On the Palaeo-ecology of the Hamptjärn Basin
I. Pollenstratigraphy

By KIMMO TOLONEN

Department of Botany, University of Helsinki

1. INTRODUCTION

The flora of the Hamptjärn area is rich in species and has become an object of floristic excursions from the section of ecological botany at the University of Umeå founded in 1967. While staying as a fellow research docent at the department in 1969–1970 the author started his stratigraphic studies on the palaeo-ecological development of the basin. The evident traces of human influence upon the fossil pollen flora and the pollenstratigraphy on the whole seemed to offer good opportunities for dating the environmental development. The project EN consequently payed the costs of the radiocarbon measurements and the greater part of the chemical analyses of the sediments. Since many problems are common to the ecological part of the actual program within EN the present investigation is published in this connection.

The Hamptjärn area with Hamp tarn itself (ca. 1.7 ha) in the central part is situated about 7 kilometres north of Umeå, North Sweden (63°53′ N, 20°13′ E) at the edge of Tjälamark village, the pond itself lying at 64 metres above sea level and the surrounding mire complex reaching an altitude of 64–70 metres. The mire is surrounded by forested hills: the top of Hamptjärn hill to the SE rises to an elevation of 95 metres and that of the Tjälamark hill to the W almost reaches an altitude of 100 metres above sea level. The slopes and hollows of the hilly landscape have predominantly a soil composed of coarse gravel and sandy moraine, lower parts of moraine of fine sand or partly of sand. Only to the north an abandoned field of arable land lies close to the tarn. The bedrock material is granite. The annual rainfall is 500–600 mm, the mean annual temperature of the coldest month about −7°C and that of the warmest month about 15°C (from Ångström, 1958). The nearness to the Gulf of Bothnia brings about a local effect of maritime climate (op. cit., p. 31) which reveals itself in lower temperatures and less rainfall in summer in comparison with the normal conditions at this latitude in Sweden.

The prevailing forest types in the areas surrounding the mire basin are dry pine heath forests of the *Vaccinium* type, moist pine and spruce moss-forests of the *Myrtillus* type (the dominant type) and its variants. Types resembling grass-herb forests occur only sporadically at the foot of Hamptjärn hill near the tarn and below a slope from a nearby hill (*Oxalis acetosella, Geranium silvaticum, Filipendula ulmaria, Rhytidiadelphus triquetrus* etc.).

Prehistoric finds including dwelling sites are known here and there in the surroundings of Umeå, though not near Tjälamark village as yet, however (according to Västerbotten Museum's Archives). It must be kept in mind that no systematic excavations have been made so far. All information has been collected more or less sporadically. The oldest written source in "Jordha Boocken wthaaff Westhrabotnen", (printed in 1543) (Nordlander, 1905), mentions four houses in "Tielemar" village. Since then the name of the village is found in the literature and it can be mentioned that it was one of the few places in the area which escaped being burned by the enemy in 1719–20.

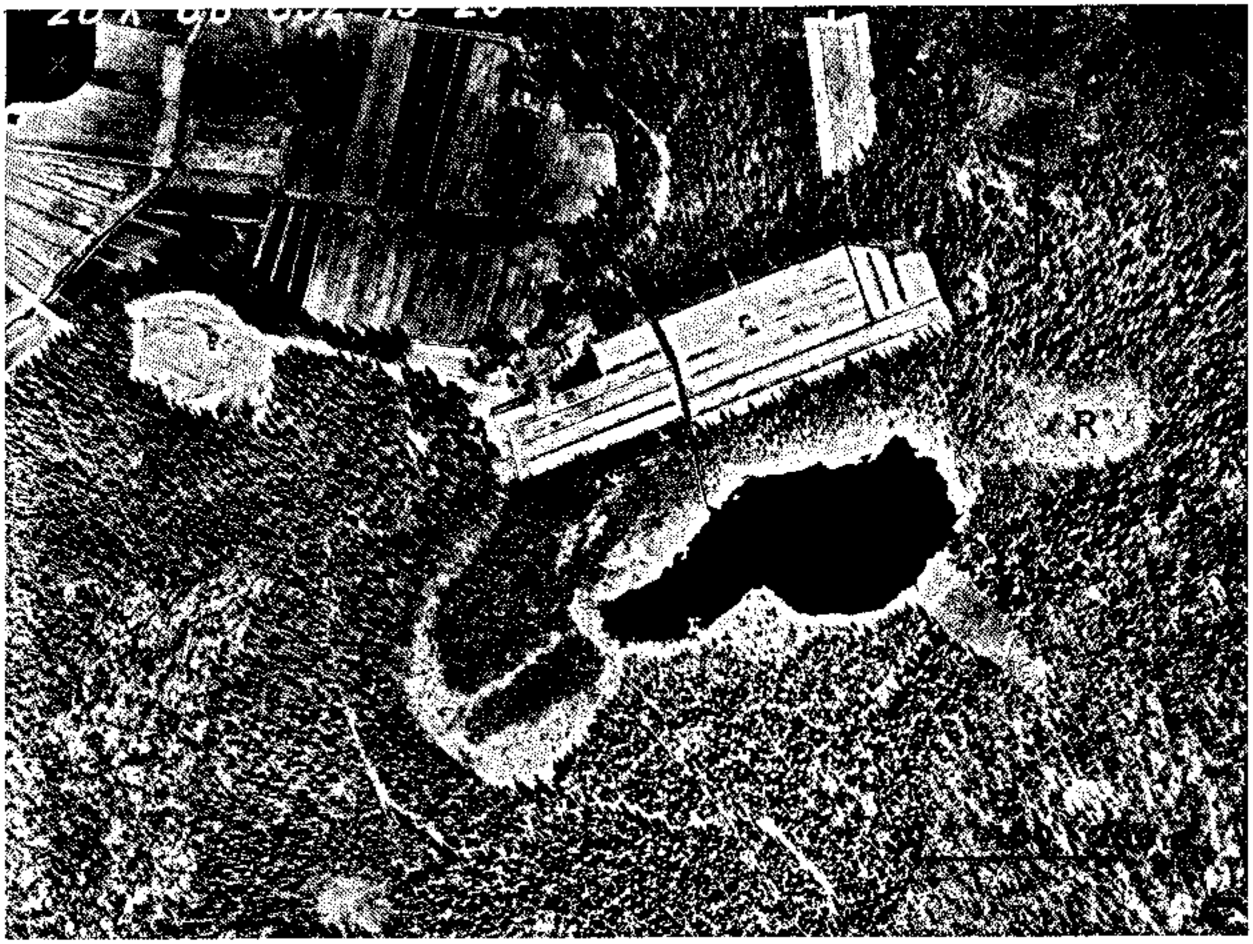


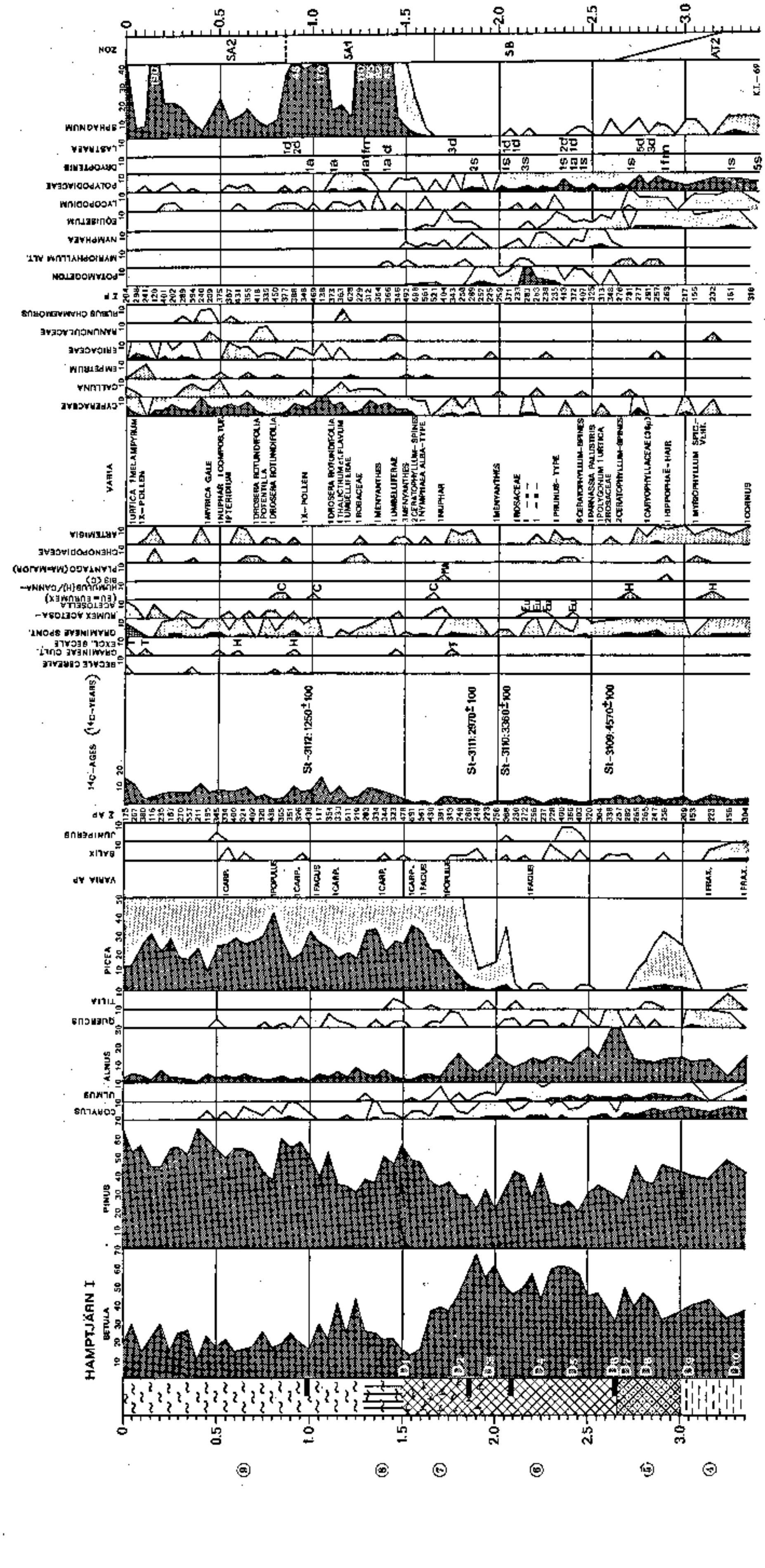
Fig. 1. Aerial photograph of the Hamptjärn area. A light marginal fen is clearly visible around the tarn, forming a narrow minerotrophic lagg against the mineral ground, in the western part of the basin. The western ombrotrophic *Sphagnum fuscum* pine bog (grey) is divided by fen soak a "dråg" of sedge mire vegetation (light). *R* = rich fen on the eastern side of the tarn. *I–IV* = the boring sites of profiles H I–H IV. (Photographed by Rikets Allmänna Kartverk 1968 and published by permission obtained from Rikets Allmänna Kartverk, 18.8.1970).

2. HYDROLOGY AND VEGETATION OF THE TARN AND MIRE

The tarn. There is no affluence to the tarn and only a tiny effluence at the north side of the lake. Because of a rather great quantity of spring water flowing down the tarn from the south which is unfrozen even in winter it may be looked upon as a spring lake. This supposition is confirmed by following measurements. Though the tarn is wholly surrounded by mires its water is only slightly brown (the colour value was 40 mg Pt/l on March 30, 1970 and the depth of visibility over 3.5 m on June 25, 1969). The water is nearly neutral (pH 7.1 on June 25, 1969), during the winter season the pH values alternate from 6.4 to 6.5 (measurements made on February 30, 1969 and on September 18, 1969, also on January 18, 1970 and on March 30, 1970). Conductivity, $\varkappa_{20}$ varied correspondingly from 60 microS (a summer result) to 80–100 microS (autumn and winter results). In the open spring on the southern side of the pond a pH value 7.4 was measured on June 25, 1969. On September 18, 1970 the values were as follows: pH 7.7 and $\varkappa_{20}$ 112 microS.

Some other results can be seen from the data in Table 1, the values being read from a water sample on January 18, 1970.

Total P	0.02	ppm
°dH	2.4	
$KMnO_4$-consumption	83	mg/l
HCO_3^-	42.7	ppm
Cl^-	1.5	ppm
Kjeldahl-N	0.5	ppm
K	0.5	ppm
Na	2.3	ppm


HAMPTJÄRN I
BETULA
PINUS
CORYLUS
ULMUS
ALNUS
QUERCUS
TILIA
PICEA
VARIA AP
SALIX
JUNIPERUS
14C-AGES (14C-YEARS)
St-3112: 1250±100
St-3111: 2970±100
St-3110: 3360±100
St-3109: 4570±100
SECALE CEREALE
CYPERACEAE
CALLUNA
EMPETRUM
ERICACEAE
RANUNCULACEAE
RUBUS CHAMAEMORUS
POTAMOGETON
NYMPHAEA
EQUISETUM
LYCOPODIUM
POLYPODIACEAE
DRYOPTERIS
LASTREA
SPHAGNUM
ZON
SA2
SA1
SB
AT2
K.T.-69

Ca		13	ppm
Sr	below	0.5	ppm
Fe	below	0.5	ppm

The amount of Ca 13 mg/l is rather high even if the winter value is compared with those found by Lohammar (1938, p. 129, 132, 133, 195) in North Sweden and it is of the same size class in the northern *Stratiotes* lakes in Norrbotten (Hedlin *et al.*, 1957; Hedlin & Tolonen, in prep.) and in Finnish Lapland (Kotilainen, 1956). The spring-like character of the water in the tarn may also appear in the O_2 values of Jonsson (1959). He found a sudden rise in the oxygen saturation from 30% up to 70% near the bottom of the tarn (at the surface 100% and at a depth of 1 m 92%).

The nymphaeid vegetation (*Nymphaea candida, Nuphar luteum,* and *Potamogeton natans*) is well developed in the whole of the tarn, especially flourishing is the layer of isoetids: *Chara globularis* (dominant), *Nitella opaca f. atrovirens* (pcc), *Scorpidium scorpioides* (cpp), *Calliergon megalophyllum, Drepanocladus* (several species), and *Fontinalis antipyretica* (pc). Furthermore *Calliergon giganteum* (cp) is growing in the spring water. Four species of elodeids have been found: *Utricularia minor, Sparganium minimum, Potamogeton pusillus* and *P. alpinus.* The helophytic vegetation is poor in species and fairly sparse, the most important are the following: *Phragmites communis* (pc), *Carex lasiocarpa, C. rostrata, Cicuta virosa,* and *Equiseum fluviatile.*

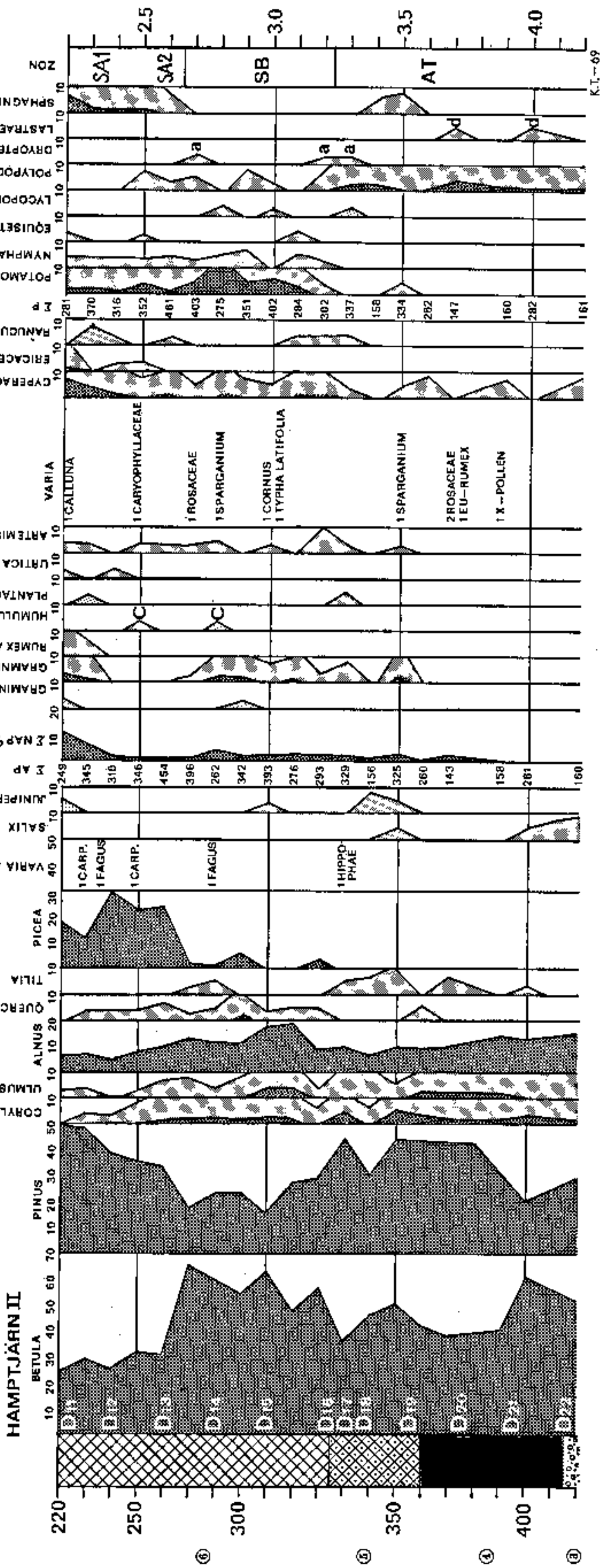
The Hamptjärn mire. The mire is rather complex and both ombrotrophic and minerotrophic vegetation is represented (Fig. 1). Along the north and west margins of the tarn the mire vegetation contains the most extended bog elements. Lesser parts of such vegetation are found to the south of the tarn. These boggy areas are changed into a minerotrophic lagg next to the woody vegetation. The *Pinus* dwarf shrub type predominates. The hollow vegetation is extremely sparsely represented at least in the purely ombrotrophic virgin vegetation but one must bear in mind that ditches and peat-diggings may have changed the boggy vegetation to drier stages. Nevertheless there are still to be seen areas with such plants as: *Scheuchzeria palustris, Sphagnum balticum, S. rubellum,* and *S. tenellum* (on the north bog part pH 3.9, $\varkappa_{20}$ 13 microS and on the western part pH 4.0, $\varkappa_{20}$ 2 microS on September 18, 1969). Only in hollows can *Sphagnum cuspidatum* and *S. lindbergii* be found (pH 3.7 and $\varkappa_{20}$ 0 microS). Around the tarn there is a minerotrophic mire belt with a number of different plant communities: at the south and east margin and in the lagg the fen vegetation is mainly of the rich fen type with *Carex diandra, Parnassia palustris, Sphagnum contortum, S. warnstorfii, S. jensenii* var. *annulatum, Cinclidium stygium,* and *Scorpidium scorpioides.* In other parts it is of the poor fen type: *Carex lasiocarpa, C. rostrata, C. limosa* and on the brink of the water *C. diandra* and *Phragmites communis,* moreover *Menyanthes trifoliata, Scheuchzeria palustris, Rhynchospora alba* and among bryophytes *Drepanocladus exannulatus, Sphagnum fallax, S. angustifolium, S. papillosum, S. riparium, S. obtusum, S. lindbergii, S. pulchrum,* and *S. majus.* Through the western mire part from the forest lagg to the tarn a mesotrophic-oligotrophic fen area is clearly distinguishable on the aerophoto. The vegetation of this part becomes gradually poorer from the proximal part (*Trichophorum alpinum, Phragmites, Carex chordorrhiza, Drepanocladus revolvens, D. badius, Oncophorus virens, Sphagnum warnstorfii;* pH 6.0) to the distal and lower part (*Carex lasiocarpa, Trichophorum caespitosum, Sphagnum pulchrum, S. subfulvum, S. majus*; pH 4.6).

A rich fen with a clearly soligenous character is found on the eastern side of Hamptjärn. It slopes downward to the tarn at a rather conspicuous angle and in the shape of a trough from the margins to the centre. The water from the centre gave a pH value of 6.3 and $\varkappa_{20}$ 91 microS on September 18, 1969. Of the flora can be mentioned *Selaginella selaginoides, Juniperus communis* (in plenty), *Eriophorum latifolium, Carex diandra, Molinia, Polygonum viviparum, Potentilla erecta, Parnassia palustris, Crepis paludosa, Solidago virgaurea,* and *Cirsium heterophyllum, Campylium stellatum, Drepanocladus intermedius, Scorpidium scorpioides, Sphagnum teres* and *S. warnstorfii* are predominant in the bryophyte communities. Among other mosses may be mentioned *Rhizomnium perssonii, Plagiomnium rugicum, P. rostratum, Cinclidium stygium, Oncophorus virens, Paludella squarrosa, Tomentypnum nitens, Calliergon richardsonii, C. sarmentosum, Drepanocladus badius, D. procerus, D. revolvens, Sphagnum subfulvum, S. centrale, Riccardia pinguis* and still nearer the surface of the tarn *S. contortum* and *S. obtusum.*

Fig. 2. Pollen diagram from core profile H I. Explanations: *4* = silt, *5* = clay-gyttja, *6* = coarse detritus gyttja, *7* = peaty gyttja, *8* = *Carex-Sphagnum* peat, *9* = *Sphagnum* peat. For details, see text. Abbreviations: *a* = assimilis, *d* = dilatata, *fm* = filix-maas, *s* = spinulosa.

3. METHODS

For the measurements of pH a glass electrode Beckman pH meter E 280 A has been used in field (ex-


HAMPTJÄRN II
BETULA
PINUS
CORYLUS
ULMUS
ALNUS
QUERCUS
TILIA
PICEA
VARIA AP
SALIX
JUNIPERUS
Σ AP
Σ NAP %
GRAMINEAE CULT.
GRAMINEAE SPONT.
RUMEX ACETOSA/ACETOSELLA
HUMULUS/CANNABIS
PLANTAGO
URTICA
ARTEMISIA
VARIA
CYPERACEAE
ERICACEAE
RANUNCULACEAE
Σ P
POTAMOGETON
NYMPHAEA
EQUISETUM
LYCOPODIUM
POLYPODIACEAE
DRYOPTERIS
LASTRAEA
SPHAGNUM
ZON
SA1
SA2
SB
AT
K.T.–69

cept for the winter measurements of the water made in laboratory with a Radiometer (Copenhagen) pH meter 26; for the determination of the conductivity a YSI Model 31 Conductivity Bridge meter and for the reading of the oxygen content (also measured in the field) a YSI Model 54 Oxygen Meter have been used. Specific conductivity ($\varkappa_{20}$) has been reduced for hydrogen ions according to Sjörs (1952).

Russian peat samplers (5 cm and 10 cm in diameter) which are adaptations of the model described by Jowsey (1966; see Tolonen, 1967) were used in taking samples for pollen analysis. The samples were boiled in KOH except for those from the upper layers in the H I series, where also the usual acetolysis was used. As to the simple procedure its benefit was that the size of pollen grains was better preserved and the perine of fern spores generally was retained. The samples were mounted in glycerol jelly coloured with saffron and the glasses were fixed with nail polish. Critical or important microfossils have been documented on microphotographs taken with a Wild M 20 with phase contrast illumination, Zeiss Contenta with interference contrast illumination etc. Exacta Varex with scientific sight was used. In most cases films have been either Agfa Agepe FF or Agfa Copex Ortho. Samuelsson's (1970) microphotographic instructions have in general been followed, as far as possible.

The construction of the diagrams corresponds, with a few minor exceptions, to that described by Sorsa (1965, pp. 317–318; see also Tolonen, 1967 p. 223). The amounts of counted pollen vary according to pollen density; more than two preparations were not counted: the arboreal pollen count in the H I diagram is in average 317, that in the H II diagram being 288. The most important among the handbooks used at the determination are the following: Beug (1961), Erdtman, Berglund & Praglowski (1961), Erdtman, Praglowski & Nilsson (1963) and Faegri & Iversen (1964).

The ^{14}C-datings from four samples in the Hamptjärn I series were carried out by Dr Lars Engstrand in 1969 in the radiocarbon laboratory of Stockholm station. The ages have been calculated according to $T\frac{1}{2} = 5\,568 \pm 30$ years for ^{14}C using the PDB-standard. The corrects on ^{13}C are as follows: ^{13}C in St-3109 = −3.11 %, ^{13}C in St-3110 = −3.05 %, ^{13}C in St-3111 = −3.46 % and ^{13}C in St-3112 = −2.52 %. The uppermost ^{14}C-samples have been taken with a spade, the lowest ones with a Russian peat sampler (10 cm diam.) and with a Reissinger piston drill (see Faegri & Iversen, 1964, p. 55) (12 cm in diameter).

Fig. 3. Pollen diagram from core profile H II. Strata: *3* = shell containing sand; *4* = clay and silt; *5* = clay-gyttja; *6* = coarse-detritus gyttja. Abbreviations as in Fig. 2.

4. DESCRIPTION OF SEDIMENTS

Hamptjärn I

Depth below bog surface (metres)	Stratum number	Description
0 –1.25	9	Sphagnum peat, decomposition grade H 1–5
1.25–1.50	8	Carex-Sphagnum peat with Bryales remains H 3–6
1.50–1.90	7	Mud-like coarse-detritus gyttja with moss remains
1.90–2.65	6	Coarse-detritus gyttja (brown-green – green)
2.65–3.00	5	Clay-gyttja
3.00–3.35	4	Clay (in the bottom-most part mixed with sand)

Hamptjärn II

Depth below lake surface (metres)	Stratum number	Description
2.20–3.35	6	Coarse-detritus gyttja (brown-green – green)
3.35–3.60	5	Clay-gyttja
3.60–4.15	4	Clay and silt
4.15–4.20	3	Fine sand – Sand.

5. ZONING

Previous studies, e.g. by von Post (1906 and 1930) and by Malmström (1923) have shown the outlines of the development of forests of southern and central Norrland. The pollen-analytical leading levels (*lednivåer*) from *a* to *e* of von Post are as follows: The level *e* represents the beginning of the pollen curve for *Alnus*, the *d* level means a large *Betula* maximum during the postglacial warm period, the *c* level is the rational limit of the *Picea* curve (Pc^0), the *a* and *b* levels are *Picea* maxima above the *c* level. From these levels, which von Post considered to be synchronous over large areas, in fact only the *c* and *e* levels have proved to be so clear that they can be discerned without doubt in all diagrams (see J. Lundqvist, *1969*, p. *181–185*). The *e* level is, as far as is known, relatively synchronous, too. The age of the *c* level is obviously rather constant within smaller areas but it becomes younger westwards, a problem which will be treated later on in this paper.

In 1930 the pollen zonation for Central Norrland was published by Booberg. A more exact and certain dating was worked out by Fromm (1938). The zones of Booberg have proved to be suitable in South and Central Norrland in general (J. Lundqvist, op. cit., p. 181), but in my opinion there is no easily found equivalent for them either in the Hamptjärn diagrams or in those of Västerbotten constructed by Granlund (1943) or in those of the coastal regions of Norrbotten by Fromm (1965). It is obvious that the shares of *Betula* and *Pinus* at *Pc*⁰ level and beneath are somewhat irregular and do not coincide in the system of Booberg. On the other hand the zones from I–VI of Booberg can again be determined in a pollen diagram from Adak, the inland of Västerbotten by G. Lundqvist (1957).

It seems likely that one must separate two different pollen diagram types for Norrland: one for the coastland, another for the inland. The fact is clearly visible in the material of Ångermanland by P. Huttunen & M. Tolonen (1972). In this paper the zone system of T. Nilsson (1964) has been employed, in spite of the fact that it has been worked out for South Sweden. J. Lundqvist (1959) has earlier done so in Jämtland. The intention is to define the zones in accordance with climatic indications and not after the course of the pollen curves, e.g. Pc^0.

a. Zone SA (Sub-Atlantic)

The zone boundary SA/SB is determined after the clear decline of the curves for *Betula*, *Alnus* and QM where coniferous trees, especially spruce, increase. It is younger than the *c* level of von Post, on the basis of the sedimentation age in this basin it is 2 500 ± 100 B.P. or about 550 B.C. The zone has been divided conventionally into two: SA 1 extends from the sudden rise of *Picea* to its second maximum (which corresponds to the *b* level of von Post), and SA 2 from the *Picea* maximum to the present. In the upper part of SA 1 the shares of *Alnus*, QM and *Corylus* are reduced to nearly zero. The transition SA 1/SA 2 (or the *b* level?) has been ^{14}C-dated to about 800 A.D. The result corresponds to the ^{14}C-datings from Jämtland made by J. Lundqvist (1959, p. 183). In the general diagram by Fromm (1938) the *b* level was dated approximately to the birth of Christ.

b. Zones SB and AT (Sub-Boreal and Atlanticum)

The zone boundary SB/AT has been tentatively drawn on the basis of the rising curves for QM + *Corylus* and *Alnus*. In the curve of *Polypodiaceae* a clear rise is also to be seen (cf. Sorsa, 1965, p. 404). A radiocarbon measurement has given an age of 4 570 ± 100 B.P. or 2620 B.C. to the zone boundary. The ^{14}C-sample was taken just from the isolation point of the lake, which with reference to its altitude (61 m) from the boundary of Ancylus and Litorina (7 000 years ago at 120 m height) is 4 510 years, calculated according to the chronology in the land uplift curve of Granlund (1943, pp. 127, 150). If the results of Fromm (1970) in his investigation on the varve chronology are considered, we have to add 200 years, in which case the age would be 4 710 years. As it is more likely that $T\frac{1}{2}$ for radiocarbon is 5 730 years (e.g. Godwin, 1962) the age of the dated sample from Hamptjärn ought to be 4 707 years. The dating result seems to be relatively certain and it also supports the assumption that other ^{14}C-datings in the diagrams are fully reliable. The zone boundary SB/AT itself can be situated somewhat lower, because in Jämtland it has been tentatively dated to 3100 B.C. (J. Lundqvist, op. cit.). Whatever the fact is, it is clear that the *d* level of von Post (1930) (or the *Betula* maximum of the climatic optimum) cannot be used as a basis for zoning in the Hamptjärn profiles. In both of them, one maximum lies admittedly at the same stratigraphical point just below the *Picea* rise, being about 3 400 years old, but both Sandegren (1924) and Fromm (1938) have geochronologically dated it as early as to 4200 B.C. Both *Betula* maxima, in H I at a depth of 2.3 m and in H II at 3.5 m and at 4.0 m suits the time limits of J. Lundqvist (1969) 5 000–2 000 B.C., but they have scarcely more than a local dating value. Equally indistinct is the *Betula* maximum of zone III of Granlund in the diagrams of Tavelsjö (north of Umeå) and Byske (Granlund, 1943, p. 130, 133).

6. STRATIGRAPHIC INTERPRETATIONS

a. The immigration of spruce

As to the dating results of the general spread of spruce $Pc^0 = 2\,970 \pm 100$ B.P. or 1020 B.C. (H I: 185 cm) and to the starting of the continuous pollen curve (208 cm) 3 360 ± 100 B.P. = 1410 B.C. they are well in harmony first and foremost with each other but also with the chronology from the coastal area of Ångermanland expressed by Fromm (1938, Fig. 7, p. 379). The former dates from 1000 B.C. and the latter 1300–1400 B.C. According to G. Lundqvist (1957, Fig. 5, p. 16) the beginning of the continuous curve of *Picea* in Adak 190 km NW of Umeå is 1045 B.C. The definite spruce invasion is however obviously some hundreds of years younger, since the curve rises by 5% and more about 25 cm above the dated level. In the promille diagram with several radiocarbon measurements by Königsson (1970) from Byske, North Västerbotten, the "tail" of *Picea* has been dated to 3 300 B.P. and Pc^0 to 3 000 B.P.

The results from the Hamptjärn mire are well in accordance with the isochronous *Picea* fronts in Finland by Aartolahti (1966, p. 375, see also Moe 1970). The sections of the line for 3 000 B.P. in Finnish Lapland and in SW Finland can be extended to Umeå and Byske. In this case the tentative line runs close to the adjacent lines. By means of the reliable radiocarbon datings of *Picea* advance in Ångermanland it seems to vary from 2 500 to 3 000 B.P. (Huttunen & M. Tolonen, 1972). In the northern parts of Gävleborg county the immigration of spruce took place at about 800–400 B.C. (G. Lundqvist, 1963, p. 103–150) and in Jämtland from 650 B.C. to some time after the Birth of Christ (J. Lundqvist, 1969, p. 183). Pc^0 shows a tendency to transgress in time towards younger dates from the coastal areas westwards, being in western parts of Värmland 480 B.C., in the middle 210 B.C., and on the west coast of Bohuslän 300 A.D. (Fries, 1951). At Namdalen in Nord-Trøndelag (64°30′ N, 11°45′ E) the great spruce expansion took place as late as 1300 A.D.; obviously scattered occurrences of *Picea* had existed earlier (150 A.D. and 2500 B.C.) (Brynhild Vorren, 1970).

One must also take into consideration the earlier appearance of *Picea* up to 3% at a level of 275–305 cm of Atlantic origin.

With reference to the methods employed a contamination is out of question, and spruce is supposed to have grown in rather small quantities in the surroundings. The diagram of Granlund (1943, p. 132) from Mulltjärnmyr in Degerfors where spruce occurs in ten samples at the deposits of the climatic optimum supports the idea that the same conditions prevailed in parts of Västerbotten. Analogous small appearances of early spruce have seldom been met, e.g. in Norrbotten (Fromm, 1965, Fig. 205, p. 203), in Ångermanland (Fromm, 1938, Fig. 2, p. 368, Fig. 7, p. 379), in Jämtland (J. Lundqvist, 1969, Fig. 175, p. 366), in Gävleborg county (G. Lundqvist, 1963, Fig. 116), in Kopparbergs county (G. Lundqvist, 1951, Fig. 123, p. 177) and also in Värmland (J. Lundqvist, 1958, Fig. 130, p. 191, Fig. 114, p. 169). It must be brought in mind that older pollen-analytical studies have mostly been worked out from samples taken with the Hiller bore, which is liable to contamination. The results must therefore be a little uncertain.

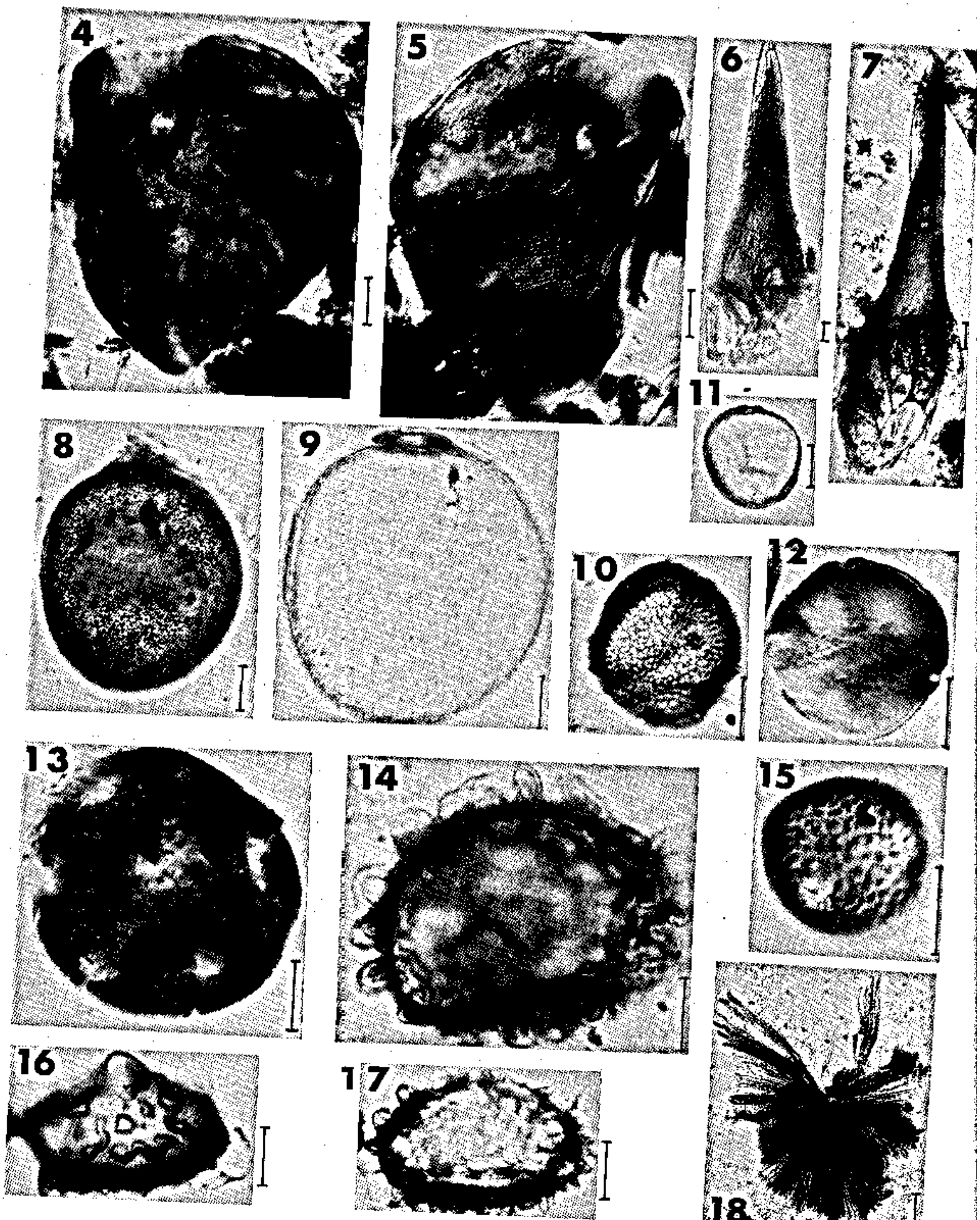
b. Occurrence of certain plants, especially culture-indicating pollen types (CIP)

Hippophaë. One pollen grain has been found in the H II profile just at the isolation level. In somewhat older brackish water sediment of the H I series there was found a nearly complete hair (Fig. 18). After the water of the basin changed from salt to fresh the plant disappeared.

Ceratophyllum. Close to the brackish water limit in limnic sediments eight spines of *Ceratophyllum demersum* have been found and two more of the same species at the upper zone boundary SA/SB. The species indicates a greater electrolyte content or at least a higher alkalinity of water during the time it existed, a fact that is supported by both diatom analysis and other palaeolimnological analyses.

From the *Humulus/Cannabis* type *Cannabis* has been identified after distinctive marks given by Godwin (1967, p. 72) also using the size of the pollen as a distinctive character (Erdtman et al., 1961, p. 19–20). In the H I series two *Humulus* pollen were found in AT and they may originate from natural vegetation. Four grains of *Cannabis* pollen type have been identified in the H I series and two in the H II series, from just above *Picea*° or from 800 B.C. onwards. The beginning of the appearance of *Cannabis* pollen coincides with some other CIP-pollen: *Plantago major, Rumex acetosella* coll., and *Cerealia.*

Cerealia. When fulfilling all the three criteria by Beug (1961, p. 31) concerning pollen measures, it has been possible to separate the *Cerealia* pollen from the *Gramineae spont.*-group. Certain whole and easily distinguishable grains have been identified in greater detail. *Hordeum* and *Triticum* types have been found and *Secale* has been separated from *Hordeum* (see Beug, op. cit., p. 37). *Cerealia* pollen were found sporadically in the upper part of SB starting from 1000 B.C. until the present day. The intensity of farming seems, according to these finds, to have increased from about 700 A.D. when the culture-indicating pollen become more frequent. The oldest confirmed pollen grains of the *Hordeum* type and of *Secale cereale* derive from this period (see Figs. 4–5). The oldest pollen of *Triticum* type is dated to 900–800 B.C. and several grains have been found near the surface of the mire. The oldest pollen belongs to the genus *Triticum* according to the size, 59 μ, and the pore diameter, 8 μ (Beug, 1961, p. 38).



Figs. 4–18. Pollen grains and some other plant subfossils from Hamptjärn. Pollen samples in parentheses; scale 10 μ. Figs. 4–5, *Secale cereale* (H I 90). 6–7, *Ceratophyllum demersum*, leaf spines (H I 265). 8–9, *Hordeum* type (H I 60). 10, *Rumex acetosa/acetosella* type (H I 170). 11–12, *Cannabis* type (H I 165). 13, *Caryophyllaceae* (H I 290). 14, 16–17, *Dryopteris assimilis* (H I 240). 15, *Plantago major* (H I 170). 18, *Hippophaë rhamnoides*, hair (H I 290).

Plantago major. One pollen grain in the H I series at 1.75 m depth (Fig. 15) is a CIP pollen, since the species does not grow naturally on the lake shores.

Rumex acetosella coll. (Fig. 10) nearly always has a continuous curve of over 1 % from a depth of one metre upwards (the earliest appearances with the first cultivated plants near the zone boundary SA/SB). — CIP.

Dryopteris and *Lastraea*. It has been possible too identify these fern spores with perine according to the descriptions by Sorsa (1964). Most of the *Dryopteris* species were *Dryopteris assimilis, D. dilatata, D. filix-mas, D. spinulosa* and *Lastraea dryopteris* in layers from the postglacial optimum period. No regularity can be demonstrated in the appearance of these species on the different stratigraphical levels.

7. CONCLUSIONS REGARDING HUMAN INFLUENCE

An earlier culture phase from 900–800 B.C. onwards in the immediate vicinity of Hamptjärn has been discovered on the basis of the pollen finds of *Triticum, Plantago major, Cannabis, Rumex acetosella* coll. and *Cerealia* coll., moreover possibly *Artemisia.* These records correspond to most of the archaeobotanical finds from Anundsjö parish, Ångermanland (M. Tolonen & Huttunen, 1972) and to that from Byske in northern Västerbotten (Christianssson, 1965, p. 10; 1970, p. 39. Königsson, 1970) where the first trace of farming (barley and wheat, resp. barley) has been met even as early as about 2000 B.C., resp. 1800–1700 B.C. H. Hjelmqvist (verbal communication 7.4.1970) has verified the last-mentioned pollen-analytical results by certain macroscopic impressions from 40 pieces of naked barley and a piece of four-row barley. For comparisons outside Norrland, one may turn to a study by M. Tolonen & Huttunen, published in this volume.

When considering pollen of *Secale cereale*, the inception of continuous and increasingly intensive farming, indicated by CIP from about one metre, dates from about 750 A.D. Other species of prime importance are: The *Hordeum* type, *Cannabis*, a nearly unbroken *Rumex acetosella* curve, species of *Chenopodiaceae*. This farming phase contemporaneous with the Viking period is characterized by nearly the same pollen flora both in Ångermanland and in Västerbotten, Byske (op. cit.). In Ångermanland the cereals dating from the Iron Age also included *Avena*.

As to the *Cannabis* pollen from the Viking period (about 800 A.D.) the results are corroborated by the macroscopic finds from Själland, Norway and Sweden (see Fries, 1958, p. 43, and literature cited by him). Whether hemp was sometimes soaked in the tarn or in the water hollow of the mire is impossible to say despite its name, "Hamptjärn" (Hemp tarn) (at least in the 18th century map from the year 1784). According to historical notes the growing of hemp became very intensive in the coastal area of Västerbotten as late as in 1730 (Axelson, 1947, p. 94), but obviously it began much earlier.

9. ACKNOWLEDGEMENTS

I wish to express my warmest thanks to Professor Bengt Pettersson, Section of Ecological Botany, University of Umeå, for providing working facilities and to Assistant Professor Evert Baudou for covering the expenses of the radiocarbon datings within the EN project. The English manuscript was read by Professor Pettersson. The courtesy of EN in publishing this paper is sincerely acknowledged.

10. REFERENCES

Aartolahti, T. 1966. Über die Einwanderung und die Verhäufigung der Fichte in Finnland. — Ann. Bot. Fenn. *3:* 368–379.

Ångström, A. 1958. Sveriges klimat. — 108 pp. Stockholm.

Axelson, C. A. 1947. Hampodlingen i Lappmarken under äldre tid. — Tidskr. f. Västerbottens läns hushållningssällskap år 1948, 94–95.

Beug, H.-J. 1961. Leitfaden der Pollenbestimmung. Lieferung 1. 63 pp. — Stuttgart.

Booberg, G. 1930. Gisselåsmyren, en växtsociologisk och utvecklingshistorisk monografi över en jämtländsk kalkmyr. — Norrländskt Handbibliotek *12,* 1–329.

Christiansson, H. 1965. De arkeologiska undersökningarna vid Bjurselet i Byske. — Västerbotten år 1965.

— 1970. Nordarkeologi gräver. — Ibid. 1–12. År 1970, 36–43.

Erdtman, G., Berglund, B. & Praglowski, J. 1961. An introduction to a Scandinavian pollen flora. — Grana Palynol. *2:* 3, 3–92.

Erdtman, G., Praglowski, J. & Nilsson, S. 1963. An introduction to a Scandinavian Pollen Flora. II. 89 pp. — Stockholm.

Fægri, K. & Iversen, J. 1964. Textbook of Pollen Analysis. Second rev. edn., 237 pp. — Copenhagen.

Fries, M. 1951. Pollenanalytiska vittnesbörd om senkvartär vegetationsutveckling, särskilt skogshistoria, i nordvästra Götaland. (Ref.: Pollenanalytische Zeugnisse der spätquartären Vegetationsentwicklung, hauptsächlich der Waldgeschichte, im nordwestlichen Götaland (Südschweden).) — Acta Phytogeogr. Suec. *29:* 1–220.

— 1958. Vegetationsutveckling och odlingshistoria i Varnhemstrakten. En pollenanalytisk undersökning i Västergötland. (Ref.: Vegetationsentwicklung und Siedlingsgeschichte im Gebiet von Varnhem. Eine pollenanalytische Untersuchung aus Västergötland (Südschweden).) — Ibid. *39:* 1–64.

Fromm, E. 1938. Geochronologisch datierte Pollendiagramme und Diatoméenanalysen aus Ångermanland. — Geol. Fören. Stockh. Förhandl. *60:* 365–381.

Fromm, E. 1965. Beskrivning till jordartskarta över Norrbottens län nedanför gränsen. English summary. — Sverig. Geol. Unders., ser. Ca *39:* 1–236.

— 1970. An estimation of errors in the Swedish varve chronology. *In* C^{14} and Varve Chronology. — Nobel Symposium *12:* 163–172.

Godwin, H. 1962. Half-life of Radiocarbon. — Nature *195:* 4845, 984.

— 1967. Pollen-analytic evidence for the cultivation of *Cannabis* in England. — Rev. Paleobot. Palynol. *4:* 71–80.

Granlund, E. 1943. Beskrivning till jordartskarta över Västerbottens län nedanför odlingsgränsen. Zusammenfassung. — Sverig. Geol. Unders., Ser. Ca *26:* 165 pp.

Hedlin, B., Julin, E. & Pekkari, A. 1957. *Stratiotes*-sjöar i Norrbotten. — Svensk Bot. Tidskr. *51:* 317–343.

Hedlin, B. & Tolonen, K. Manuscript in prep.: Paleolimnologic studies from Stratiotes-lakes in Norrbotten county (N. Sweden) and Kittilä (Finnish Lappland).

Huttunen, P. & Tolonen, Mirjami 1972. Pollen analytical studies of prehistoric agriculture in northern Angermanland. — Early Norrland *1,* 9–34.

Jonsson, T. 1969. Inventering av vegetation och flora vid Hamptjärn med särskild hänsyn till några miljöfaktorer. — Examination work. Manuscript in archive at Section of Ecological Botany, Umeå University. 115 pp.

Jowsey, P. C. 1966. An improved peat sampler. — New Phytol. *65:* 245–248.

Königsson, L.-K. 1970. Traces of Neolithic human influence upon the landscape development of the Bjurselet settlement, Västerbotten, Northern Sweden. — Skytteanska Samfundets Handl. *7:* 13–30, Umeå.

Kotilainen, M. J. 1956. Vorläufiges über die Wasserchemie der *Stratiotes*-Seen in Kittilä, Finnisch-Lappland. — Arch. Soc. "Vanamo", *10:* 153–160.

Lohammar, G. 1938. Wasserchemie und höhere Vegetation schwedischer Seen. Symb. Mot. Upsal. *3:* 1, 1–252.

Lundqvist, G. 1951. Beskrivning till jordartskarta över Kopparbergs län. — Sverig. Geol. Unders., Ser. Ca *21:* 213 pp.

— 1957. C^{14}-analyser i svensk kvartärgeologi. English summary. — Sverig. Geol. Unders., Ser. C *557:* 1–25.

— 1963. Beskrivning till jordartskarta över Gävleborgs län. English summary. — Sverig. Geol. Unders., Ser. Ca *42:* 182 pp.

Lundqvist, J. 1958. Beskrivning till jordartskarta över Värmlands län. English summary. — Ibid. *38:* 229 pp.

— 1969. Beskrivning till jordartskarta över Jämtlands län. English summary. Ibid. *45:* 1–418.

Malmström, C. 1923. Degerö Stormyr. En botanisk, hydrologisk och utvecklingshistorisk undersökning över ett nordsvenskt myrkomplex. (Ref.: Degerö Stormyr. Eine botanische, hydrologische und entwicklungsgeschichtliche Untersuchung eines nordschwedischen Moorkomplexes.) — Medd. Skogsförsöksanst. Stockh. *20:* 1–206.

Map from the year 1784, "1784 års karta öfver Tjälamarks by". Avvittringskarta.

Moe, D. 1970. The post-glacial immigration of Picea abies into Fennoscandia. — Bot. Notiser *123:* 61–66.

Nilsson, T. 1964. Standardpollendiagramme und C^{14}-Datierungen aus dem Agerödsmosse im Mittleren Schonen. — Lunds Univ. Årsskr., N.F. (2), *59:* 7, 1–52.

Nordlander, J. 1905. (utg.) Jordha Boocken Wthaaff Westhrabotnen. — Norrl. Saml. Häfte *6.* Stockholm, 1905.

v. Post, L. 1906. Norrländska torfmossestudier. I. Drag ur myrarnas utvecklingshistoria inom "lidernas region". — Geol. Fören. Stockh. Förh. *20.*

— 1930. Norrländska Torfmossestudier. II. Några huvudpunkter i skogens och myrarnas postarktiska historia inom södra Norrland. — Ibid. *52.*

Samuelsson, K. E. 1969. Elements in microphotography with ordinary light. — Sverig. Geol. Unders., Ser. C *641* (Årsb. *63:* 4) 35 pp.

Sandegren, R. 1924. Ragundasjöns postglaciala utvecklingshistoria enligt den subfossila florans vittnesbörd. — Sverig. Geol. Unders., Ser. Ca *12,* 55 pp.

Sjörs, H. 1952. On the relation between vegetation and electrolytes in North Swedish mire waters. — Oikos *2:* 241–258.

Sorsa, P. 1964. Studies on the spore morphology of Fennoscandian fern species. — Ann. Bot. Fenn. *1:* 179–201.

— 1965. Pollenanalytischen Untersuchungen zur spätquartären Vegetations- und Klimaentwicklung im östlichen Nordfinnland. — Ibid. *2:* 301–413.

Tolonen, K. 1967. Über die Entwicklung der Moore im finnischen Nordkarelien. — Ibid. *4:* 219–416.

— 1968. Soiden kehityshistorian tutkimusmenetelmistä. II. Turvekairoista. (Ref.: On methods used in studies of the peatland development. II. On the peat samplers.) — Suo. *18:* 86–92.

— On the palaeoecology of the Hamptjärn basin. II. Bio- and chemostratigraphy. — Early Norrland. I, 53–77.

Vorren, Brynhild, 1970. Picea abies og pollenanalytiske lednivåer i Namdaler, Nord-Trøndelag. — Kvartärgeologernas vintermöte i Köpenhamn, 1970, p. 42.

Received 1.1.1971
Printed 30.12.1972