is high in the former half of the period, but then decreases distinctly. *Corylus* increases markedly and culminates

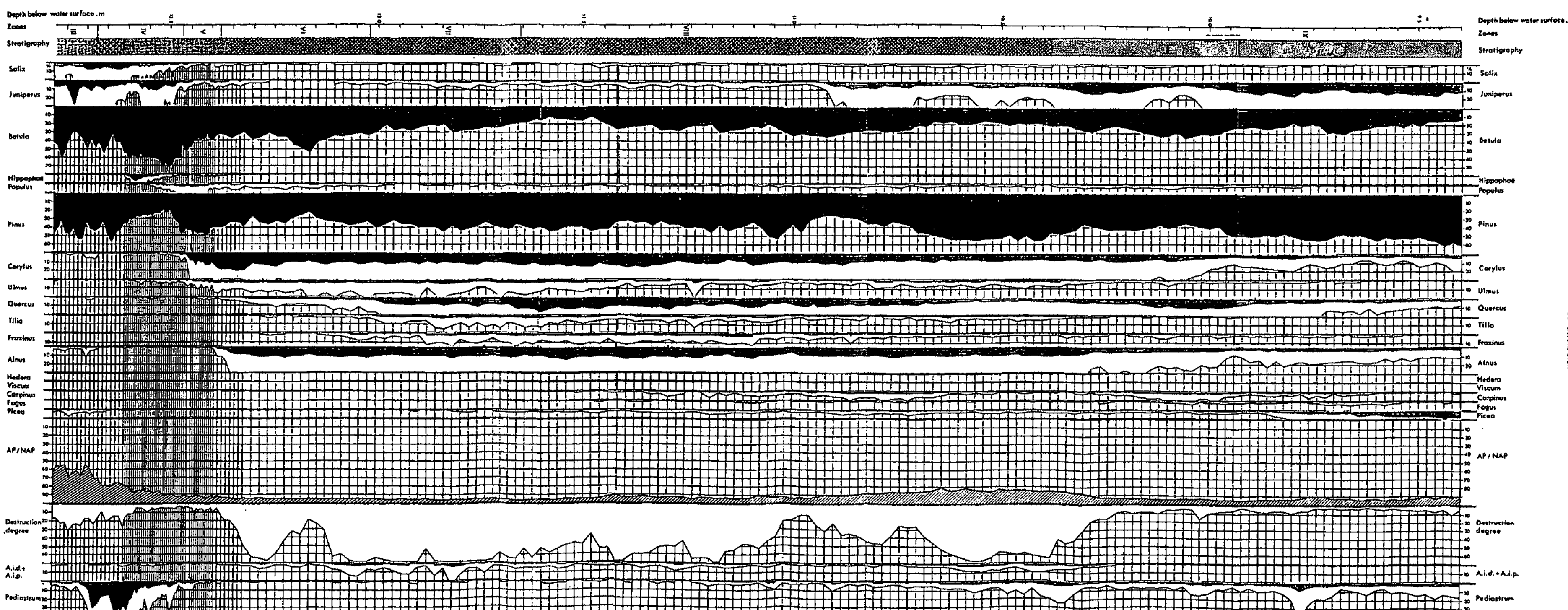

Fig. 3. Pollen diagram from the Lojsta area of Central Gotland, Sweden (After Påhlsson, 1977).

towards the end of the period. *Ulmus* is present in low frequencies at the beginning, a rise of the curve occurs in the middle stage and the rational limit is reached contemporaneously with the empirical limit of *Alnus* falls just before the Late Boreal period. The frequencies of NAP are declining; appreciable amounts of *Artemisia*, *Filipendula*, *Calluna*, *Empetrum*, *Rumex acetosella*, and *Lastrea dryopteris* have been recorded (Påhlsson, 1977).

The boundary between the Preboreal and Early Boreal periods has been fixed at the empiric limit of *Corylus*.

(5) Late Boreal period : Zone VI

Betula and *Pinus* are predominant throughout this period. *Pinus* decrease gradually and the representation of *Betula* is slightly unchanged, but increases gradually towards the end of this period, contemporaneously with a *Pinus*'s decrease. *Corylus* culminates in the early stage of the period, after which a distinct decline occurs. The values of "Quercetum mixtum" gradually increase. *Ulmus* is the most important genus in the early stage of this period. The rational limit of *Quercus* is found around the middle stage, before which *Quercus* is only found in low values. *Fraxinus*, *Tilia*, *Hedera*, and *Acer* are present in low frequencies. *Alnus* increases gradually and has a small culmination in the late stage of this period. *Juniperus* and *Populus* have maxima around the early stage, and thereafter decrease gradually. *Salix* and *Hippophaë* are represented by very low values, the latter only from the earliest stage. The NAP values are low and gradually decrease towards the later stage (Påhlsson, 1977).

The empirical limit of *Alnus*, which coincides with the rational limit, has been fixed as the boundary between the Late Boreal and Early Boreal periods.

(6) Atlantic period : Zone VII

Pinus is predominant throughout the period, a certain increase of the curve occurs in the late stage. The frequencies of *Betula* decrease slowly but distinctly towards the latest stage. *Corylus* and *Alnus* are unchanged usually. Among the "Quercetum mixtum" constituents, *Ulmus* and *Quercus* occur in the same values in the former half of the period. *Tilia* is found in very low values; the curve has an increase contemporaneous with the further increase of *Quercus*. At about the same level, the rational limit of *Fraxinus* is found. *Salix* and *Populus* are found in low values. *Juniperus* has a secondary maximum in the late stage. The NAP frequensies are low (Påhlsson, 1977).

The lower boundary has been settled at the time in the pollen diagram when the *Tilia* curve becomes continuous, and is very indistinctly developed and the delimitation of the period is thus rather uncertain. A certain delay in the immigration of *Tilia* cannot be excluded.

(7) Subboreal period : Zone VIII

Pinus predominates in the earlier and later stages of this period. After a pronounced minimum at the beginning, the frequencies of *Betula* increase distinctly, and its curve culminates in the middle stage. After a small culmination in the earliest stage, *Corylus* decreases. *Alnus* is unchanged on Comparison with the Atlantic period. The frequencies of "Quercetum mixtum" decrease slowly. *Quercus* becomes the most important genus among the genera of "Quercetum mixtum". *Ulmus* has a low, secondary culmination in the middle stage. *Frax-*

inus has its greatest distribution during the Postglacial in the former half of the period. *Carpinus* increases and has a culmination in the middle stage. *Picea* and *Fagus* record in very low values. *Juniperus* increases towards the late stage from the middle stage, together with a smaller increase of *Populus*. The NAP curve increases gradually. *Plantago lanceolata* is found from the beginning of this period (Påhlsson, 1977).

The lower boundary has been settled at the beginning of the decrease of the *Ulmus* curve.

(8) Subatlantic period: Zone IX

Pinus is predominant distinclty, especially in the late stage. *Betula* decreases from a culmination in the early stage. *Corylus* and *Alnus* decrease markedly. *Ulmus*, *Tilia*, and *Fraxinus* are further restricted in occurrence, and are represented by very low frequencies towards the end of the period. *Carpinus* shows lower values. *Fagus* is found in low frequencies, and its curve is indistinctly developed. *Picea* spreads in the later stage. *Juniperus* becomes more common than in the Subboreal period. *Populus* is found in decreasing values. Anthropochors and apophytes are more common, especially *Secale* (Påhlsson, 1977).

The delimitation of the beginning of this period is problematic and is, therefore, only tentative. Concerning the immigration of *Picea* into the central part of Eastern Scandinavia, it seems that there was a certain delay.

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