GEOLOGINEN TUTKIMUSLAITOS

BULLETIN

DE LA

COMMISSION GÉOLOGIQUE

DE FINLANDE

N:o 207

ON THE LATE-QUATERNARY DISTRIBUTION IN FINLAND OF THE FILBERT (*CORYLUS AVELLANA* L.)

BY

MARTTI SALMI

WITH 22 FIGURES AND TWO TABLES IN TEXT

HELSINKI 1963

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ABSTRACT

The author has investigated thirteen finds in bogs of filberts, or hazelnuts *(Corylus avellana L)*. These finds were made north of the present range of the plant and represent its most northern known occurrences in Finland. All the finds date from the sub-Boreal period. Comparative pollen studies and the elevations at which the sites of the finds are located indicate that the filbert struck root in southeastern Fennoscandia during the Alleröd, after having been transported mainly across the sea. A floating test was made to study the distribution of the species in Finland.

Helsinki 1963. Valtioneuvoston kirjapaino

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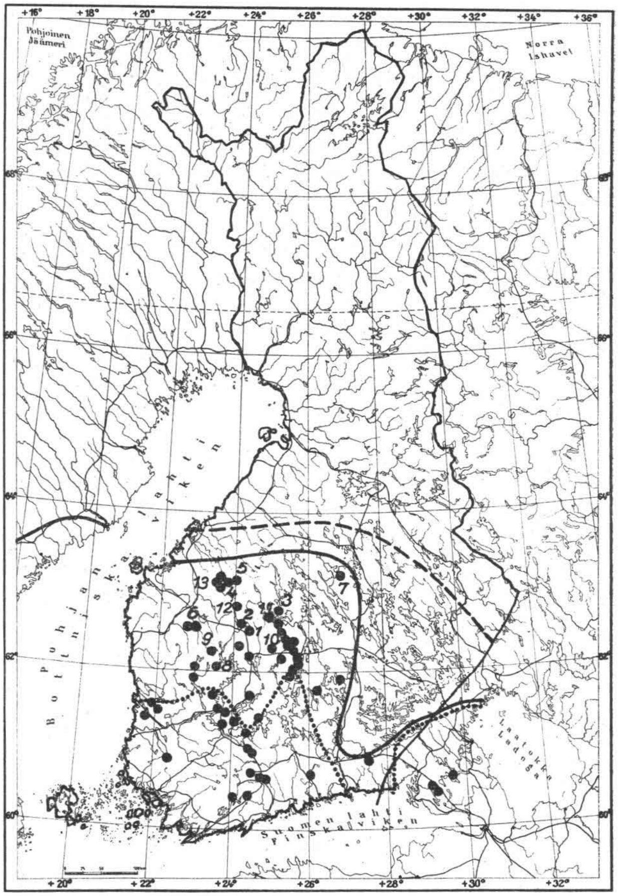

Fig. 1. The black dots indicate the sites of subfossil hazelnut finds. Nos. 1 to 13 are included in the material of the present study. The dotted line indicates the northern limit of the present range of *Corylus*, after Lagerberg, Linkola & Väänänen (1938) (cf. Fig. 15). The solid line represents the ancient northern limit of the species' occurrence in the light of nut finds, and the broken line the corresponding limit according to the evidence of pollen analyses.

INTRODUCTION

The author has investigated thirteen subfossil nut finds **north of** the present range of the filbert (*Corylus avellana* L.) All the sites **are in** bogs and represent the northernmost finds made in Finland. The **map in** Fig. 1 shows the hazelnut finds made in this country as reported in the literature

(Sauramo 1940, Erkamo 1947, Hultén 1950, V. E. Valovirta 1959, Tolonen 1960 and E. J. Valovirta 1960) and supplemented by information obtained by the present writer. The finds to be discussed are numbered 1 to 13 on the map, which also has marked on it the northern limit of the present distribution of *Corylus* according to Lagerberg, Linkola and Väänänen (1938). The finds made in the area of the Karelian Isthmus (formerly Finnish but now Soviet territory) cast further light on the distribution of the plant in this country, so they have likewise been marked on the map.

Bog profiles have been taken from the sites of the finds in order to determine by means of pollen analyses the date when the nuts were deposited in the bogs. In certain cases it has been necessary to use only the result of a pollen analysis of a peat specimen obtained in conjunction with the nuts. The elevations of the sites have been levelled, in a couple of instances with a barometer.

Of the finds marked in the figure, Nos. 1, 5 and 8 were made in conjunction with peat investigations carried out by the Department of Surficial Deposits of the Geological Survey. The first was made by Mr. Einari Valleala, a forester, in a bog called Pieni Tupasuo, in the commune of Ähtäri, in the summer of 1945; the second by Mr. V. E. Valovirta, Lic.Phil., in the bog named Varkkasalonräme, in the commune of Vimpeli, in the summer of 1947; and the third by the latter's research assistant, Mr. A. Leino, in the bog named Pallineva, in the commune of Kuru, in the summer of 1960. All the other finds had been common knowledge among the local inhabitants for many years, perhaps even decades, the information having been reported to the writer or been obtained by him during his travels by asking questions. The Saarijärvi find (3) was reported by Mr. H. Laine in 1945; the one at Olkiahonsuo, Ähtäri, (2) by Mr. Lauri Makkonen, farmer, in 1947; the one at Tuomikorpi, Vimpeli, (4) by Mr. Oskari Harju, schoolteacher, in 1947; the one at Hautaneva, Soini, (12) by Mr. K. Pesola, schoolteacher, in 1947; and the find at Koiraanneva, Jalasjärvi, (6) by the owners of the Koivisto farm in 1957. The find of Pielavesi (7) was reported in 1960 by Mr. O. L. Pulkkinen, schoolteacher, who also sent samples of the nuts; site 9 by Mr. Niilo Vehkapuru, farmer, in 1950; site 10 by Mrs. Aili Salonen, schoolteacher, in 1949; site 11 by Mr. K. Loune, business man, in 1948; and site 13 by Mr. Eino Savola, building contractor, in 1949.

The series of samples from site 5 was taken by the finder just mentioned, from sites 7 and 13 by the persons making the report and their assistants, and from No. 8 by Mr. A. Leino. The rest of the samples were collected by the author. The pollen analyses relating to finds 10 and 11 were made using a single specimen of the peat enveloping the nuts.

The pollen diagrams have been divided into forest and climatic zones, using the central European zonal classification developed by Jessen (1935) and Firbas (1949). The zones are the following: I = Older Dryas, II = Alleröd, III = Younger Dryas, IV = pre-Boreal, V = Boreal, VI = Older Atlantic, VII = Younger Atlantic, VIII = sub-Boreal and IX = sub-Atlantic.

NUT FINDS

THE SITES

1. PIENI TUPASUO, ÄHTÄRI

Pieni Tupasuo is situated in the commune of Ähtäri some five or six kilometers toward the northeast from the station of Myllymäki, on the southern side of the Myllymäki—Saarijärvi highway. The area of the bog is roughly 100 hectares. The middle of it is an open space in which various treeless bog types alternate. Along the margins of the area there occur pine bog with subshrubs and, in places, swampy forest consisting of spruce and broadleaved trees.

The site of the nut find is practically in the middle of the bog. The nearest islet of till lies about 100 meters away. The thickness of the peat at the site of the find is 2.9 m, underneath it lying a dense deposit of till. The elevation of the bog surface at the site is 193.9 meters.

Fig. 2 presents a profile of the peat deposit at the site of the nut find. Throughout the peat is dominated by *Sphagnum*. Additional constituents are *Eriophorum vaginatum*, for the most part, and *Carex*, which occurs in spots. Attention should be called to the fact, in particular, that at a depth of 2.0—2.2 m, representing the sub-Boreal period, the *Eriophorum-Sphagnum* peat contains the remains of shrubs. Three nuts were dug up from this layer when the bog was investigated. No more were found during further explorations.

The humification of the peat (H), which is presented in the same column with the peat varieties, has the value of 9, according to v. Post's 10-scale, at the bottom of the profile and 7 in the layer containing the nuts. Higher up the humification value varies between 5 and 7 at a depth of approximately a meter and remains less than 5 from that point on up to the surface.

Paludification started in Pieni Tupasuo at the site of the nut find during the latter half of the Atlantic period as heathy land began to turn into bog.

Betula dominates the lower part of the pollen diagram from Pieni Tupasuo to a depth of 2.1 m with contents of between 60 and 70 %, and it con-

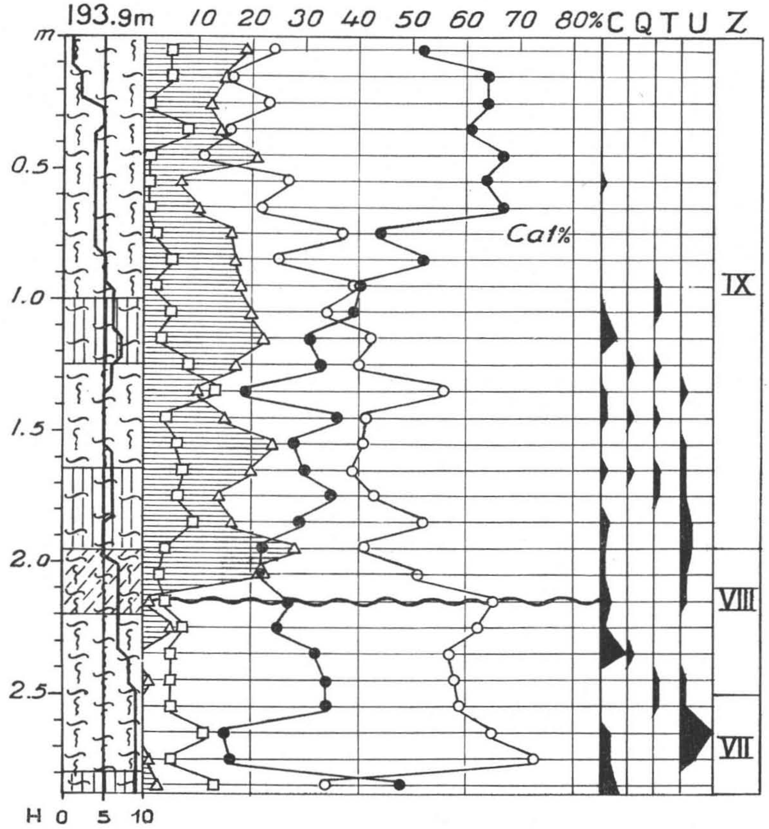

Fig. 2. Pollen diagram of Pieni Tupasuo (1). The wavy line indicates the depth at which nuts were found in the bog.

tinues to be the most prevalent of the pollens all the way to the 0.9-m level with values varying between 40 and 50 %. After that it is *Pinus* that takes the ascendancy with percentages of from 50 to 65. *Picea* gains its final position in the diagram immediately after the depth at which the nuts were found, or around 2.1 meters, and extends to the surface with values varying on both sides of 20 per cent. *Corylus* and *Ulmus* occur as uniform and relatively strong sectors in the peats dating from the Atlantic and sub-Boreal periods, the former registering a maximum of 5 % and the latter of 6 %. The occurence of each continues discontinuously up to the sub-Atlantic period, where *Quercus* and *Tilia* appear in greatest abundance in the diagram. The only point at which *Carpinus* occurs in the diagram is at the 0.7-m level, or the point at which *Pinus* begins to increase rapidly upward and the humification of the peat to diminish.

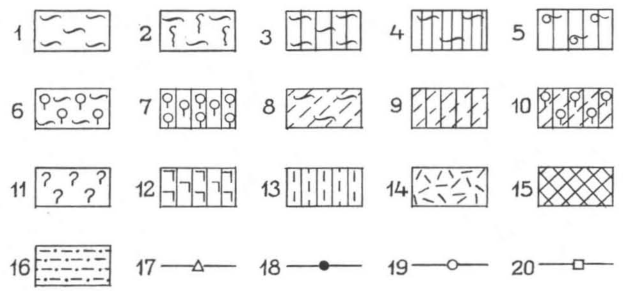

Fig. 3. Key to symbols. 1 = *Sphagnum* peat 2, = *Eriophorum-Sphagnum* peat, 3 = *Carex-Sphagnum* peat, 4 = *Sphagnum-Carex* peat, 5 = *Bryales-Carex* peat, 6 = deciduous-*Sphagnum* peat, 7 = deciduous-*Carex* peat, 8 = nanolignidi-*Sphagnum* peat, 9 = nanolignidi-*Carex* peat, 10 = nanolignidi-deciduous-*Carex* peat, 11 = fern peat, 12 = *Equisetum-Carex* peat, 13 = *Phragmites-Carex* peat, 14 = allochthonous peat, 15 = coarse detritus ooze, 16 = silt, 17 = *Picea*, 18 = *Pinus*, 19 = *Betula*, 20 = *Alnus*, C = *Corylus*, Q = *Quercus*, T = *Tilia*, U = *Ulmus*, Ca = *Carpinus*, Fr = *Fraxinus*, Hipp. = *Hippophaë*.

2. OLKIAHONSUO, ÄHTÄRI

Olkiahonsuo is situated in the area of Niemiskylä, Ähtäri commune, on a point of land jutting into Lake Niemisvesi on the eastern side of the motor-road leading from Inha station to Soini. The bog covers an area of some ten hectares and the elevation of the surface at the site of the find is 178.7 meters. Peat has been dug out of the bog as soil-improvement material for dozens of years; large pits are to be seen there as evidence of this activity. On the corridors of land between the pits there grow various species of grass and deciduous trees in abundance. According to my guide, a farmer named Lauri Makkonen, nuts occurred only in a layer about 20 cm thick.

The profile shown in Fig. 4 reveals that the depth of the bog at the site of the find is 1.4 m. The bottom of the bog is sand. The peat layer consists throughout of well humified *Spagnum-Carex* peat containing the remains of deciduous trees. A total of eighteen nuts were found, occurring at a depth of 1.2 m, in a deposit consisting of deciduous-nanolignidi-*Carex* peat. The site of the find was approximately 30 m from the edge of the bog, the shore rising from the bog as a low stretch of ground composed of till.

The paludification of the forest land in the locality of the Olkiaho nut find did not begin until the sub-Boreal period. The predominance of deciduous trees in the lower part of the peat layer — marked by an abundance of *Alnus* and *Betula* pollens and *Polypodiaceae* spores up to a depth of 1.0

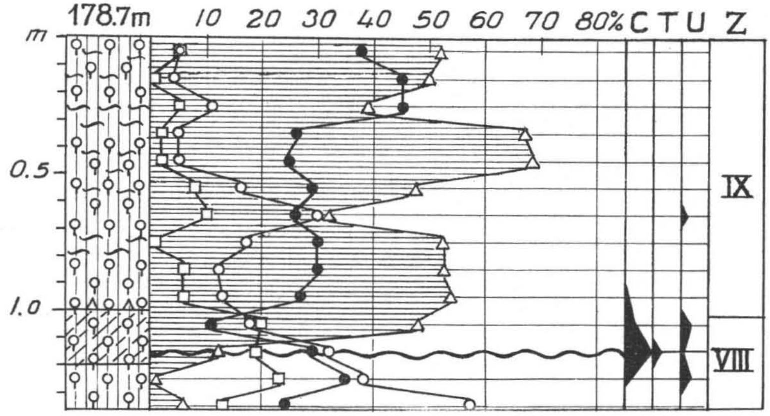

Fig. 4. Pollen diagram of Olkiahonsuo (2).

m — indicates that the area of the bog was originally a rich swampy forest or one consisting of spruce and broadleaved trees in which *Corylus* was represented and in the near surroundings of which also, apparently, *Ulmus* and *Tilia* also grew. It is in zone VIII, coinciding with the layer containing the nuts, that *Corylus* achieves its maximum of 5 %; but after that it soon disappears from the diagram altogether. Upward from the one-meter level the spruce rapidly gains the predominant position in the pollen diagram with values between 40 and 50 % or even, in some places, 70 %. *Pinus* gives increasingly high values toward the surface and in the upper part of the diagram nearly equals the pollen percentage registered by *Picea*. Forests of pine and spruce dominate the area throughout the sub-Atlantic period.

3. TERVAHAUDANSUO, SAARIJÄRVI

The bog in which the nuts were found is known by the name of Tervahaudansuo. Measuring about a hectare in area, it is situated alongside a moraine ridge on the eastern side of a small lake named Saarijärvi, in a locality known as Kangaskylä, roughly eight kilometers north of the parish center of Saarijärvi. Peat has been dug out of the bog for many years as material used to improve soil. The numerous pits have caused the peat layer to dry and shrink. In the rather dried-out bog there nowadays grow *Alnus, Populus tremula, Sorbus aucuparia, Salix* sp., some spruce and an abundance of various species of grass. Taking the level of the bog barometrically in the summer of 1962, I found it to lie 190 meters above sea level.

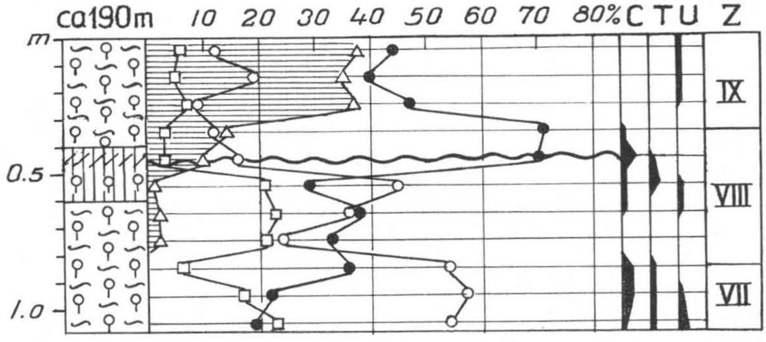

Fig. 5. Pollen diagram of Tervahaudansuo (3).

The owner of the bog and my guide, Farmer A. Tarvainen, told me nuts have been found in the bog in such abundance that they have been gathered by the handful for children to play with. Moreover, it has been observed that in this bog, too, the nuts occur only in a particular, easily distinguishable layer.

The peat pit from the sides of which nuts were sought is located some ten to fifteen meters from the moraine, the top of which lies more than 200 m above sea level. Nuts were found — fifteen of them — at a depth of between 0.45 and 0.6 m in a layer about 15 cm thick, but not a single one at any higher or lower level. The layer could be followed all around the pit. It consists of deciduous-*Carex* peat containing a large number of stems and twigs of deciduous trees as thick as a man's finger or thinner. For the most part they have been identified as filbert remains.

At the spot where the nuts were found there is a peat layer 1.1 m thick overlying stony till. It will be seen from the profile in Fig. 5 that, with the exception of the stratum containing the nuts, it consists of deciduous-*Sphagnum* peat. The bog started to evolve during the latter part of the Atlantic period as paludification of forest land.

In the light of the pollen diagram, the forests of the vicinity were dominated by *Betula* during the initial stage of the peat layer, but *Alnus* was also common, judging by its 20 % value in the diagram. The period of ascendancy of the deciduous trees is also marked by the occurrence of rare species, among which *Corylus* is the most common. It registers a value of 3 % at the depth of the find in zone VIII but soon disappears after that. *Tilia* and *Ulmus* occur sporadically. It is around the nut stratum that the dominance of deciduous species ends, with *Pinus* first rising to its 70 % maximum and soon thereafter also *Picea* registering percentages of between 35 and 38, with which it approaches the frequency of *Pinus* pollen in the upper part of the diagram.

Under the microscope, *Corylus* cell remains could be detected in the peat at depths of 90 cm and between 30 and 60 cm, i.e., right at the beginning of the sub-Boreal and again at the end of it. *Polypodiaceae* spores occur sparsely in the lower part of the diagram to the 0.5 m level but upward from there quite abundantly.

4. TUOMIKORPI, VIMPELI

Tuomikorpi is located in the commune of Vimpeli about 1.5 km to the east from Lappajärvi. Situated on a slope with a southern exposure, the few hectares of the bog are at present under cultivation. According to my guide, Mr. O. Harju, the local schoolteacher, the bog used to be fed by numerous springs. It has been kept cleared for cultivating for several generations by burning over the surface, with the result that the top layer of peat has been destroyed to a depth of between 0.3 and 0.5 meters. Before the period the area has been under cultivation, besides numerous kinds of grass, there have grown in it *Alnus glutinosa, Lonicera xylosteum, Ribes nigrum* and *Prunus padus* — the last-mentioned quite abundantly —, indicating that the bog had evolved out of a rich swampy forest. Half a meter below the surface there are to be found in many spots vivianite and siderite lenses 0.3 to 0.5 m thick, which account for the luxuriance of the plant life supported by the bog.

Nuts have been found in the bog over a period of several decades and they occur here, too, in a specific layer. When the author visited the area, a brief search yielded ten nuts, which were found at the edge of a ditch. The layer in which they occurred is ten centimeters thick and lies at a depth of between 0.2 and 0.3 m. The bog at this point is at an elevation of 90.4 m (Fig. 6), which very nearly approximates the highest Littorina limit in the region (Salmi 1949).

The depth of the bog at the site of the find is 1.6 m. Underlying it is sand. The peat is principally of the deciduous-*Carex* variety, but at the depth where the nuts occur, in zone VIII, the peat is of a deciduous-dwarf shrub variety which is in an advanced stage of humification — as is the case also at 0.6—0.7 m. The peat of the lower part contains considerable fine sand, apparently owing to the action of spring water. The process of paludification started during the early part of the Atlantic period when the area consisted of forest land.

Noteworthy in the pollen diagram is the strong occurrence of *Alnus* in zones VI to VIII, where it accounts for between 40 and 60 % of the pollen up to approximately the 0.5-m level. It is later overshadowed by *Betula* and *Pinus*, but upward from the layer containing the nuts the pollen dia-

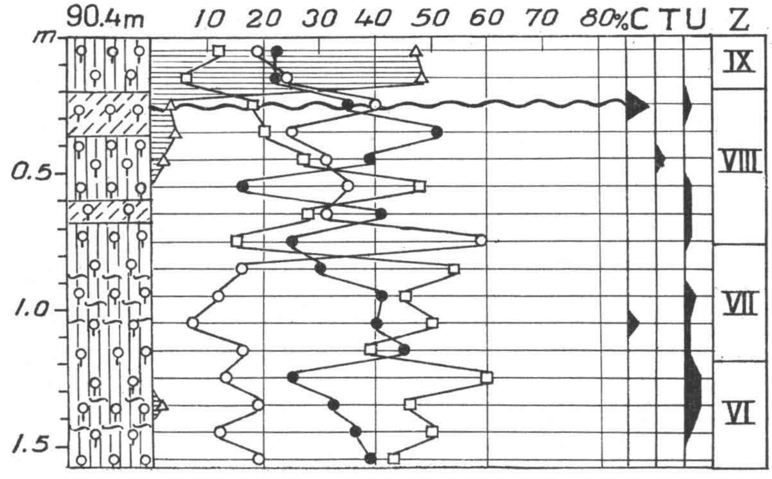

Fig. 6. Pollen diagram of Tuomikorpi (4).

gram is dominated by *Picea*, with concentrations of nearly 50 % of the total count.

With the exception of *Ulmus*, pollen representing a mixed elm forest occur sparsely in the diagram. *Corylus* appears at only two points, the 4 % maximum coinciding with the layer containing nuts. *Polypodiaceae* spores are generally present in the peat except for the two uppermost specimens. The spores occur most abundantly in the halfmeter thick layer overlying the 0.8-m level. Together with the evidence provided by the varieties of peat, they indicate that the bog had always been the site of a rich swampy forest.

5. VARKKASALONRÄME, VIMPELI

Varkkasalonräme is located in the vicinity of the village of Sääksjärvi, Vimpeli commune, quite close to the limestone area of Vimpeli. The bog covers a stretch of some sixty hectares and, compared to the generally oligotrophic bogs of the surrounding country, it supports rather rich vegetation. It may be described as representing for the most part pine bog of the fen type. Among the plants, noteworthy are *Carex flava*, *C. panicea*, *C. Godenowii*, *Eriophorum gracile*, *E. latifolium*, *Pedicularis ceptrum carolinum*, *Galamagrostis purpurea*, *Equisetum limosum*, *Sphagnum teres*, *S. Warnstorfii* as well as, here and there, *Sphagnum fuscum*, which forms hummocks. Furthermore, rather dense pine woods and scattered birch trees grow in the area of the bog.

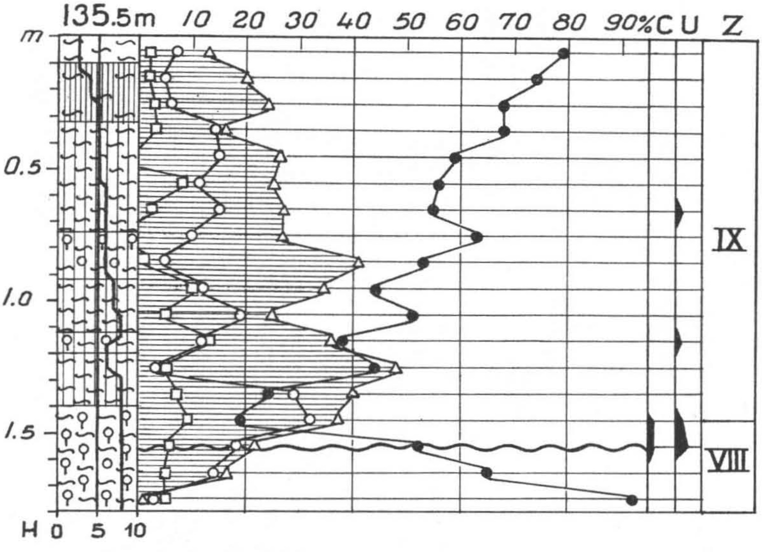

Fig. 7. Pollen diagram of Varkkasalonräme (5).

One broken nut was found in the bog investigation. Numerous drillings failed to bring to light more nuts when the author visited the site. The lone nut was run across some thirty or forty meters from the edge of the bog. The elevation of the bog is 135.5 meters and the thickness of the peat layer at the spot of the find 1.8 m. Underneath is sand. Fig. 7 shows that the peat layer is alternately dominated by *Sphagnum* and *Carex*. Lowermost is eutrophic deciduous-*Sphagnum* peat, with a pH of 6.5. It was in this stratum that the nut was found at a depth of 1.6 m. The pH of the peat is throughout high, varying between 6.5 and 7.2 and increasing toward the surface. The effect of limestone on the peat is evident, as I have previously pointed out in another connection (Salmi 1958). The ash content of the peat is 7 or 8 %.

Paludification started on the site during the sub-Boreal, involving as in all the other cases reported in the foregoing, the conversion of forest land to bog. Immediately thereafter the filbert struck root in the area.

The decomposition of the peat has advanced farthest toward the bottom, a value of 8 being met with at about the 0.5-m level. Higher up the state of humification varies between the values of 6 and 8 to roughly the 0.6-m level, then toward the surface first drops to 5 and at a higher level below that figure.

The pollen diagram is throughout dominated by *Pinus* and *Picea*. At the lowest level *Pinus* registers the positively exceptional high value of 92 %,

Fig. 8. The site of the nut find of Koiraanneva. The moraine lies at a distance of about 100 meters.

but right above the level containing the nut *Picea* momentarily gains the ascendancy, rising to a maximum of 48 %. Higher up *Pinus* once more accounts for the majority of the pollen grains, its values steadily increasing toward the surface, though *Picea* also continues to register quite high percentages.

On the whole, pollens representing a mixed oak forest appear sparsely in the diagram. It is only at the depth at which the nut was run across that *Corylus* scored a value of 1 % in two successive specimens. Ulmus likewise occurs in its greatest abundance at the same point, but it is to be met with elsewhere, too, being represented by a couple of separate occurrences.

6. KOIRAANNEVA, JALASJÄRVI

Koiraanneva is located in the vicinity of the village of Luopajärvi, Jalasjärvi commune, roughly a dozen kilometers northwest of the church near the communal boundary of Kurikka. The bog covers an area of c. 150 ha. Extensions of it are the considerably larger Kyrönneva and Tuulineva, located to the northeast and the northwest. Koiraanneva consists mostly of raised bog with hummock ridges and broad pools. Along its margins occur *Calluna* and *Ledum* pine bog and, in spots, wet treeless *Carex* bog.

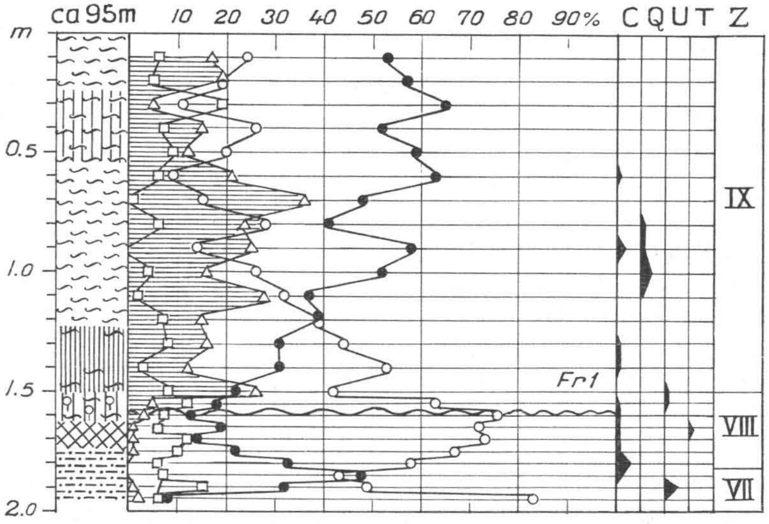

Fig. 9. Pollen diagram of Koiraanneva (6).

The margins of the southern part of the bog have been brought under cultivation.

The spot where the nuts were found is located on the southeastern margin of the bog, about 500 m north of the Koivisto farm, the people of which made the find. At the spot in question the bog has been cleared for cultivation across a stretch about 100 m broad. The nuts were found at the bottom of the ditch separating the cleared stretch from the part of the bog still in its natural state (Fig. 8). The finders said the nuts always occur in the same layer, c. 10 cm thick, near the boundary marking off the mineral soil. A search resulted in the finding of four more nuts in the same layer at a depth of 1.6 m (Fig. 9). The layer consists of *Sphagnum* peat containing the remains of deciduous plants. Underneath the layer in which the nuts were imbedded lies 15 cm of coarse detritus and under that 20 cm of silt, which is underlain by till. Above the »nut layer» lies, first, c. 30 cm of *Carex* and, then, *Sphagnum* peat. The latter variety is mixed with *Carex* near the surface for a short space. The elevation of the site, according to the topographic map, is approximately 95 m.

The diatom flora of the silt in the lower part of the profile consists mainly of *Pinnularia* and *Eunotia* species, judging by which the locality was covered by a small freshwater lake at the turn of the Atlantic and sub-Boreal periods. Following the infilling of the lake, peat began to form after the middle of the sub-Boreal period and soon the hazel was growing in the bog. It was apparently as a consequence of the dry climate prevailing during the sub-Boreal that the lake began to dry up and the bog to spread across the basin.

The lower part of the pollen diagram is dominated by *Betula*, but at the level of the »nut layer» its position weakens and *Pinus* begins correspondingly to gain strength toward the surface of the bog. *Picea* also increases in frequency and retains its high values in the diagram close to the surface, where, however, *Betula* and, in places, also *Alnus* usurp its position.

Among pollens representing rare species, *Corylus* has the highest frequency in zone VIII. *Ulmus* and *Tilia* also occurred around the same time. *Quercus* did not appear until late in the sub-Atlantic period. The only *Fraxinus* pollen in the diagram was found directly above the nut layer. *Polypodiaceae* spores are present generally from the bottom of the profile up to the 1.5-m level, where they abruptly cease to occur.

According to the pollen diagram, *Corylus* pollen occurs in greatest abundance, registering a value of 3 %, in the detritus ooze underlying the layer of peat containing the nuts, in which layer the value is only 1 %. *Corylus* pollen grains have even been found in certain specimens taken from a higher level. Around the level of the nut layer, the pollens representing rare species generally diminish in frequency — for instance, the sole occurrence of *Tilia* is at that level.

7. ILOMÄTÄS, PIELAVESI

The site of the find is a boggy meadow located roughly 3.5 km northeast of the church of Pielavesi in the vicinity of the village of Pajumäki and 350 meters toward the southeast from the farmhouse of Ilomätäs, where the owner of the property lives. There used to be a bog covering half a hectare on the site, but nowadays it consists partly of reclaimed meadow and partly of peatland grown over with *Salix*.

Nuts have been found in the boggy area now and then for quite some time. They have attracted attention when peat has been hauled to fields to improve the soil. The present writer received a report on the find in August, 1960, when Mr. O. L. Pulkkinen, the local schoolteacher, sent some of the nuts to the Geological Survey. At my prompting and assisted by Messrs M. Valkonen, Eino Hyvärinen and V. Jäntti, he took a series of peat specimens from the site and further supplied information on the finds as well as a sketch map of the place.

According to this source, nuts are to be found in the peat bed at a depth only of between 150 and 160 centimeters. At this level the peat contains the remains of trees. The specimens were collected by digging with a spade, but it was not possible to go down deeper than 180 cm owing to the water

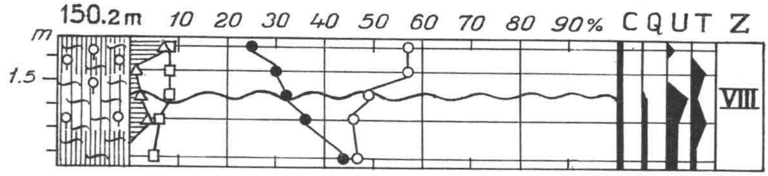

Fig. 10. Pollen diagram of Ilomätäs (7).

below. The peat bed continued more than a meter further down. According to a levelling performed in 1962, the bog lies 150.2 meters above sea level.

Fig. 10 shows the varieties of peat at the site of the find together with the pollen diagram drawn according to the specimens. At depths between 130 and 180 cm, the *SC*- and *CS*-peat here and there contains the remains of deciduous trees. At the levels mentioned, the pollen is dominated by *Betula*, with *Pinus* ranking second. The uniform occurrence of *Picea* is only beginning at this stage. Judging by this and the previous diagrams, the peat dates back to the sub-Boreal period. There is a considerable occurrence in the diagram of pollens from rare deciduous trees, notably *Ulmus* and *Tilia*. The value registered by *Quercus* and *Corylus* pollens is only 1 %, the latter, however, being present throughout the series of specimens. After the level containing the nuts, the pollen frequency of rare species abruptly decreases.

8. PALLINEVA, KURU

Pallineva is situated about 25 km northwest of the church of Kuru and roughly five km north of the village of Luode, as measured by following the road leading to Aurejärvi and Kihniö. Situated right next to the eastern side of the road, the bog covers an area of some 90 ha. Pallineva is a raised bog on which small pines grow; it can be subdivided into types according to the plant life growing there: shrubs, *Sphagnum* and *Eriophorum vaginatum*. The peat is predominantly of the *ErS* variety, the lower part being *CS*.

In conjunction with the peat-geological investigation of the bog, two nuts were brought up by the drill from a depth of 3.6 m; but, in spite of many additional drillings, no more nuts were extracted. The find was made at the southern end of the bog at point A I +20 in the network of investigation lines. The bog narrows there to a passage about 150 m wide, and it was in the middle of this stretch that the successful drill hole was made. The thickness of the peat layer at this site is 4.5 m, and it is underlain by 20 cm of allochthonous and coarse detritus ooze. Lowermost is a thin

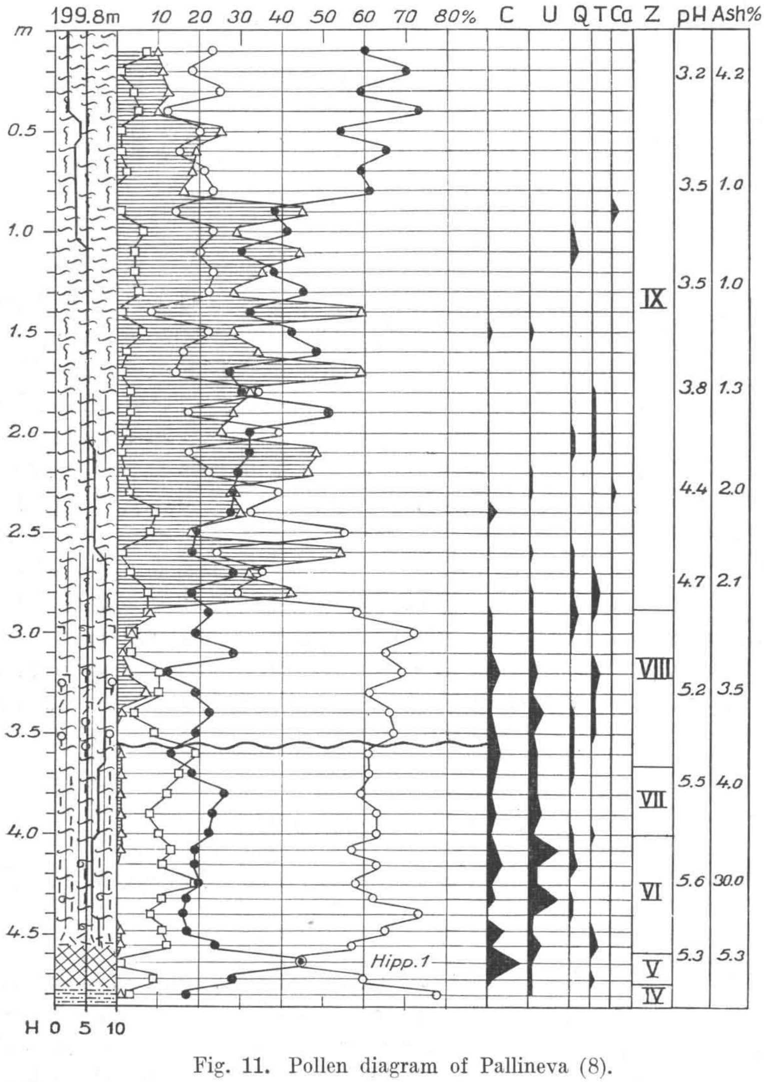

Fig. 11. Pollen diagram of Pallineva (8).

layer of silt covering a base of till. The elevation of the surface of the bog at the site is 199.8 m.

It may be seen from Fig. 11 that the lowest level consists of *CS*-peat mixed with *Phragmites* and, in places, *Bryales*. Upward from the depth at which the nuts were found, the *CS*-peat contains, as additional components, the remains of deciduous trees, dwarf shrubs and plants of the genus *Equisetum*. Moreover, between the depths of 3.6 and 3.0 meters, the peat bed contains *Scheuchzeria* and *Nymphaea* cell tissue as well as *Sparganium* and *Typha* pollen. The impression is gained that the peat had originated in a spruce-and-broadleaved-tree swamp, where the water had apparently been in motion, at least from time to time. Similar conditions are suggested also by the pH and ash content of the peat, represented on the right-hand side of Fig. 11.

In the lower part of the peat bed, the pH registers between 5.2 and 5.6 from the depth of three meters downward, but the figure decreases upward toward the surface. Uppermost it is 3.2, a typical value for oligotrophic *S*-peat. The first-mentioned values are fitting for peat that had originated under the conditions prevailing in a spruce-and-broadleaved-tree swamp, and the same may be said of an ash content exceeding 3.5 %. The exceedingly high ash content of 30 % in the lower part of the bed gives quite a convincing picture of mineral matter transported by running water.

The decomposition of the peat registers from 7 to 6 at the lowest level, and it is at the depth of the layer containing the nuts that the highest value of 8 in the profile occurs, continuing for a meter or so upward. The humification value diminishes gradually toward the surface of the bog, the lowest value of 2 being registered by the *S*-peat of the surface layer.

Diatom flora is only very sparsely present in the specimen situated lowest in the profile, comprising fresh-water diatoms. Noteworthy among them are the cold-water species *Pinnularia braunii* and *P. appendiculata* as well as *Epithemia*, *Eunotia*, *Frustulia*, *Melosira*, *Navicula*, *Stauroneis* and *Tabellaria*. Uncertainly identified, to be sure, there is also a fragment of the salt-water species *Rhabdonema arcuatum*. In the coarse detritus ooze, the *Fragilaria* species and *Melosira italica* have the greatest frequency, while higher up, as far as the depth of 4.3 meters, *Eunotia robusta*, *Tabellaria fenestrata*, *T. flocculosa* and *Stauroneis anceps fo. gracilis* predominate. The diatoms just mentioned all belong among small, fresh-water flora. The process of paludification thus got started after the infilling of a lake or pond. According to the pollen diagram, this took place at the turn of the pre-Boreal and Boreal periods. If the occurrence of the salt-water diatom fragment mentioned were to be accepted as evidence, the Yoldia Sea would have extended as far as the region of Pallineva. Judging by the bog's elevation of nearly 200 meters, it would signify the highest and oldest stage of the Yoldia Sea, Yoldia I, the height of the shore of which, according to Hyyppä's (1960) relation diagram, was approximately 200 meters above present sea level, or about four meters higher than the bottom of Pallineva.

With the exception only of the brief time of the Boreal *Pinus* maximum, *Betula* dominates with frequencies of between 60 and 70 % the lower part of the pollen diagram of Pallineva up to the 2.9-m level. Upward from this point in the diagram, *Picea* occurs in greatest abundance. The peaks of its somewhat uneven occurrence vary between 40 and 60 % up to the 0.9-m level, after which *Pinus* predominates with values ranging from 60 to 70 %. During the Atlantic period, represented by zones VI and VII, it is the mixed oak forest that has the greatest frequency. *Corylus* and *Ulmus* appear with their maximums of 8 and 7 %, respectively, and their continuous columns extend, slightly narrowed, to the end of the sub-Boreal period, from the beginning of which the nuts date. *Tilia* and *Quercus* are at their highest frequency during the last-mentioned period, each with values of one and two per cent. *Carpinus* is met with at a couple of points in the diagram, each during the sub-Atlantic period. The upper of them occurs chronologically at the same time during the beginning of the great increase in *Pinus* as *Carpinus* in the Pieni Tupasuo diagram of Fig. 2. Evidently, the scattered occurrences of *Carpinus* pollen quite commonly appearing in pollen diagrams from southern and western Finland on the level in question are the result of long-distance flights, possibly from *Carpinus* groves in the southwestern part of the country.

9. KIIMANEVA, KIHNIÖ

Kiimaneva is located in the vicinity of the parish center of Kihniö, roughly two kilometers east of the church. The bog covers an area of c. 30 ha and lies between 155 and 158 meters above sea level. At the southern end of the bog stands the steep hill known as Kiimavuori, the top of which, according to the topographic map, rises to an elevation of c. 167 meters.

Kiimaneva has been partly cleared for cultivation and peat has been dug up from it to improve fields of mineral soil. Nuts have been found in the diggings on numerous occasions and in 1950 a sample including two nuts was received from a farmer, Niilo Vehkapuru.

In the fall of that year the author visited the site, guided by Mr. Vehkapuru. On this occasion, one more nut was found at a depth of 110 cm, in addition to which specimens of peat were taken. According to the farmer, the nuts have always been imbedded at depths between 90 and 110 cm. The surface of the bog at the spot where the specimens were taken lies 157 meters above sea level.

From the profile shown in Fig. 12 it will be seen that the bog is 2.4 meters deep there. The lower part consists of deciduous-*Carex*-allochthonous peat. Higher up occurs telmatic deciduous-*Equisetum-Carex* peat, which changes to *Sphagnum-Carex* and that, in turn, to *Carex-Sphagnum* peat. The depth of 120 cm marks the beginning of a layer of deciduous nanolignidi-*Carex* peat. It was in this layer that the nut was found, and apparently it was the same layer that had contained the rest of the nuts dug up from

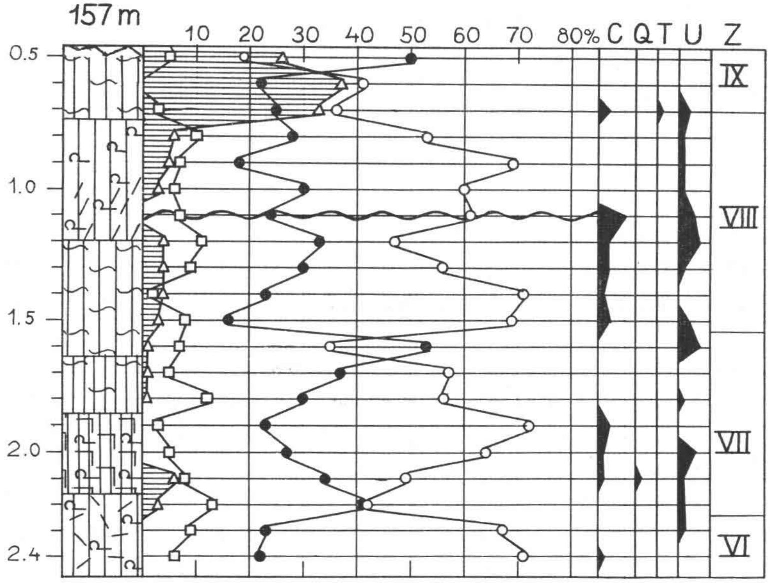

Fig. 12. Pollen diagram of Kiimaneva (9).

Kiimaneva. Closest to the surface is *Carex-Sphagnum* peat. Because the peat of the surface layer had been worked up for cultivation, no specimen of it was taken.

The pollen diagram is relatively clear-cut. It is characterized by the high frequency of *Betula*. Among pollens of rare deciduous trees, *Corylus* and *Ulmus* occur in considerable abundance, whereas there is a paucity of other species. The most uniform column of *Corylus* pollen occurs between the beginning of the sub-Boreal period and the layer containing the nuts, where a maximum value of 5 % is observed. Upward from there the occurrence of this species is only incidental, as in many other cases reported in the foregoing. It should be pointed out, moreover, that in the lowest sample represented in the profile there are 174 grains of *Cornus* pollen for every 100 grains of tree pollen. Typical habitats of *Cornus* are shores and swampy and grassy forests.

10. KALTEENMÄKI, UURAINEN

The find was made at a depth of about 1.5 meters in a bog belonging to the Kalteenmäki farm in the vicinity of the hamlet of Kuukkajärvi, Uurainen commune. The bog is situated in a hollow along the southern

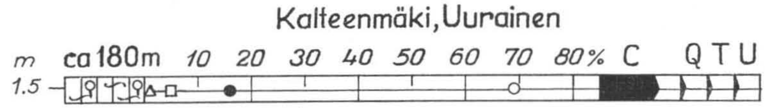

Fig. 13. Pollen diagram of Kalteenmäki (10).

slope of a moraine rising to an elevation of c. 230 m. Streams of spring water run down the slope. According to a barometric levelling carried out by the present writer in 1962, the bog lies about 180 meters above sea level.

Nuts were found by Eino Kalteenmäki, owner of the farm, in 1933; and the find was reported in 1949 by the local schoolteacher, Mrs. Aili Salonen, who also sent along 83 well-preserved nuts. Many of the nuts were enveloped in *Carex-Sphagnum* peat containing remains of deciduous trees. A pollen analysis of the peat was made, and the result is presented in Fig. 13.

The low frequency of *Picea* and the high one of *Betula* registered in the analysis indicate, in the light of the data obtained in connection with other finds, the sub-Boreal period, when the beginning of the vigorous spread of *Picea* occurred. The abundance of rare species of deciduous trees also fits in well with the period referred to, and the unusually high value of 11 % registered by *Corylus* pollen suggests that the hazel was a common species in the locality. This conclusion is supported further by the abundance of the nuts found.

Among non-arboreal pollen (NAP), *Myriophyllum* warrants mention, as do *Lycopodium* and *Polypodiaceae* spores, too. To judge by the occurrence of the first-mentioned pollen, the filberts grew directly on top of detritus ooze.

11. HERRAINKORPI, SAARIJÄRVI

The find was made in the cultivated bog known as Herrainkorpi belonging to the farm of Ähtävänlahti in the hamlet of Mahlunkylä, Saarijärvi commune. The bog is situated on the western shore of Mahlunjärvi (lake). The sample sent to the Geological Survey comprised three nuts and a lump of peat, in which the depressions left by the nuts could be seen. The nuts were found by Mr. Lauri Leppimäki, a farmer.

The nuts lay at a depth of 0.8 meters, where the peat is of the deciduous-*Equisetum-Bryales* variety. The result of the pollen analysis made from the peat is to be seen in the lower diagram of Fig. 14. Judging by the high frequency of *Picea* (35 %) and also of *Alnus*, the layer containing the nuts dates from the turn of the sub-Boreal and sub-Atlantic periods. Confirmation of this was obtained by means of the specimen series collected in the

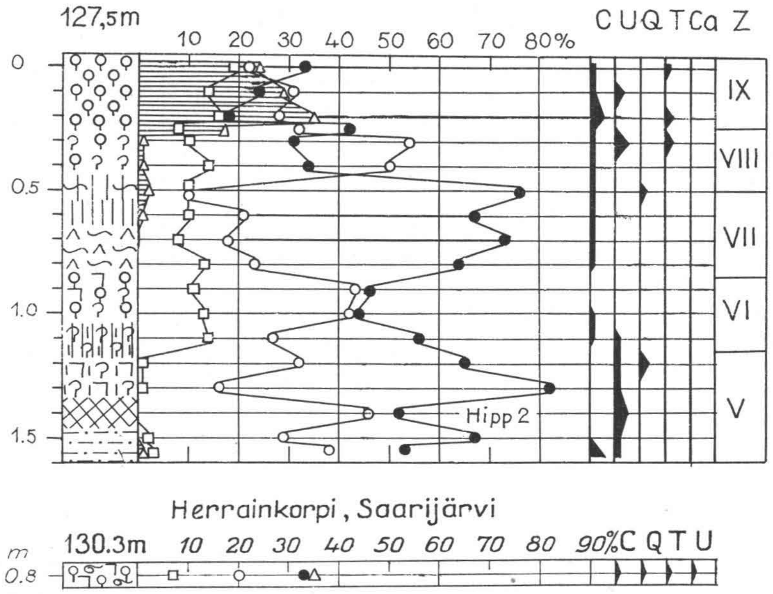

Fig. 14. Pollen diagrams of Herrainkorpi (11) bog. The lower diagram represents the peat in which the nuts were imbedded, the upper one the peat bed situated about 30 meters from the site of the find.

spring of 1962 approximately thirty meters from the spot mentioned. The profile is presented in Fig. 14. In it *Picea* rises steeply from 1 % to 35 % at the level where, according to report, nuts have also been found. None were unearthed in taking the series of specimens, it is true, but the report indicates that *Corylus* had grown there over a rather extensive area. Pollens of rare deciduous plants are only sparsely present in the specimens, yet four different species have been identified. In each case, *Corylus* yields a value of only 1 % at the depth containing the nuts. In the latter diagram, pollen grains occur all the way up — but the surface layer of peat has been broken up by the plow.

The water level of Mahlunjärvi is at an elevation of 121.7 m. The surface of the bog at the site of the nut find has been levelled at 130.3 meters above sea level. The series of samples collected in the spring of 1962 comes from a spot roughly three meters lower down.

12. HAUTANEVA, SOINI

While on a research trip to Soini in the summer of 1947, I heard from a number of people living there that nuts had been found some ten years before in the bog known as Hautaneva, situated about a kilometer from the church toward the southeast. The nuts had come to light when peat had been dug up for use as soil improvement material. However, a search for nuts failed to lead to results in spite of many drillings. No samples were taken from the bog, either, for this reason. The elevation of the bog, according to a levelling carried out along the road running past it, is approximately 190 meters. It is worth noting that the highest point in the vicinity of the parish center of Soini is about 213 meters above sea level.

The local schoolteacher, Mr. K. Pesola, mentioned further that nuts had been found in the cultivated bogs belonging to the parsonage as well as in a certain bog located about seven kilometers from the church toward the southeast. This information indicates that the hazel had at one time been quite a common plant in the elevated region of the watershed where the village of Soini is located.

13. TARVOLA, LAPPAJÄRVI

In March, 1959, one nut was found in the boggy area of the hamlet of Tarvola, Lappajärvi commune, at the point of Hiismäenkoski, when the headstream of Myllypuro was cleared. The nut was sent to the Geological Survey by Mr. Eino Savola, a building contractor. He reported the elevation of the place to be 77.5 meters, which was verified by levelling in the summer of 1962. He also sent a series of peat samples from the site of the find, the depth of wich was given as 1.4 meters. Since no more nuts have been dug up in the area since then, the level at which the one occurred remains uncertain. A pollen diagram has been made from the sample series, but it is not reproduced in this connection. At the reported depth there occur deciduous-*Carex* peat and *Corylus* pollen registering 1 % of the total count. The frequency of *Picea* is approximately 20 %. Insofar as the level of the find was correctly estimated, it would fall at the turn of the sub-Boreal and sub-Atlantic periods, or a point where *Picea* had risen to a fairly high frequency. The beginning of its rise occurs 20 cm lower in the profile.

Several other nut finds have been made in the surroundings of Lappajärvi. Odenwall has orally reported having run across nuts in the shore bars of Isoniemi at the southern end of Lappajärvi as well as on the northwestern shore of the lake. All the evidence points to the vicinity of Lappajärvi as having at one time afforded *Corylus* a hospitable habitat.

THE SHAPE OF THE NUTS

According to their length and width, Andersson (1902) has classified the nuts into three groups. They are: 1) round, *f. silvestris,* the difference

Table 1. The nuts included in the material of this study, classified according to shape.

Site of find	*f. silvestris*	*f. ovata*	*f. oblonga*	Total
1 Pieni Tupasuo	1	2	—	3
2 Olkiahonsuo	3	2	—	5
3 Tervahaudansuo	9	3	—	12
4 Tuomikorpi	6	3	1	10
5 Varkkasalonräme	—	1	—	1
6 Koiraanneva	2	1	1	4
7 Ilomätäs	10	8	2	20
8 Pallineva	—	1	—	1
9 Kiimaneva	1	2	—	3
10 Kalteenmäki	52	22	9	83
11 Herrainkorpi	1	2	—	3
Total	85	47	13	145
Per cent	58.6	32.4	9.0	100

between the length and width is one or two millimeters; 2) longish, *f. ovata,* the corresponding difference of which is between two and four millimeters; and 3) long, *f. oblonga,* the difference between the length and width of which is at least 6 mm.

On the basis of his extensive material, comprising subfossil nuts from Sweden as well as nuts of recent date from Sweden and Finland, Andersson has observed that *f. silvestris* is distinctly the most common but northward *f. oblonga,* in particular, increases in frequency and *f. ovata* decreases in relation to the other varieties. This is illuminated by the results presented by Andersson from the zone lying between 60° and 64° N Lat., the value registered farther south being given first: *f. silvestris* 53.0—57.5 %, *f. ovata* 39.2—26.7 % and *f. oblonga* 7.8—15.8 %.

The material at hand includes altogether 145 nuts in measurable condition. They fall into different groups, as shown in Table 1. The percentages 58.6, 32.4 and 9.0 in the different groups correspond quite closely to the values obtained by Andersson with subfossil nuts from northern sites. The localities where the present material was collected are situated so close together, on both sides of the 63d parallel of latitude, that from the geographical standpoint they may be considered of equivalent value.

According to the measurements reported by Andersson, the nuts are mostly of normal size except for the *f. ovata* group, in which they are generally small. The greatest lengths and smallest widths met with in the different groups are as follows: *f. silvestris* 15 and 12 mm, *f. ovata* 15 and 18 mm, and *f. oblonga* 19 and 13 mm.

THE STRATIGRAPHIC POSITION OF THE NUT FINDS IN THE BOGS

All the nut finds in the material have been made in peat. In the cases where observations could be made or where the finders have followed the appearance of nuts for years, the occurrences have been limited to a particular layer between ten and twenty centimeters thick. The main mass of the peat in this layer in most cases consists of *Carex* remains, with deciduous trees invariably supplying accessory components and brushwood frequently being present, too. This variety of peat is confined in some cases only to a thin layer at the depth at which the nuts have been dug up. Many samples of the peat from this layer also contain residual *Polypodiaceae* cell tissue and spores in considerable abundance. In profiles 2 to 6, such spores and plant remains occur all the way up from bottom of the swamp to the »nut layer», after which they cease immediately. In general, the peat changes above the level at which nuts have been found so as to take on an oligotrophic character. In the nut layer and, especially, underneath it, the peat is frequently mesotrophic and sometimes even eutrophic.

Below the nut layer the thickness of the peat varies at the different sites between 0.2 and 1.5 meters. At sites 2, 5 and 6 there is only about 0.2 cm of peat underneath the nut layer and overlying either sand or silt. In many cases the thickness of this layer of peat is around half a meter, in some cases even more. At Pallineva (8) there is a full meter of peat underneath the point where the nuts were found, and at Tuomikorpi (4) and Ilomätäs (7) approximately 1.5 m. Nuts by the dozen and even by the hundreds have been found in quite a few places, while at Tervahaudansuo (3) large numbers of filbert stems and twigs have been dug up in addition. In the light of the present study, it may be confidently stated that *Corylus avellana* has grown in bogs. It may further be stated on the strength of this material that the occurrences are situated a few dozen, at most between 100 and 150, meters from the edge of any of the bogs or from any stretch of mineral soil jutting out into the bog.

The depth of the layer containing nuts, as measured from the surface of the bog, varies quite considerably at different sites. At sites 4 and 3 it is less than half a meter, but in each case the bog's peat layer has settled as a result of human activity — the factors in the former case being burning-over and ditch-digging operations, and in the latter, numerous peat-winning pits. The greatest depths at which nuts have been obtained have been in bogs that at the time of finding have been in a natural state. Thus, at Pieni Tupasuo (1) the nut layer lies at a depth of about 2 m, at Varkkasalonräme (5) about 1.5 m and at Pallineva (8) about 3.5 m. At the other sites nuts have been dug up from depths ranging from 0.8 to 1.5 meters. In these cases, the peat layer had dried and settled because of pits dug to win the peat. In bogs still in a natural state, accordingly, the depth of the finds has been appreciably greater.

The degree of humification of the peat at the level containing the nuts is generally high, or 7 to 8. It was determined in conjunction with field investigations only in the bogs still in a natural state, or Nos. 1, 5 and 8. The results are shown in the corresponding profile drawings. Judging by the dry specimens, the state of decomposition of the peat in other profiles as well has been farthest advanced at the level containing the nuts.

On the basis of pollen analyses, it has been possible to place the nut layers in the chronology of the evolutionary history of the Baltic Sea, the regional climate and the forests. All the finds included in the study thus belong to the end of the Littorina period or the postglacial warm and dry period, zone VIII. The find of Pallineva (8), in Kuru commune, which is slightly farther to the south than the others, must be dated at the beginning of the sub-Boreal and the next most southern find, that of Kiimaneva (9), Kihniö commune, around the middle of the same period. The foregoing sites are also among the ones situated farthest west. The rest of the finds date back to the latter half of the sub-Boreal, sites 11 and 13 belonging to the turn of this period and the sub-Atlantic. These datings have been based on the assumption that the spruce became common in the various localities at approximately the same time. All the finds either coincide with the beginning of the vigorous increase in the frequency of *Picea* or slightly antedate it. Insofar as it would turn out that the emergence of the spruce as a common species in the vicinity of the western sites 8 and 9 had occurred later than farther east — which is likely enough, considering that *Picea* arrived in this country from the east —, all the nut finds discussed in the present study would be roughly of the same age.

Dating the layers containing nuts as sub-Boreal also agrees with the observation that they consist of mixed peat containing the remains of trees and subshrubs, i.e., that they represent a variety of peat indicating a dry period. The same conclusion is supported by the high degree of humification exhibited by the peat layers. According to Blütt-Sernander's theory of climate, the sub-Boreal was drier than the earlier Atlantic or the later sub-Atlantic period.

Special attention is attracted by the fact that the layers containing nuts generally have little *Corylus* pollen. At sites 5, 6, 7 and 11, the analysis yielded only 1 %, at Pieni Tupasuo (1) between 1 and 2 % and at the others between 3 and 5 %. The highest figure, or 11 %, was from Kalteenmäki (10), but the analysis was carried out with a peat specimen scraped off nuts, which may have something to do with the exceptional value.

The reason why *Corylus* pollen is so sparsely present especially in the nut layers may be connected with the origin of the peat under the conditions prevailing in spruce-and-broadleaved-tree swamps. The abundance of oxygen under such conditions has the effect of dispersing vegetable matter, as demonstrated, for instance, by the advanced stage of decomposition of the layers under consideration. Owing to its weak resistance, *Corylus* pollen underwent destruction. According to Firbas (1949), numerous different researchers have observed that in Central European swamps providing a habitat for spruce and broadleaved trees there is a sparse occurrence of *Corylus* pollens. In the case of Varkkasalonräme, the occurrence of CaO in the surroundings and the high pH of the peat might likewise have caused the destruction of pollens.

Noteworthy, too, is the circumstance that *Corylus* pollen is often only sparsely and sporadically present also underneath the layers containing nuts, i.e., in peat dating from the Atlantic period, although in both Finland and Sweden *Corylus* is generally believed to have flourished during that time. The Pallineva (8) diagram represents an exception in this respect. It is further significant that the occurrence of *Corylus* pollen ceases in numerous places immediately above the layer containing nuts — or, at least, the pollen frequency decreases, its occurrence becomes sporadic and ceases at the beginning of the sub-Atlantic. However, in the diagram from Pieni Tupasuo, *Corylus* extends quite high. In the diagram presenting the vicinity of the find at Herrainkorpi, Saarijärvi commune, pollen grains of *Corylus* would seem to extend all the way to the surface (Fig. 14), but it must be pointed out that the surface peat is missing there on account of farming activity.

Pollen analyses give the impression that *Corylus* disappeared from at least the majority of the localities investigated at the end of the sub-Boreal period and from all of them during the early part of the sub-Atlantic. The sporadic and sparse occurrences of *Corylus* pollen indicated higher up in the diagrams are likely to be due to long-distance flights. It should be noted, however, that also in areas where *Corylus* occurs at present its pollen is only sparsely present in peat layers dating from the post-Littorina period. This is evidently due to the small size of the plant and the limited spaces in which it can grow, hemmed in, moreover, by forests. Its pollen grains are unable to any appreciable extent to spread beyond the near environs of the plants, and occurring in conjunction with the massive pollen output of the surrounding forests, the modest quantity of *Corylus* grains is bound to appear insignificant in the pollen statistics.

ON THE DISTRIBUTION OF *CORYLUS*

PAST AND PRESENT HABITATS

According to Hiitonen (1933), the hazel grows in the grass-herb forests and meadows and on the wooded slopes of southern Finland. Lagerberg, Linkola and Väänänen (1938) have made the same observation. It is pcinted out that *Corylus* requires good soil and an open space to grow in. The present writer has succeeded in finding no mention in the literature that *Corylus avellana* has been observed to grow nowadays in soil composed of peat, as was the case with the ancient plants discussed in this paper. Conditions must therefore have been different from what they are today in the northernmost stations in Finland where *Corylus* thrived in times past.

Certain nut finds in Finnish bogs have been reported before. Among the most interesting are the observations made by Auer (1924) in connection with his investigations of the vicinity of Vanajavesi. He concluded that *Corylus* grew, for instance, in ground composed of peat in *Alnus glutinosa* swamps that had evolved out of filled-in lakes throughout the Atlantic period. Later, during the dry sub-Boreal times, the bogs began to be overgrown with forests, following the advent of the spruce. At this stage *Corylus* still grew in the bogs but retreated at the end sub-Boreal or the beginning of the sub-Atlantic to the edges of the bogs, whereupon hydrophilic *Sphagnum* associations blanketed the bogs.

V. Valovirta (1959) has described a bog find of subfossil nuts made at Kinkomaa, Muurame commune. The place is situated roughly 20 km north of the *Corylus* occurrence at Korpilahti. The nuts were contained in deciduous-*Polypodiaceae* peat indicating luxuriant plant life, and the researcher estimates their age at 5 000 years. Accordingly, the nuts would date back to the beginning of the sub-Boreal and approximate the age of those found at Pallineva (8).

Tolonen (1960) has run across nuts in the bog known as Mahlaneva, Jalasjärvi commune, quite near Koiraanneva (6). In the pollen diagram this find coincides with the beginning of the general spread of *Picea*, i.e., just as does the Koiraanneva find. Thus, it likewise dates back to the sub-Boreal.

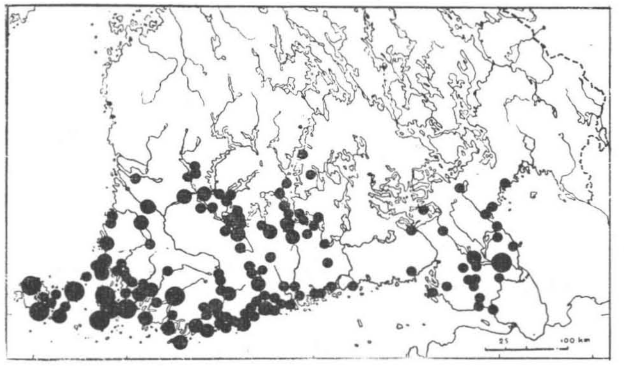

Fig. 15. The present distribution of *Corylus* in Finland, after Lagerberg, Linkola and Väänänen (1938).

Numerous nut finds in peat have been made in Sweden. They have been reported by, among others, Hedström (1893), Andersson (1902) and Fries (1956 a). Many are sub-Boreal, some older.

Fig. 15 shows the present distribution of *Corylus avellana* in this country according to Linkola (Lagerberg, Linkola and Väänänen 1938). The plant is met with in greatest abundance in the Åland Islands, the archipelago and coast of southwestern Finland and all along the coastal area of southern Finland as far as the environs of Kotka. In the Finnish interior, *Corylus* occurs quite commonly along the shores of certain lakes and the banks of rivers connected with them. Noteworthy are the Vanajavesi-Pyhäjärvi-Näsijärvi-Kyrösjärvi region and the areas bordering Kokemäenjoki as well as the southern end of Lake Päijänne and the areas around the nearby lakes. The foregoing areas might be designated as together comprising the western range of *Corylus* in this country as apart from its less extensive eastern area of occurrence along the southern shore of Lake Saimaa. The latter range extends down of the Karelian Isthmus and the shore of Lake Ladoga, in Soviet territory. Between the western and eastern ranges there is a broad region where the filbert does not grow. Hiitonen (1946) says that this is due mainly to edaphic circumstances. In this region is situated the great massif of Viipuri rapakivi granite, which, he reports, does not afford a favorable habitat for *Corylus*.

Fig. 15 gives the impression that in this country *Corylus* is primarily a coastal plant that thrives under maritime climatic conditions but also occurs along the shores of lakes and rivers. The occurrence of *Corylus* in the hinterland may be taken as evidence of the appearance there of the species back in times when the localities were part of the Baltic coast. Particularly the most northern occurrences are scattered and represent the

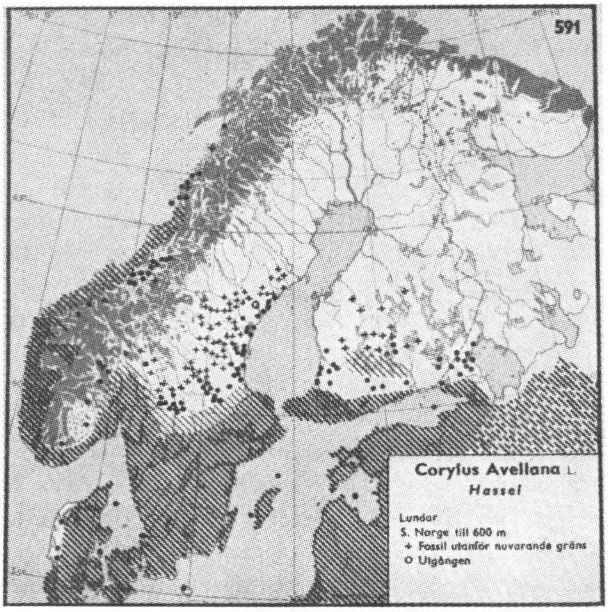

Fig. 16. The present range of *Corylus* in Fennoscandia, after Hultén (1950). Dense ruling = common, sparse ruling = less common, broken lines = sparse observations, dots = scattered occurrences, crosses (+) = subfossil nut finds.

most favorable stations, which must thus be regarded as relicts. The most northern station of all, at Vaarunvuori, Korpilahti commune, lies approximately in lat. 62° N. In southeastern Finland the northern limit of the species' distribution is slightly farther south, or around 61° 31′ N.

The map drawn up by Hultén (1950) in Fig. 16 shows that *Corylus* is a common plant nowadays in Denmark and along the southern coasts of the Baltic Sea and the Gulf of Finland, extending east to the Karelian Isthmus. Farther east on the map, the broken lines signify that the information on the occurrence of the species is scanty. In the southern part of Sweden, *Corylus* is commonly met with up to about 60° N Lat., but sporadic occurrences have been reported from the Bothnian coast as far as roughly 63° N. Along the western coast of Norway the filbert commonly occurs up to 62° N, then continues to grow as a rare species up the Atlantic seaboard nearly to the Arctic Circle, and sporadically appears even in the Lofoten Islands, or around 68° N Lat. Study brings out the fact that *Corylus* generally thrives on the seaboard and under maritime climatic conditions. That (Fig. 16) the plant has withdrawn from its ancient habitat in the river valleys extending deep into the hinterland to the present-day seacoast adds to the evidence. *Corylus* has thus shown partiality to the seaboard in

Scandinavia also in postglacial times, for the river valleys referred to used to be inlets of the Baltic Sea, just as the lake systems of Finland were once upon a time.

Rudolph (1930) has observed that the Boreal hazel period and even later times are represented in the western part of Germany, along the Baltic coast and at the highest elevations of certain mountain ranges by high frequencies of *Corylus* pollen. The precipitation in these regions is greater and the summers there are cooler than in lowlands, where there is a paucity of *Corylus* pollen. There appears to be a low frequency of *Corylus* pollen in sediments of the Boreal period in lowland regions where the annual precipitation nowadays is less than 600 mm (Firbas 1949). It may be added that the most abundant occurrences of *Corylus* in Finland today are in areas where the precipitation exceeds 600 mm a year, and the situation appears to be the same elsewhere in Fennoscandia (Hultén 1950).

Many researchers have focussed their attention on the northern occurrences of the filbert in Sweden. Andersson (1902) noted that the filbert often grows in these localities at the rocky base of steep cliffs as well as on slopes with a southern exposure. Humus and nutrients are constantly being washed down precipices by rain, and the waters running down keep the soil at the base damp. It is also conceivable that the heat absorbed during the summer by the great rock massifs and the boulders heaped up at their base is only gradually given off in the fall and winter months. As a result the climate in the immediate surroundings of massive rocks would be more favorable than at some distance away. Also Okko's researches suggest this (1958). He has observed that rocky stretches on eskers and piles of stones used in macadamizing store up heat in summertime so abundantly that snow falling on them in winter keeps on melting away in places. Measurements have proved that even under weather conditions of between 20° and 30° below zero C, air streams out of heaps of rocks or stones with temperatures of + 4° to + 8° C.

Also Halden (1956) and Pettersson (1950) have had their attention attracted by the rockiness of the filbert's habitat. The latter has even published a couple of illuminating photographs of such stations. He has noticed plants favoring lime, notably mosses, sharing the localities up north in which *Corylus* occurs. Halden, again, as a geologist, has particularly studied the bedrock of the localities of occurrence and found it to consist invariably of basic rocks. His conclusion is that the most important conditions for the filbert's survival in its northern stations are calcareousness and dampness of the soil. Even slight limestone veins are likely to insure a congenial environment for the growth of *Corylus*. Halden regards edaphic factors as extremely important, more so than the local climate, which in Andersson's view is decisive.

The northernmost *Corylus* occurrence in Finland, that at Vaarunvuori, Korpilahti commune, is also, according to Söyrinki (1946), in rocky terrain. On his visit there, the filbert plants were five meters high and thriving. Growing on them in considerable abundance were green nutshells, which were empty. According to Erkamo (1956), nuts do ripen there when the weather conditions are favorable in summer. Close by at Vaarunvuori there grow other exacting plants normally found in a more southern habitat, which suggests congenial circumstances. Among the species might be mentioned *Tilia, Ulmus scabra, Daphne* and *Lactuca muralis.* According to Frosterus' (1902) petrographic map, Vaarunvuori is located in a granite and amphibolite contact zone. It is apparent that the explanation for the occurrence there of *Corylus* and other plants not adapted to rigorous conditions lies in the basic properties of the bedrock, though in the case of *Corylus* the stony ground may be a significant contributing factor. Also the locality of the find at Kinkomaa, on the southeastern slope of a hill, is, according to E. J. Valovirta (1960), heavily broken rocky terrain. It must not be forgotten, however, that man has brought under plow the choicest areas in which *Corylus* had flourished in mineral soil. The filbert has thus vanished from such areas, whereas in rocky places it has been left alone. These places accordingly appear to be hospitable to the species in the hinterland to an exaggerated extent — and this remark applies especially to the northern range of the plant.

The nut finds discussed in the present paper have been made in bogs that in many cases have provided a luxuriant habitat for the filbert. In certain cases the edaphic conditions were exceedingly favorable. In the eutrophic peat of Varkkasalonräme in the limestone area of Vimpeli (5), the effect of the lime is to be seen in high pH values, and it is apparent also in the present vegetation of the bog. According to my researches, the CaO-content of ashes of peat from there is a high 43 to 49 per cent, whereas in most cases in Finland it is less than 20 %. Also the southern slope of Tuomikorpi (4), Vimpeli commune, with its plentiful springs, and the vivianite and siderite lenses of the peat layer as well as the rich swampy forest of past and present encompassed by the bog bear witness to the favorable conditions under which the filbert could grow there. It has not been possible to establish the other nut finds to be so clearly associated with a soil containing lime and nutrients. Yet, considering pollens, spores, vegetable cell tissue and certain other factors, it can be concluded that without exception in these localities, there had also prevailed the fertile conditions characterizing rich swampy forests or spruce-and-broadleaved-tree swamps. In numerous instances, one would never suspect on seeing the present surface vegetation of the bog — which is apt to be oligotrophic — that the filbert had once grown in the same place in times past.

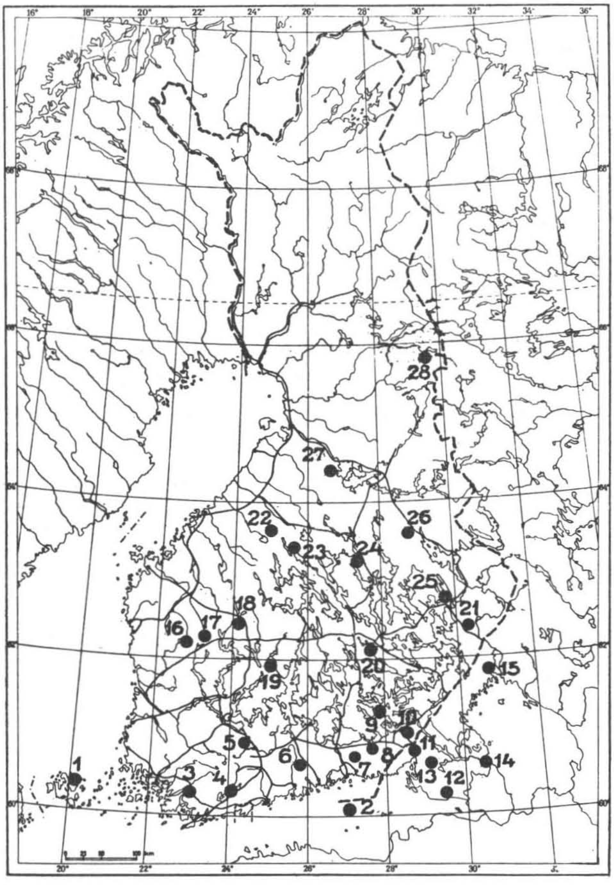

Fig. 17. Sites of pollen diagrams used in making comparisons.

FREQUENCY IN THE POLLEN DIAGRAMS

The nut finds dealt with in the present paper go back to the sub-Boreal times at the end of the postglacial warm period, that is, a very late date. However, numerous pollen diagrams show that throughout the Atlantic period *Corylus* pollen occurs most abundantly in the southern part of Finland. In places, pollen grains are present in considerable quantity even in older sediments.

The occurence of *Corylus* pollen in various diagrams will be considered in the following. They have been selected from different parts of the country and in the main have been published before; but included is also unpublished material studied by the author. The localities represented by the diagrams are marked in the map presented in Fig. 17 with the numbers from 1 to 28. Fig. 18 shows the columns representing *Corylus* pollen as taken from the diagrams, the climatic zones or stages of the Baltic Sea, the kinds of deposits in the series of layers and the elevations of the localities. The localities are geographically classified as follows: southwestern and southern, southeastern, central and northern areas.

Because the pollen diagrams have been dated either by forest-historical zoning or by division accordind to the stages of the Baltic Sea, the time divisions are given according to each author's interpretation.

The southwestern and southern area where *Corylus* at present generally grows — except in its eastern part — is represented by seven diagrams. In Figs. 17 and 18 they are numbered from 1 to 7.

Locality 1 is from the Åland Islands, the diagram depicting the bog called Jansmyren, in Saltvik commune (Backman 1943, p. 19). The lower part of the sediment sequence dates from the Littorina period. The deposit is for the greatest part organogenic.

During the first half of the Littorina, the *Corylus* column is strong, with a maximum of 16 %. Toward the end of the period it narrows and becomes discontinuous. The specimens from the surface layer of the bog lack *Corylus,* and yet the plant grows at Saltvik and throughout the Åland Islands today as quite a common species. In certain other diagrams from the Åland Islands drawn by Backman *(op. cit.)*, *Corylus* is even more prominent and in spots extends with frequencies of 1 and 2 % up to the surface. On the whole, it may be stated in this connection that the *Corylus* frequencies are higher in the Åland diagrams than in those representing other parts of the country. Unfortunately, there is no data from there on the pollen flora of sediments antedating the Littorina period.

Diagram 2 is from Liivalahdensuo, Suursaari, U.S.S.R. (Sauramo 1958, p. 174). Also in this diagram, which represents the islands of the Gulf of Finland, the *Corylus* column is strong. It rises several times to values of 7 or 8 % in coarse detritus ooze. Frequencies of 1 and 2 % are met with in a few consecutive specimens dating already from the pre-Boreal, but the continuous occurrence of *Corylus* does not begin until the turn of the pre-Boreal and Boreal periods. The highest values are registered during the postglacial warm period in zones VI to VIII. The continuity of *Corylus* is broken at the beginning of the sub-Boreal. However, it is met with for some distance higher up as sporadic occurrences, but is lacking altogether in the peat of the surface layer. The filbert no longer grows on Suursaari, as far as is known.

Diagrams 3—5 represent the western part of southern Finland. Diagram 3 is from Håmarjärvensuo, Perniö commune (Aurola 1938, p. 61), diagram 4 from Nälköönlammensuo, Lohja (Sauramo 1958, p. 123) and diagram 5

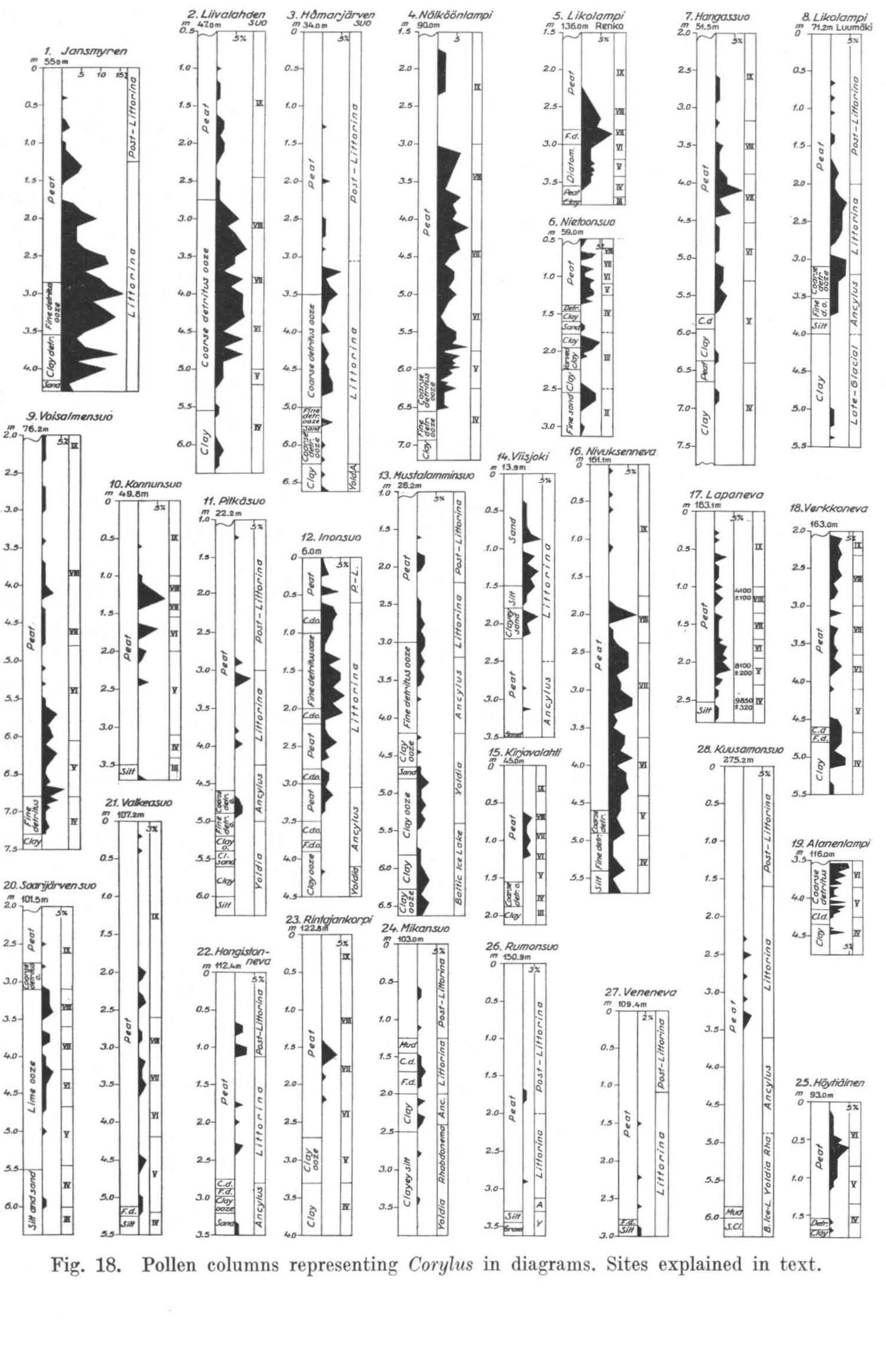

Fig. 18. Pollen columns representing *Corylus* in diagrams. Sites explained in text.

from Likolammensuo, Renko (Sauramo 1958, p. 245). In diagram 3 the *Corylus* column is more fragmentary and narrower than in both the others. In it the *Corylus* maximum is 5 %, in the others 8 %. A common feature of diagrams 4 and 5 is the fact that in both the continuous and very prominent occurrence of *Corylus* begins in the organogenic sediments of the pre-Boreal. In all three diagrams the continuous *Corylus* column is broken right at the end of the warm period. In the two preceding cases its pollen appears at higher levels only as a few sporadic occurrences and disappears altogether in approaching present times. Yet the diagrams cited are from localities where *Corylus* commonly grows nowadays (Fig. 15).

Diagram 6, from Nietoonsuo, Askola (Tynni 1960, p. 152), deviates from the foregoing ones on account of the nature of its older sediments, which are minerogenic. The frequency of *Corylus* is between 4 and 5 % in the sediments of both Alleröd and the Younger Dryas. The more continuous occurrence of *Corylus* pollen begins at the end of the pre-Boreal and it forms a very broad column extending throughout the postglacial warm period. *Corylus* no longer grows in the Askola area but it does grow quite close by to the south (Fig. 15).

The easternmost diagram representing southern Finland, No. 7, is from Hangassuo, Sippola (Salmi 1948, p. 7). In the pre-Boreal clay, *Corylus* pollen grains are scantily present, but they begin their actual occurrence in peat dating from the latter half of the Boreal period, and the column extends, if somewhat discontinuously, as high as the middle of the sub-Boreal period, the maximum being 7 %. Later there are a couple of sporadic occurrences at the 2.6-m level. The *Corylus* column from Hangassuo is narrower than in the preceding diagrams. The bog is in the rapakivi granite area of Viipuri. Fig. 15 indicates that the filbert does not grow at present in Sippola. The nearest localities where the species does occur are approximately twenty kilometers away to the west and to the south.

The southeastern range, which is represented by nine diagrams, or sites 8 to 16, includes the Karelian Isthmus up to Lake Saimaa as well as the Ladogan coast.

Diagram 8 is from Likolampi bog, Luumäki commune, about 3 km SE of the railroad station of Taavetti (Hyyppä 1937, p. 113). The late-glacial clay contains a slight amount of *Corylus* pollen, but during the middle of the Ancylus the pollen column gains strength and reaches its maximum of 4 % at the beginning of the Littorina. The column continues almost without change in breadth to the end of the period just referred to, after which it rapidly narrows. At the end of the post-Littorina period, a few sporadic 1 % frequencies of *Corylus* are registered. At the present day the filbert does not grow in the near surroundings (Fig. 15). The nut find Somerharju, Luumäki (Tolonen 1960), however, proves that *Corylus* had previously grown close to Likolammensuo (Fig. 1). This is furtber demonstrated by the high frequency of *Corylus* during the Littorina in diagram 8.

In pollen diagram 9 (Lappalainen 1960, p. 80) representing the island of Voisalmi in Lake Saimaa near Lappeenranta, the continuous occurrence of *Corylus* begins during the pre-Boreal and extends as a column varying in breadth between 1 and 6 % up to the middle of zone VI. Later *Corylus* grains occur sporadically after some brief gaps in 1 % frequencies up to the surface of the bog. The upper part of the profile has not been included because the occurrence of *Corylus* there is similar to what it is at the depths between 4 and 2 meters. Such a consistent if slightly discontinuous and weak *Corylus* column in the pollen diagram suggests the proximity of the species' habitat. Fig. 15 shows that the filbert grows at the present day in a few places along the southern shore of Lake Saimaa.

In diagram 10 from Konnunsuo (Salmi 1959 a, p. 59) and diagram 11 from Pitkäsuo, 10 km NW of Viipuri (Hyyppä 1937, p. 140), the occurrence of *Corylus* is like that described in the foregoing, discontinuous but nevertheless from time to time strong. The highest value in the former diagram is 7 % and in the latter 4 %. The principal occurrence of *Corylus* is concentrated at Konnunsuo in zones V—VIII, corresponding to the sediments of the Ancylus and Littorina periods in diagram 11. In the diagrams presented by Sauramo (1951 and 1954) from Konnunsuo, the frequency of *Corylus* is considerably higher than in the one reproduced here and the occurrences begin in zone III. *Corylus* grows at the present day near Konnunsuo but not in the vicinity of Pitkäsuo (Fig. 15). The latter is situated in the Viipuri rapakivi-granite area, which may be one reason for the sparse occurrence of *Corylus* throughout the diagram. On the other hand, also diagrams 7 and 8 are from the rapakivi-granite area, but in them *Corylus* has very high frequencies in sediments dating from the postglacial warm period. *Corylus* does not grow in either vicinity at present.

The western part of the Karelian Isthmus is represented by diagram 12, the central part of it by diagram 13 and the eastern part by diagram 14. The true occurrence of *Corylus* in the bog of Ino, depicted in diagram 12 (Hyyppä 1937, p. 176), begins in the peat dating from the latter half of the Ancylus and continues with only slight gaps up to the surface. The column is at its strongest during the Littorina period. The highest, 6 % peaks occur around the middle of this period. The filbert grows at the present day in the Ino area (Fig. 15).

The clay of the lower part of diagram 13 from Mustalampi, Kämärä (Hyyppä 1937, p. 15), antedates the Yoldia period, being contemporaneous with the Baltic Ice Lake. It corresponds in diagram 6 to zone III, or the Younger Dryas, and at the lowest level apparently is even older. In the sedimets representing the Baltic Ice Lake, the *Corylus* column is continuous with values of between 1 and 3 %. In the Yoldia sediments there is a corresponding occurrence. Thereafter, *Corylus* appears only sporadically, until at the end of the Ancylus there begins a column which extends continuously throughout the Littorina period but remains surprisingly narrow, registering values of only 1 or 2 %. Following the Littorina period, *Corylus* is met with only sporadically but, according to the original diagram, all the way to the surface. According to Fig. 15, *Corylus* grows at present in the vicinity of Kämärä.

In the diagram 14 of the bluff bordering Viisjoki in the commune of Metsäpirtti (Hyyppä 1942, p. 159), it is not until the Littorina period begins that *Corylus* pollen is appreciably present, with values between 1 and 5 %. The area is within the present range of *Corylus*.

In diagram 15 (Sauramo 1958, p. 349) showing the bog of Kirjavalahti, Sortavala, situated near the northern coast of Lake Ladoga, *Corylus* pollen occurs in zones VI—VIII, but only in frequencies of 1 or 2 %, and in later zones not at all. Judging by the low frequencies, in spite of the continuousness of the column, the species probably did not grow in the locality. The presence of the *Corylus* pollen grains must thus be attributed to long-distance flights from filbert occurrences in the surroundings during the postglacial warm period. The present station of *Corylus* on the northwestern shore of Ladoga lies some thirty or forty kilometers from the town of Sortavala to the southwest (Fig. 15).

The central area is represented by diagrams 16—21. The localities lie some distance north of the present range of *Corylus* and near the northernmost nut finds reported here.

The westernmost diagram from this area, No. 16, depicts Nivuksenneva, in Parkano commune. It is made up of previously unpublished material. The *Corylus* column extends in the diagram from the pre-Boreal to the end of the sub-Boreal quite continuously, ranging in value from 1 to 7 %. On higher levels the species occurs sporadically all the way to the surface. Owing to the strength of the *Corylus* column in zones VI—VIII, this diagram resembles No. 4, from Nälköönlampi, Lohja commune.

Diagram 17 (Salmi 1962 b, p. 198) from Lapaneva, Kihniö, resembles the diagram from Nivuksenneva with respect to the *Corylus* column. In the diagram from the barren watershed bog of Lapaneva, the column, it is true, is narrower all the way (1—4 %). The column runs almost continuously from the pre-Boreal period close to the surface of the bog. The formation of peat at Lapaneva started during the pre-Boreal period, thus deviating from the majority of the other diagrams at hand. A radiocarbon determination has confirmed the fact that the peat dates back to the pre-Boreal. The oldest allochthonous peat in the lower part of the profile has yielded a result of 9 850 $\pm$ 320 years B. P. (Salmi 1962 b). Pollen-analytically this corresponds to the latter half of the pre-Boreal period. The nearest present-day stations of *Corylus* are from localities 16 and 17, some seventy kilometers farther south, in the vicinity of Kyrösjärvi (Fig. 15). On the other hand, the sub-Boreal nut find No. 9 from Kiimaneva, Kihniö, discussed in the foregoing, is from the half-way point of diagrams 16 and 17, approximately 5 km west of Lapaneva.

Diagram 18 is from Verkkoneva, Pihlajavesi (Mölder and Salmi 1955, p. 80). The *Corylus* column is continuous and strong (1—4 %) as early as the end of the pre-Boreal and the beginning of the Boreal period. Pollen of the species is lacking at the end of the Boreal but begins to appear again in zone VI and continues as a column encompassing a breadth of 1—3 % to the early half of the sub-Atlantic period. *Corylus* pollen grains appear in the diagram even later as 1 % sporadic occurrences up to the 0.8-m level. The locality clearly belongs to the ancient range of distribution of *Corylus*.

Diagram 19 is from Alanenlampi, Jämsä (Sauramo 1958, p. 288). The diagram includes only zones IV—VI. *Corylus* is found even in pre-Boreal clay, where it registers a value of 4 %. Higher up, on the level containing detritus ooze, the column representing the species is an almost continuous one, with a breadth of 1—4 %. Alanenlampi lies not far, or at a distance of some 30 km to the west, from Vaarunvuori, the northernmost station of *Corylus* in this country.

Diagram 20 is from Saarijärvensuo, Joroinen (Valovirta 1962, p. 44), the northernmost present-day station of *Cladium mariscus*. *Corylus* is scantily present starting from the pre-Boreal period, but its more continuous 1—3 % occurrence is concentrated in zones VI—VIII, when the plant evidently grew in the vicinity. On high levels its pollen takes a sporadic turn. The closest localities where *Corylus* occurs at present are more than 100 km away to the southwest and southeast (Fig. 15). Subfossil nuts, on the other hand, have been found at Pielavesi, more than 100 km farther north, as well as at distance of around 50 km to the southwest; but east of the locality none have been run across (Fig. 1). Valovirta *(op. cit.)* has found remains of *Cladium mariscus* in Saarijärvensuo from as deep a level as the early Boreal. Saarijärvensuo is a bog fed by springs and at its bottom is 2.5 m of lime ooze. The locality would thus afford *Corylus* a very congenial habitat.

Diagram 21 is from Valkeasuo, Tohmajärvi. It has not been previously published. Compared with the ones discussed earlier, the occurrence of *Corylus* pollen in this diagram is scanty on the whole. The oldest occurrences are in fine detritus ooze and peat dating to the Boreal period, but more continuous frequencies of 1 or 2 % occur in zones VII and VIII. Grains of the pollen are present here and there all the way to the surface of the bog. This suggests the possibility of long-distance flights even in the case of the oldest sediments, when the *Corylus* stations were evidently nearer and the pollen concentrations therefore greater than at present. It is also possible that the species had grown in the vicinity as a flowering plant. The soil around Valkeasuo would certainly have provided favorable stations for the plant. Even at the present day species requiring rich soil grow there in abundance — for instance, *Aconitum* occurs a short distance south of Valkeasuo. Some seventy kilometers south of Valkeasuo, Rillinkisuo in the commune of Saari contains such an abundance of *Corylus* pollen in zones IV—VIII, according to the unpublished diagram from there, that *Corylus* must have grown there. Thus, the vicinity of Valkeasuo probably was situated at the margin of the ancient range of *Corylus*. The nearest stations of the plant at the present day are about 100 km south of Valkeasuo (Fig. 15) and the nearest nut finds even farther away (Fig. 1).

The northern area includes seven diagrams, localities 22—28. They are all clearly situated north of the present range of the filbert and also north of the nut finds, except for locality 24 (Fig. 1), which is slightly on the southern side of the Ilomätäs nut find, in Pielavesi commune, though some 40 km to the east-southeast.

Diagrams 22 and 23 resemble each other closest among the diagrams from this area. Locality 22 is from Hongistonneva, Toholampi (Okko 1949, p. 38) and locality 23 from Rintajankorpi, Pihtipudas (Sauramo 1958, p. 303). In both diagrams *Corylus* occurs sporadically. In the former the pollen frequency ranges from 1 to 3 %, in the latter from 1 to 4 %. In diagram 22, *Corylus* is present from the Ancylus period to the first half of the post-Littorina, but in diagram 23 it occurs only on the level of the Atlantic period in zones VI and VII. Occurrences of this strength suggest that *Corylus* had grown during the Littorina period in the vicinity of each of the places. The *Corylus* columns of each bring to mind especially diagrams 10 and 11. The Pielavesi nut find is from Rintajankorpi, roughly sixty kilometers to the southeast.

Diagram 24 is from Mikansuo, Siilinjärvi (Lumiala 1940, p. 4). The same bog has yielded *Trapa natans* nuts. This *Trapa* find is the second most northern made in this country — coming after the one at Evijärvi (V. Valovirta 1960). The appearance of *Corylus* begins with sporadic 1 % values in the Yoldia sediment; the frequency increases during the Ancylus period to 2 % and it then forms a column between 1 and 2 % in breadth extending through several specimens from the Littorina period. Pollen grains are also met with at higher levels in small amounts. Diagram 21, from Valkeasuo, is brought to mind especially. It is evident that *Corylus* grew at Siilinjärvi as a blossoming plant around the same time as *Trapa natans* flourished in the lake later filled by Mikansuo. The *Trapa natans* finds were made at Mikansuo at a depth of only 140 or 150 cm, or at the level were the continuous

Corylus pollen column ends. The general emergence of *Picea* begins in the diagram at the 120-cm level. *Trapa* thus had grown in the basin of Mikansuo during the sub-Boreal period. Around the same time it had also gro wnat Evijärvi (Valovirta, *op. cit.*). In the bogs of the Kuopio vicinity, according to Donner (1957), *Corylus* pollen occurs in considerable abundance, but starting at the level of zone IV the frequency drops low.

Diagram 25 is from Lahdenpohja bog adjacent to Lake Höytiäinen (Sauramo and Auer 1928, Sauramo 1958, p. 392). Höytiäinen became isolated from the Yoldia Sea, according to Sauramo (1958), during the pre-Boreal period, when the area began to undergo paludification. The bog was inundated by the transgression of Höytiäinen during the Atlantic period. The diagram shows a couple of 1 % sporadic occurrences of *Corylus* pollen at the pre-Boreal level, but the continuous column encompassing frequencies between 1 and 4 % begins at the end of the Boreal and breaks off in zone VI, at the beginning of the Atlantic period. A *Corylus* column as prominent as this must be taken as evidence that the filbert had grown in the Höytiäinen vicinity since the end of the Boreal period.

Diagrams 26, 27 and 28 resemble each other in that they all present low frequencies of *Corylus* pollen. Diagram 26 is from Rumonneva, Valtimo (Kilpi 1937, p. 72), diagram 27 from Veneneva, Pelso (Salmi 1952, p. 9) and diagram 28 from Kuusamonsuo, Kuusamo (Hyyppä 1941, p. 603). In diagrams 26 and 27 *Corylus* occurs only sporadically in frequencies of 1 %. The sporadic 1—2 % occurrences of Kuusamonsuo are limited to the Littorina period.

The localities just discussed lie several hundreds of kilometers from the nearest *Corylus* station of the present day. Localities 26 and 27 are more than 100 km and Kuusamonsuo several hundreds of kilometers from the northernmost finds of subfossil nuts.

Lumiala (1939) could find no *Corylus* pollen in Vanhalammensuo, Kuusamo. On the other hand, Kanerva's (1956) diagrams show sporadic 1 % occurrences here and there. In a number of Vasari's (1962) diagrams from Kuusamo, *Corylus* registers also values of 1 or 2 % and in spots occurs as continuous columns extending through several specimens. In diagrams from Koverinjärvi and Lehmilampi, such occurrences continue close to the surface, judging by which the *Corylus* pollen of the area must in all cases represent long-distance transportation through the air.

Corresponding sporadic occurrences of *Corylus* pollen — comparable to those, that is, of localities 26 and 28 — have been met with, according to the present writer's unpublished material, in, among other places, the bog profiles of Sodankylä, Lapland. This observation applies also to other rare deciduous species. Aario (1940) has discovered *Tilia* and *Ulmus* pollens even in surface samples from the bogs of Petsamo, near the Arctic coast.

In that remote province their occurrence can unquestionably be attributed to long-distance flights. The same explanation can be given to account for at least the presence of *Corylus* pollen in diagrams 26, 27 and 28.

A study of the pollen diagrams has revealed that in the case of the diagrams from Kämärä and Askola, Nos. 13 and 6, *Corylus* had such high frequencies during the Baltic Ice Sea and Alleröd times as to suggest the plant's having grown then on the Karelian Isthmus and in the southern part of this country. The edge of the continental ice sheet coincided in those times with the Salpausselkä belt. Auer came to the conclusion in 1928 that *Corylus* had grown on the Karelian Isthmus as early as the period of the Salpausselkä belt. Hyyppä (1936) likewise considers it possible that *Corylus* had grown in the forests of the Karelian Isthmus during the time of the Baltic Ice Sea. Further, Mölder, Valovirta and Virkkala (1957) and Salmi (1959 b) have found abundant *Corylus* pollen in sediments dating back to the Alleröd period in Southern Finland.

In diagrams 2, 3, 4, 5, 9, 16, 17, 18 and 19 from southern and western Finland, the pre-Boreal sediments contain considerable *Corylus* pollen. Scantier occurrences are met with in diagrams 7, 8, 20 and 25 from eastern Finland. On the other hand, the series of sediments in the diagrams mentioned do not extend down to older times or they have not been analyzed as, for instance, in the case of the profile from Hangassuo (7). Its lowermost clays, which go down at least 1.5 m deeper, could not be brought up by drilling. In diagrams 10, 11 and 12 from the Karelian Isthmus as well as diagrams 21, 24 and 25 from eastern Finland, *Corylus* pollen occurs in abundance only beginning with the Boreal period and Ancylus sediments. In diagrams 14 and 15, from the Ladogan coast, *Corylus* occurs significantly only after the deposits representing the Littorina period have been reached. It appears around the same time also in diagrams 22 and 23, which are from the proximity of the northern limit of the subfossil nut finds. The scanty sporadic occurrences of *Corylus* in the most northern diagrams, Nos. 26, 27 and 28, in sediments dating from the postglacial warm period indicate mainly that the range of *Corylus* extended farther north at that time than at any other time since the Ice Age and that the frequency of *Corylus* was then at its highest in the forests of Finland. The pollen diagrams thus clearly show that in zones IV—VIII the frequency of *Corylus* diminishes from west to east and from south to north. The same phenomenon may be separately observed also in the area of the Karelian Isthmus. Accordingly, *Corylus* has been primarily southern and western species in this country throughout the ages.

Following the Littorina period, the frequency of *Corylus* pollen declines in the diagrams. This is clearly to be seen also in the diagrams, Figs. 3 to 14, that have been drawn from the bogs where the northern nut finds were made. On account of the deterioration in the climate after the period mentioned, species with exacting requirements begin to disappear from their northern stations, among them also *Corylus*. As *Corylus* pollen occurs but scantily in post-Littorina sediments even in localities where the plant now grows, the explanation lies mainly in the fact that the conifers — notably *Picea* in western Finland — became the dominant species of the forests at that time. On account of their abundant pollen output and the good disseminative capability of their pollens (Salmi 1962 a), the small output of *Corylus* pollen is reduced to slight frequencies in the pollen diagrams.

RELATIONSHIP TO THE HISTORY OF THE BALTIC SEA

It has been observed in the foregoing that *Corylus* thrives especially along seacoasts and that the stations of the species in the hinterland, notably along the shores of great river and lake systems, bear witness to times when such localities were on the Baltic seaboard. This suggests the thought, moreover, that the plant had arrived in Finland by water and that its dissemination by land has been very slight.

Starting with the premise that *Corylus* had reached Finland across water and at an exceedingly early stage, as the pollen diagrams reveal, the present and past stations of the species are of different ages, as determined by varying elevations, taking into account the land uplift. It is evident, as I look at it, that once the filbert had taken root in some hospitable locality, it must have continued to grow there unless conditions changed sufficiently to destroy the plant. Thus, it represents a relict in its isolated, elevated northern stations. In these places the plant has disseminated by pollination only in the immediate surroundings, or where the station has been located on a hillside or sloping shore, the nuts are likely to have rolled down and even found their way into a body of water. Transportation of nuts across water could bring about the dissemination of the species far from former stations; brooks and rivers could take the plant to considerably lower niveaus, too. On the other hand, the dissemination of nuts to higher elevations cannot be conceived of except if through the agency of, for example, squirrels and certain birds, or, perhaps, human beings. Leaving out the last-mentioned factors because their contribution cannot be considered significant, the elevations of the nut occurrences ought to indicate at least the height of the shoreline during the stage in the evolution of the Baltic Sea when the filbert arrived in the locality.

The map shown in Fig. 19 has marked on it the nut finds known in Finland. The basis of the map is the Rhabdonema Sea (Rha) stage in the evolution of the Baltic, as depicted by Sauramo (1939). This stage comprises the end of the period of the Yoldia Sea and the forest-historical *Betula*

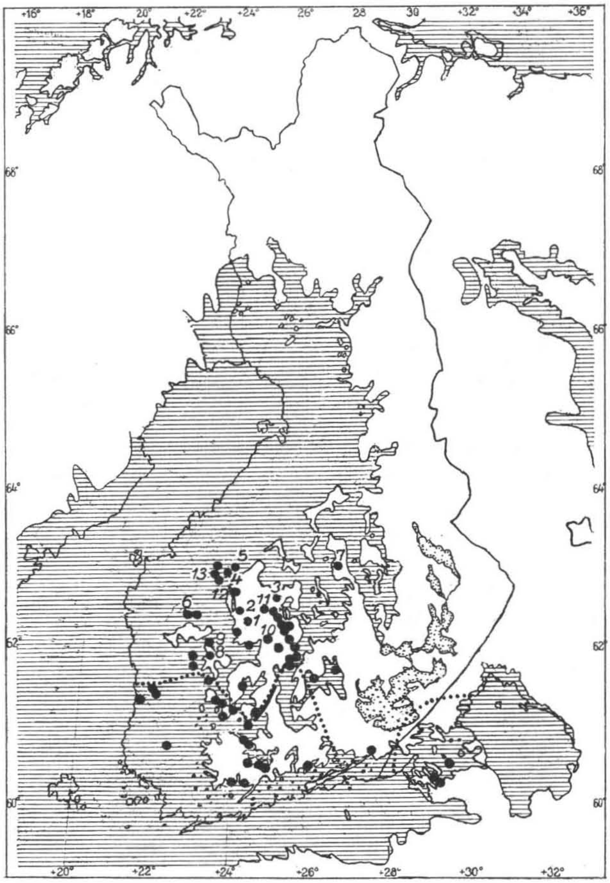

Fig. 19. Rhabdonema sea, after Sauramo (1939), and the relation of the subfossil hazelnut finds to it.

maximum from the final half of the pre-Boreal period before the beginning of the Boreal *Pinus* maximum. In Sauramo's (1958) later chronology, it corresponds most nearly to the final stage of the pre-Boreal Yoldia and the initial stage of the Echeneis Sea, and in Hyyppä's (1960) chronological table and relation diagram to the end of the pre-Boreal Yoldia period. According to Sauramo (1939), the stage under consideration lasted c. 550 years and falls on both sides of the date 7 000 B. C.

The map shows that a noteworthy part of the localities in which nuts were found are situated on the coast and on islands during the marine stage. A goodly number of the localities are situated at higher elevations and in areas older than the stage referred to. Only a slight proportion of the westernmost finds are located within the bounds of the sea as it existed in that remote time — which signifies that they represent occurrences more recent than that marine stage. The map further shows that the waters of Saimaa had extended as far as Pielinen at the time, but the lake system had reached its easternmost point even before the Yoldia period, without connections to the Baltic Sea.

Attention is at this point attracted expressly to the fact that nut finds have not been made in the eastern part of the country. On the Karelian Isthmus they are rare, as in the case of southern and southwestern Finland, too. The majority of the finds have been made in western Finland, north of the present limit of distribution of the filbert.

It is possible that for some reason no information has been made available on subfossil occurrences of hazelnuts in the eastern part of Finland. The reason for the lack of data may be due, for instance, to the fact that ditches have not been dug in the bogs of eastern Finland for drainage purposes or peat has not dug out of them as soil improvement material to the same extent as farther west, where a good part of the finds have been made in conjunction with such operations. Nor have researchers drilled bogs there to the same extent as elsewhere in the southern half of the country. Only a few nut finds have, however, been made in connection with research projects. On the other hand, basic rocks occur in the region at least as much as in the areas farther west where nuts have been found (Simonen 1960). Examples that might be cited are the olivine and serpentine of Juuka, Kaavi, Polvijärvi and Kuusjärvi (Outokumpu), the gabbroid amphibolites of Tohmajärvi, Kiihtelysvaara and Ilomantsi, the gabbros of Pieksämäki and Joroinen, the limestone of Virtasalmi and Kerimäki as well as the marble occurrences of Ruskeala (U.S.S.R.) Moreover, the climate in this region has always been more continental than in western parts of the country. The bogs in eastern Finland are comparatively shallow and rather small, and ditches have been dug in them to a sufficient extent to have made possible the making of finds. And there is no reason to believe that the people in that part of the country would not have paid attention to the appearance of nuts in the same measure as people in the more western regions. Researchers have sent out inquiries about nut finds all over the country and requests for information have been published also in newspapers and magazines. Thereby the majority of the nut finds in Finland have come to light. Accordingly, it appears evident that *Corylus* has not grown in eastern Finland in late- and postglacial times or, if it has, it has not produced nuts there. To judge by the abundance of *Corylus* pollen, the latter possibility must be taken seriously in, e.g., the vicinity of Höytiäinen and Tohmajärvi, as pointed out earlier.

The concentration of nut finds in western Finland, their absence from eastern Finland and the surroundings of the main body of Lake Saimaa, and the division of the water at the end of the Yoldia in the manner presented in Fig. 19 bolster the impression that *Corylus* was carried to Finland across water. Thus, the original source of the species must be sought across the Gulf of Finland and in the regions south of the Baltic, as well as, at a later date, southern Sweden. The spread of the filbert across the Karelian Isthmus appears to have been on a smaller scale and to have resulted in a separate eastern range. Evidently, there, too, the species had been transported by water, whether down rivers flowing from Ingria in the Leningrad district northward, across Lake Ladoga or over the Gulf of Finland, in which case westerly transport cannot be totally ignored as a possibility. The spread of the eastern range of *Corylus* toward the north was obstructed and retarded by several different factors. Among them should be mentioned the water connection between the Gulf of Finland and Lake Ladoga up to the Littorina period, the lack of rivers running northward from the Karelian Isthmus and the more rapid rate of land uplift in the northwest than in the southeast and the consequent tilting of the country toward the southeast. It is this last-mentioned factor that caused the transgression of lakes in the south and southeast. As a result of this and transgressions of waters in the Baltic Sea, the effects of which were felt in the sphere of the Karelian Isthmus and throughout southern Finland, *Corylus* associations disappeared — having been submerged on the old shores that had provided them with a hospitable environment. The disappearance of, for example *Hippophaë* from the whole of southern Finland has likewise been attributed to the postglacial transgressions (among others, Hyyppä 1932 and Salmi 1948). In addition, the Salpausselkä ridges have formed natural obstructions to the spread of the filbert northward. The Viipuri rapakivi area, again, with its nutrient-poor soil has prevented the dissemination of the species westward. It should further be noted that early in the late-glacial and postglacial periods *Picea* was already a significant factor on the Karelian Isthmus and in Ladogan Karelia as a forest tree. As the stronger rival for favorable locations, it has also prevented the spread of *Corylus* in the region. In central Europe, according to Firbas (1949), *Picea* has been the greatest rival of *Corylus* during postglacial times in the struggle between species for ground to grow in.

So-called relation diagrams based on the development of the shorelines of the Baltic Sea in Finland have been presented to facilitate a comparison between various stages of the shore in different localities. The relation diagrams drawn up by different investigators differ from each other considerably and apparently continue to be subject to revision. The elevations at which the nut finds dealt with in the present study have been made have been plotted in the relation diagram constructed by Hyyppä (1960), as reproduced in Fig. 20.

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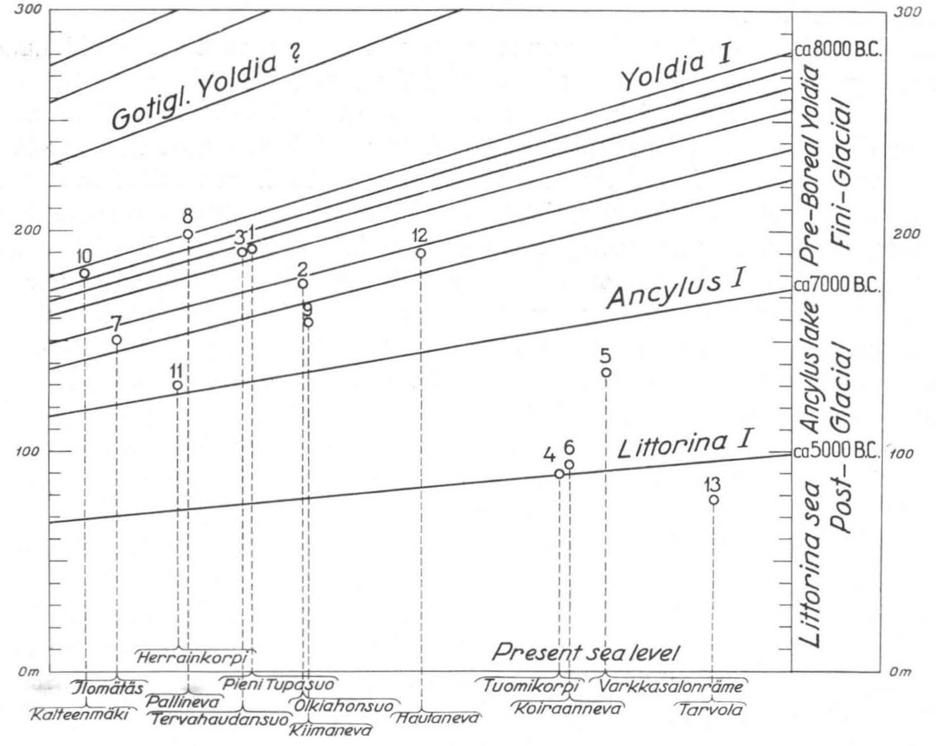

Fig. 20. Age relations of nut finds in the light of Hyyppä's (1960) relation diagram.

As a general feature the figure shows that the majority of the nut finds fall between Yoldia I and Ancylus I on the lines representing the different shorelines of the pre-Boreal Yoldia, and that only a minor portion of them are situated on a lower level.

Judging by relative heights, the oldest of the *Corylus* finds include those of Pallineva (8), in the commune of Kuru, and Kalteenmäki (10), in the commune of Uurainen. In the relation diagrams they are on around the level of Yoldia I. In the light of this evidence the regions referred to must have been deglaciated by that time and the climate must have been very nearly as temperate as it is today in the northern parts of the present range of *Corylus*. A fragmentary salt-water diatom was found — though admittedly of a doubtful nature — in a sample of the undermost sediment i Pallineva. Considered together with the elevation and the early site of *Corylus*, this find tends to support the possibility that the marine stage of Yoldia I had extended to the basin of Pallineva. The predominance in the sediment of fresh-water diatoms and the paucity of their occurrence would have to be attributed to the proximity of the ice margin.

Situated on the same level in the relation diagram are the finds of Pieni Tupasuo (1), Ähtäri commune, and of Tervahaudansuo (3), Saarijärvi commune; on a slightly lower horizon those of Olkiahonsuo (2), Ähtäri, Ilomätäs (7), Pielavesi, and Hautaneva (12), Soini, and still farther down, those of Kiimaneva (9), Kihniö commune. An absolute age determination was recently made of the peat in the lowest layer of Lapaneva, located four or five kilometers from the last-mentioned site and approximating it in elevation. A pollen analysis placed the peat at the *Betula* maximum occurring during the latter half of the pre-Boreal, and its age was determined as being 9 850 $\pm$ 320 y B.P. (Salmi 1962 b), as already mentioned. Thus, all the afore-mentioned occurrences of nuts must have grown in mineral soil in the localities where they were found even before the date given or around that time at the very latest, while finds 11, 5, 4, 6 and 13 represent later dates.

The site of the find in Herrainkorpi (11), Saarijärvi commune, is located around the Ancylus I. Fig. 14 indicates that during the *Pinus* maximum of the Boreal period there had been a shore there, one that, to judge by the diatoms, which are typical of large lakes, corresponds to the stage of the fresh-water Ancylus sea.

There is a paucity of information on the elevations of the other sites where nuts have been found in this country. Valovirta (1959) reported the nut find of Muurame to have been made 80.2 meters and Tolonen (1960) the bog of Mahlaneva, Jalasjärvi commune, to be situated c. 95 m above sea level. The latter elevation thus is the same as that of the nearby Koiraanneva (6), and the two basins are of corresponding age. In the following the approximate elevations will be given of lakes on the shores or in the vicinity of which the filbert had once grown or grows today. This will enable us to obtain at least minimum values for the following sites of growth: Kyrösjärvi 83 m, Näsijärvi 95 m, Vanajavesi 80 m, Roine 84 m, Päijänne 78 m, Vesijärvi 81 m and Saimaa 76 m above sea level. A comparison of these elevations to the Littorina limit in each locality will show that they are all considerably higher than the latter. Saimaa is even above Hyyppä's (1960 and 1962) Yoldia I. Some of the present *Corylus* stations are located close to the Littorina limit in areas at a shorter distance from the seaboard, and on the coast they are below the limit. Also subfossil nut finds (Fig. 1) are observed to be situated in the main above the Littorina limit. Only certain of the westernmost finds in the Pori district and in South Bothnia (Etelä-Pohjanmaa) lie about on the same level or below it.

In Sweden abundant data are available concerning the elevations of ancient filbert sites. Andersson (1902) has drawn up a table showing the elevations of the bogs in which nuts have been found as well as a map illustrating the relation of the *Corylus* occurrences to the Littorina sea.

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These sources show that the filbert grows nowadays north of 61° N Lat. on around the shoreline of the Littorina sea or below it, whereas farther south the plant occurs also at higher elevations. Of the subfossil nut finds some are marked at approximately the height of the Littorina shore and only a few at a lower level, but quite a considerable part higher up. The highest sites are 400 to 450 meters above sea level. But the majority lie between the altitudes of 100 and 200 meters, accounting for 46 per cent of Andersson's material, which comprises in all 179 sites. They correspond closely to the various stages of the Ancylus shoreline and older habitats of the species (G. Lundqvist 1961). The highest known subfossil nut find made in Sweden was situated, according to Fries (1956 a and b), in a bog in Jämtland about 14 km south of the church of Bräck. The bog lies 475 m above sea level and its position is roughly 63° N Lat. The nut found there lay at a depth of approximately two meters in lake ooze. The horizon of the find has been placed by pollen analysis at the end of the Atlantic period (Fries 1956 b).

The nut finds in the present material are so grouped in the relation diagram of Fig. 20 that the ones situated on low Littorina isobases coincide with older shore levels and thus represent older habitats than those situated on high isobases. This is in agreement with the direction of retreat of the continental ice sheet and with the differences in the rate of uplift of the land in different parts of Finland. It further indicates that *Corylus* arrived at its northern stations soon after the ice had retreated from the region.

In the light of the relation diagram it may be concluded that the dissemination of the plant occurred especially during periods when the water in the Baltic sphere was on the rise. It was then that the most distinct shore levels originated: examples in Fig. 20 being Yoldia I, Ancylus I and Littorina I. Clear shorelines were generally etched into the face of the earth in periods when the water level and the rate of land upheaval were in balance or when transgressions of waters occurred. During the marine stage of the early Yoldia, nuts appear to have migrated as far the northernmost sites of finds — for example, Kuru (8), Uurainen (10) and, classifiable in the same category, Saarijärvi (3) and Ähtäri (1). According to Mölder, Valovirta and Virkkala (1957), there occurred one transgression of the Yoldia sea at the turn of zones III and IV. To the latter half of the Yoldia belong the finds of Pielisjärvi (7), Ähtäri (2), Kihniö (9) and Soini (12). Their age corresponds closely to the stage of the Rhabdonema sea and its transgression, as presented in Fig. 19. Since the majority of the nut finds seem to date from this time, the dissemination of *Corylus* must then have been at its most active stage. The find at Herrainkorpi (11), in the commune of Saarijärvi, unequivocally represents the time of the Ancylus transgression; and probably one of the occurrences of Vimpeli (5) is of contemporaneous origin. Among finds dating from the Littorina transgression are the ones made at the sites of Vimpeli (4) and Jalasjärvi (6) as well as, on a slightly lower niveau, of Lappajärvi (13). In the environs of Lappajärvi nuts have also been found in the shore bars of the present lake at an elevation of roughly 70 meters, or considerably below the highest Littorina. This indicates that during the Littorina period the filbert had spread in the sphere of the same lake, locally following the shores of the shrunken body of water from higher to lower elevations. As a result of similar local dissemination *Corylus* must have migrated during the sub-Boreal period from stations in mineral soil to boggy habitats. This process was advanced by the transgression during the Atlantic period of bogs over tracts of mineral soil in which the plant had established itself.

The history of the distribution of *Corylus* largely resembles that of *Myrica gale*, which Tuominen (1946) has studied. The earliest occurrences of *Myrica* have been found on the Karelian Isthmus and date back to the Baltic Ice Sea. The plant then spread ever farther north in the wake of the retreating ice, making the greatest advances during the marine Yoldia stage. The spread of the species was checked at the end of the Yoldia, and it occurred only on a small scale during the Ancylus and the Littorina.

In Finland, *Corylus* occurs mainly in the south, the southwest and the southeast. It has spread to the western part of its range from the southern side of the Gulf of Finland and the Baltic Sea as well as from southern Sweden. The eastern area, again, has received its share mainly from Ingria. Hiitonen (1946) classifies the filbert on the Karelian Isthmus among plants in the southern group, but considering the country as a whole it may be regarded there as a southeastern arrival. According to Kalela (1961), *Corylus* arrived in this country from both southeastern and southwestern-southern directions, and both populations have remained vigorous and effectively expanded their range in Finland.

There is reason to dwell a while longer on the connection between the dissemination of *Corylus* and the transgression stages of geological history. Owing to the mechanism of land uplift, the effects of the transgressions were felt most strongly in the southern part of Finland as well as on the southern side of the Gulf of Finland and the Baltic Sea. Consequently, the filbert associations growing in coastal areas were brought ever closer to the shore. Then nuts were caught up and transported by water to a greater extent than ever. Farther north, on the other hand, as, for instance, in the regions of Häme and Central Finland, where the rate of land uplift was more rapid than the rise in the water level caused by transgressions, new land became continuously exposed along the shores. In such areas, with soil rich in nutrients, the filbert then discovered a hospitable habitat. Competition with other plants was slight. For example, the spruce, the filbert's worst competitor for living space, had not yet appeared during the Yoldia, Ancylus and Littorina stages in western Finland to challenge *Corylus*, as it had on the Karelian Isthmus, in the south and in the east. *Corylus* thus ranks as a pioneer plant. Firbas (1949) considers it possible that *Corylus* is prominently represented in the pollen statistics of the Boreal period representing those parts of Central Europe where it had time to strike root before other forest trees. By contrast, Iversen (1960) takes the view that when *Corylus* arrived in Denmark during the pre-Boreal in the wake of *Betula*, it proceeded as the tougher species to usurp the sites occupied by the shorter-lived birch trees and thereby became the dominant factor in Danish forests. *Corylus* dominates the pollen statistics of the Boreal period with frequencies three or four times as high as those registered by tree pollens.

In the regions surrounding the southern and western parts of the Baltic Sea, the strong *Corylus* maximum occurs in pollen diagrams in the first half of zone V. The probability is that this maximum and the highly active spread of the species to Finland during the Finnish pre-Boreal period are related phenomena and thus fairly contemporaneous. This parallel is explicable in the light of the fact that corresponding forest-historical zones in different regions are not synchronous but metachronous — that is, farther south they are earlier than in the north, where deglaciation occurred later.

THE FLOATING TEST FOR NUTS

The conclusion has been drawn in several connections in the foregoing that *Corylus* migrated to this country principally across water. To investigate this possibility, the author subjected nuts to a floating test.

Nuts were placed at room temperature in both sea water and tap water to float. The same results were obtained with both kinds of water, and for this reason the results were later combined. Nuts belonging to each of the three form classes mentioned on p. 27 were used in the experiment. A total of 450 nuts was used, divided equally among the three classes, which were placed into different vessels. Half-grown or imperfectly developed nuts, as judged by their appearance, were not included in the test.

The results of the test are presented in Table 2 and Figs. 20 and 21. The time unit applied was one day (24 hours). The test lasted without interruption for thirty days.

After the first two days more than half the nuts had sunk to the bottom, namely 235 of them, or 52 per cent (Table 2 and Fig. 20). After five days 406 nuts, or 90 per cent, had sunk; and after eight days 427, or 95 per cent. After that the nuts remaining on the surface continued to float so per-

Table 2. Results of the floating test, explained in the text.

Days	*f. silvestris*				*f. ovata*				*f. oblonga*				Total material			
	afloat		sunken		afloat		sunken		afloat		sunken		afloat		sunken	
	nuts	%	nuts	%	nuts	%	nuts	%	nuts	%	nuts	%	nuts	%	nuts	%
0	150	100	—	—	150	100	—	—	150	100	—	—	450	100	—	—
1	119	80	31	20	107	71	43	29	95	63	55	37	321	71	129	29
2	91	61	28	39	63	42	44	58	61	41	34	59	215	48	235	52
3	55	37	36	63	26	17	37	83	29	19	32	81	110	24	340	76
4	31	21	24	79	17	11	9	89	17	11	12	89	65	14	385	86
5	20	13	11	87	9	6	8	94	15	10	2	90	44	10	406	90
6	11	7	9	93	8	5	1	95	13	9	2	91	32	7	418	93
7	9	6	2	94	6	4	2	96	10	7	3	93	25	6	425	94
8	7	5	2	95	6	4	0	96	10	7	0	93	23	5	427	95
9	5	3	2	97	4	3	2	97	9	6	1	94	18	4	432	96
10	4	3	1	97	4	3	0	97	9	6	0	94	13	4	433	96
15	3	2	—	98	3	2	—	98	7	5	—	95	13	3	437	97
20	3	2	—	98	3	2	—	98	6	4	—	96	12	3	438	97
25	3	2	—	98	2	1	—	99	5	3	—	97	10	2	440	98
30	2	1	—	99	2	1	—	99	4	3	—	97	8	2	442	98

sistently that at the end of the thirtieth day eight of them, or 2 per cent of the total, were still afloat. And that is where the test ended.

The relative floating capacity of the differently shaped nuts is presented in Fig. 21. For the first five days the nuts in the *f. silvestris* class fared best. The other two classes were on even terms for the first four days, after which the *f. ovata* class proved to be the weakest. On the sixth day a drastic change in relative floating capacity occurred. Thereafter the nuts in the *f. oblonga* class stayed afloat best while *f. silvestris* nuts sank relatively most frequently so that after the tenth day they were evenly matched with the *f. ovata* class. The two last-mentioned classes then remained on equal terms until the end of the test, each with frequencies of approximately 25 per cent. After ten days of floating the nuts in the *f. oblonga* class stood out conspicuously as superior floaters and maintained their status of superiority to the end, when four, or 50 per cent, of the eight nuts still afloat were members of this class.

The sunken nuts were opened, as were the ones still afloat at the end of the test. The observation was made that all the nuts included in the test carried a seed inside the shell, signifying that all were germinative. This test did not include germination of the nuts. However, Eklund (1927 a and b) has carried out germination tests with numerous plants by keeping their seeds and fruit in sea water for weeks at a stretch. His tests proved that the seeds and fruits of different plants differ greatly in their capacity to stay afloat. Some sank to bottom immediately, whereas others, like *Betula* fruits, kept on floating for five or six weeks. It was further estab-

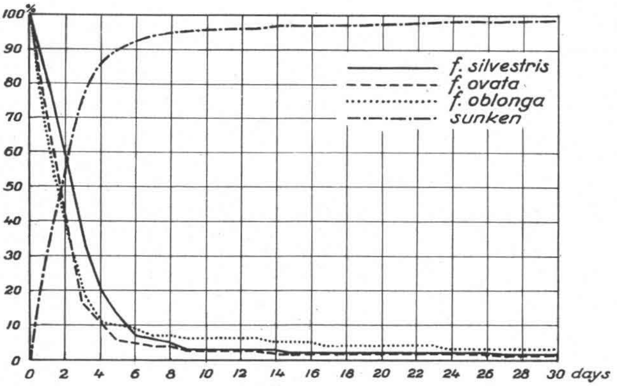

Fig. 21. The floating capacity of hazelnuts of different shapes and their combined sinking percentage daily.

lished that several weeks in water did not weaken the power of seeds to germinate. Germinal sprouts likewise retained their power of growth in spite of floating weeks on end in sea water. There is no reason to doubt that hazelnuts could likewise retain their power of germination after floating even as long as a month.

In the light of the test just described, it is fitting to consider the possibilities of the filbert's being disseminated in this country across water — and especially in the northern extremities of the plant's past range during those remote times when it had provably extended its habitat there. A basis for this discussion is provided by an oral report from Prof. I. Hela, director of the Oceanographic Institute, according to which nuts are capable of floating in the Gulf of Finland under favorable windy conditions at a speed of one kilometer an hour, or 24 kilometers a day. Under optimal conditions hazelnuts could have thus floated during the Yoldia period from Estonia to the southern Finnish coast in a couple of days, from southern Sweden in a week and from the northern coast of Poland, even in nine to ten days. Nuts could also have made their way to Pielavesi from southern Sweden in the last-mentioned time.

Since sea currents and other disturbing factors must be considered, the nuts' sea voyage to Finland must have taken considerably longer than the shortest time theoretically conceivable, but the results of the floating test demonstrate that the time range suffices. The inescapable conclusion is that transport of hazelnuts across water from lands beyond the Gulf of Finland and the Baltic Sea proper is and was possible. The migration of the species to the northern extremities of its range could have occurred in several stages as it sought sites affording congenical climatic and edaphic conditions.

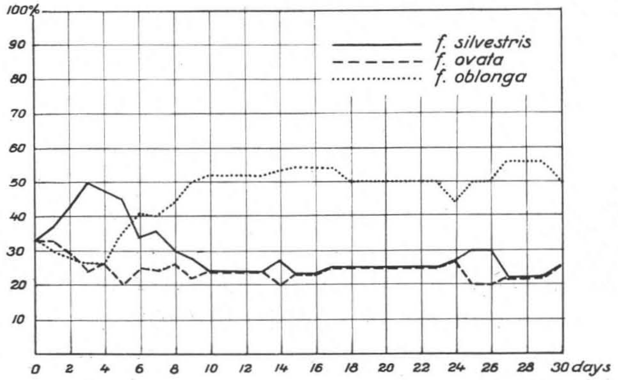

Fig. 22. The relative floating capacity of hazelnuts of different shapes.

The floating test also casts light on the distribution of hazelnuts in the sphere of the Baltic Sea in general, lending support to the conception that *Corylus* struck root in Finnish — and likewise Swedish — soil in very ancient times and expressly after being transported across the sea.

Andersson (1902) remarked in his study that the frequency of elongated hazelnuts increases in Finland and Sweden toward the north. The floating test just described revealed that oblong nuts float longer than those of other shapes, that is, *f. silvestris* and *f. ovata*. Water has thus acted as a sorting agent: relatively a greater number of hazelnuts oblong in shape were transported to far northern regions than more nearly round ones.

THE ANCIENT NORTHERN LIMIT OF DISTRIBUTION OF *CORYLUS* IN FINLAND

In the light of the present study it is possible to sketch out the ancient range of *Corylus* in this country. Nut finds provide the most reliable material. They prove incontrovertibly that *Corylus* once grew around the locality. It will, of course, never be possible to gain information on all the far northern occurrences of the species — especially in localities where *Corylus* produced fruit poorly and then only in favorable summers, as in the case of northern stations at the present day. Rarely, moreover, do nuts become imbedded in bog and water sediments, where alone can they be preserved. North of the fruit-yielding limit there exists, in addition, a zone where the plant flowers but bears no fruit. In the northern extremities of its range, the plant also tends to be completely sterile. By means of comparative pollen analyses, the northern limit of *Corylus* can nevertheless be extended with a fair degree of confidence.

The nut finds indicated in Fig. 1 enable us to draw a continuous line on the map so as to run along their northern boundary. This line represents the northern limit of the area in which *Corylus* has unquestionably grown. It extends from west to east approximately along 63° 30′ N Lat. as far as Pielavesi, after which it abruptly turns south toward the Kouvola—Lappeenranta railroad line (61° N Lat.) and from there swings northeast and follows the southern shore of Lake Saimaa along the present northern boundary of the plant's range of distribution. The subfossil nut finds in this region occur appreciably south of the present northern limit of the filbert's distribution.

The pollen diagrams serve as the basis for drawing the northern boundary of the filbert's range of distribution above the line just referred to — a broken line being used to indicate its uncertainty. It runs from west to east some forty to fifty kilometers north of the continuous line and close to the 64th parallel. After a space the boundary curves southeastward and runs past Lake Pielinen to Tohmajärvi and the national frontier. North of this line *Corylus* could scarcely have flowered. Therefore the occurrence of *Corylus* pollen in such areas must be attributed to long-distance flights.

Accordingly, in Figs. 17 and 18 diagrams 22, 23, 24, 26, 25, 21 and 15 provide the points through which the broken line has been drawn. In diagrams relating to the area northeast of Lake Ladoga, according to Sauramo (1958), there is a paucity of *Corylus* pollen. Similarly, according to an oral report from Tolonen, the pollen diagrams drawn up in Ilomantsi, which is situated northeast of Valkeasuo (diagram 21), Tohmajärvi commune, contain low frequencies of *Corylus*.

The *Corylus* boundary in the east could also be drawn to run in such a way as to turn west via the southern end of Lake Höytiäinen up to about the 28th meridian and then to curve southward and onward, paralleling the line based on the nut finds at a distance of forty to fifty kilometers, just as it does farther west, too. This would leave on the farther side of the northern limit the area encompassed by the sphere of Greater Saimaa, which before and during the early part of the Yoldia period was situated in the hinterland and where the filbert could not apparently be transported by water as happened in the case of more westerly regions. No suitable pollen material is available from this area to check matters.

The northern boundary of the ancient range of *Corylus*, as defined by means of the nut finds, conforms very closely to the features of the present limits of the plant's distribution. However, there is a difference in that in the west it runs some 200 kilometers north of the present extreme limit of distribution of the species but joins it in the southeast.

Sauramo (1940) previously drew the northern boundary of the ancient range of the filbert. Running across the country roughly along the 64° parallel, it deviates from that presented here, especially in the east.

The northern boundary in the west of the filbert's ancient range drawn in Fig. 1 conforms well with the northern limit on the opposite side of the Gulf of Bothnia, drawn according to the nut finds made in Sweden (cf. Fig. 16).

Finally, there is reason to return once again to the northern nut finds providing the subject of the present study. The sites are bogs and the finds are of nearly equivalent age, dating from the sub-Boreal. The elevations at which nuts have been found suggest, on the other hand, that *Corylus* had grown on the sites much earlier: in the high places of Kuru and Uurainen, for example, since the early Yoldia. It is noteworthy that many of the finds made in the bogs of Sweden are likewise sub-Boreal, though some of them date from the Atlantic period. Auer (1924) mentioned in his report on Vanajavesi that *Corylus* had grown there on ground consisting of *Alnus glutinosa* »sumpf» peat since the Boreal, swampy conditions having persisted there owing to continuous transgression until the latter part of the Littorina stage. *Corylus* withdrew from the bogs at the end of the dry and warm sub-Boreal or thereafter, but continues to grow in the vicinity on mineral soil.

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Considering that the hazelnut bog finds are concentrated in the sub-Boreal horizon, there must have been some reason for the species' having shifted over to a boggy habitat during that period, for nowadays it thrives primarily on fresh and nutrient-rich mineral soil. As I understand it, the reason was mainly the competition of *Picea* for living space. As the diagrams presented in Figs. 2 to 14 show, the continuous occurrence of spruce pollen in them began during the sub-Boreal, first with low frequencies but rapidly increasing above the nut layers to register as high as 50 to 60 per cent. In several cases *Picea* occurs in such abundance that it seems to be the dominant species of tree during the sub-Atlantic in the forests of the localities in question (Salmi 1962 a). This further indicates that the vicinities of the bogs under consideration had also been hospitable to *Corylus*.

The struggle waged between *Corylus* and *Picea* for space to grow in may be reconstructed as follows. Under the favorable conditions prevailing in zones VI—VIII, *Corylus* locally expanded its habitat — moving farther afield, too, down streams and across lakes — while the species was reinforced by new arrivals from neighboring lands, mainly from Sweden, to the western Finnish coast. The northern limit of the filbert's range then extended farther than at any other time following the Ice Age. Paludification was accelerated, moreover, many lakes on the shores of which *Corylus* had grown turning into bogs. During the sub-Boreal the climate became drier than it had been before but continued to be warm although the winters turned colder. By that time *Picea* had struck root in western Finland and proceeded to usurp the most congenial areas as climatic conditions began to favor the species. *Corylus* was among the victims, not being able to hold its own against the intruder.

By the beginning of the sub-Boreal, the bogs had grown in thickness and spread outward toward the sites occupied by *Corylus*. Around the edges of the bogs evolved rather dry swampy tracts, and there *Corylus* discovered a habitat satisfying its minimal requirements. The drying process extended across the surface of the bogs as a whole, too, as the types of peat and their advanced state of humification indicate. At the end of the sub-Boreal and the beginning of the sub-Atlantic, the climate turned damp and cool, more rigorous. As a consequence of this change, *Sphagnum* began in most cases (Figs. 2—14) to play a prominent role in the formation of peat in the bogs. The bogs became waterlogged and under such unfavorable conditions *Corylus* disappeared from boggy tracts. Frost completed the destruction. Some of the hazelnuts that had grown in the bogs have been preserved in peat, however, and they provide a splendid body of evidence of the ancient range of the species and the northern bog sites in which it had struck root. The present study indicates that *Corylus* grew on bogs only during the sub-Boreal period.

Around the same time *Corylus* abandoned the bogs in the northern parts of its ancient range, it likewise disappeared from its stations on mineral soil there. In no case was it able to shift its habitat by the conquest of new stations. This is to be seen from the pollen diagrams connected with the nut finds, in which the *Corylus* pollen rapidly diminishes in frequency and disappears subsequent to the sub-Boreal period. It was then that the retreat southward of the species began — toward its present stations. Only under exceptionally favorable conditions has the species survived as a relict in the proximity of the northern limit of its ancient range, as, for instance, at Vaarunvuori, in Korpilahti commune.

SUMMARY

The bog sites of the hazelnut finds described in the present study are the most northern known in Finland. They are located on both sides on the 63° parallel. The finds are numbered from 1 to 13 in the map presented in Fig. 1.

The majority of the nuts found are classified with reference to their shape as *f. silvestris* (58.6 per cent). Ranking second in frequency (32.4 per cent) is the *f. ovata* class of nuts and third the *f. oblonga* class (9.0 per cent).

All the nut finds proved to date from the sub-Boreal period. They were imbedded in deciduous-nanolignidi-*Carex* peat. At various points underlying the layer containing nuts, the thickness of the peat bed varies between 0.2 and 1.5 meters, and the layer lies at depths of 0.8 to 3.5 meters below the surface. In most cases, the nuts were found a few dozen meters from the edge of the bog, the maximum distance being about 100 meters.

Corylus occurrences are nowadays concentrated in the Åland Islands and along the southwestern and southern coast of the mainland. The plant also grows on the shores of the great lakes in the southern interior of the country (Fig. 15). The northernmost station, at Korpilahti, is ocated in approximately 62° N Lat., but in the east the *Corylus* occurrenceslare south of Lake Saimaa. The distribution of the species proves that it prefers a marine climate; in both Finland and the entire Baltic sphere its occurrences tend to adhere to the seaboard (Fig. 15 and 16). The plant's stations in the hinterland are relicts of times when they stood on the seacoast.

The present-day northern habitats of *Corylus* are located, at least in many cases, in areas where the bedrock is basic and the soil plentifully supplied with water and where the microclimatic conditions are congenial. The undermost varieties of peat in the bogs where nuts have been found also give evidence of ground rich in nutrients.

The pollen diagrams made from the bog profiles at the sites of hazelnut finds generally show a paucity of *Corylus* pollen (Figs. 2 to 14). Even in the layers containing nuts, the pollen frequency of the species is often as low as 1 or 2 per cent. Above this level its occurrence most often ceases or becomes sporadic. In many of the pollen diagrams from bogs situated

in the southern half of the country, *Corylus* is most abundantly present in zones VI and VII of the Atlantic period (Figs. 17 and 18). In diagrams from the Karelian Isthmus and the southern part of the country, there is such an abundance of *Corylus* pollen in the sediments representing the Baltic Ice Lake that the plant must have grown at least in the Isthmus at a time when the margin of the continental ice sheet stood along the line of the Salpausselkä glacial formations. The pollen registers a high frequency in diagrams from the west starting with the pre-Boreal level.

When the subfossil hazelnut finds are placed on the map (Fig. 19) representing the extent of the Rhabdonema sea during the final Yoldia stage, the majority of them fall on the coast and in the islands. A portion, however, are situated in areas that at that time lay in the interior, that is, on higher and older ground than the marine stage in question, but another portion on lowlying and younger ground. The concentration of the occurrences mainly in the western half of southern Finland and on the Karelian Isthmus suggests that *Corylus* migrated to this country primarily across the sea. No finds have been made in an extensive area in the eastern half of southeastern Finland in the vicinity of the Saimaa chain of lakes, which had been cut off from the Baltic before the middle of the Yoldia.

The distribution of the occurrences and their elevations in the relation diagram (Fig. 20) indicate that those situated on the lower Littorina isobases represent the older shores as Yoldia I and those on higher isobases younger ones, such as Ancylus I and Littorina I. The conclusion may be made that *Corylus* arrived in this country in the wake of the retreating continental ice sheet. With respect to the history of its distribution in the southern and western parts of Finland, it is a western and southwestern plant, and in the region south of Lake Saimaa, a southeastern plant. The filbert stock of the former region arrived from lands south of the Gulf of Finland and the Baltic Sea as well as from southern Sweden, having been transported by water, while that of the Karelian Isthmus migrated, partly overland, from the Ingrian region. The latter population is the older, having started to spread to the Karelian Isthmus and southern Finland as early as the Alleröd, whereas it was not until the pre-Boreal that the filbert stock of the western range began to strike root in Finnish soil.

The floating test made by the author proved that it was possible for hazelnuts to cross the sea from distant lands (Figs. 21 and 22). Furthermore, the migration across water sorted the nuts with respect to shape in such a way that the ones in the *f. oblonga* class are most abundantly represented in the far northern sites. The northern boundary of the plant's range in ancient times has been drawn in accordance with the evidence provided by the finds, while a less definite one has been drawn in the light of pollen frequencies (Fig. 1).

The northern hazelnut finds have proved that the species occurred in sub-Boreal bogs, although normally its habitat presupposes nutrient-rich mineral soil. Its worst competitor for living space appears to have been *Picea*. Inasmuch as the nut finds investigated date back to peat layers contemporaneous with the times when *Picea* was starting its conquest of western Finnish forests, the probability is that *Corylus* was compelled to retreat from the usurper's path, despite the favorable sub-Boreal climatic conditions, to the wooded swampy margins of the bogs, where the species could satisfy its minimal requirements. Later, the climate rapidly deteriorated to the extent that *Corylus* vanished from the boggy tracts. Nor was it able to hold fast to its stations on mineral soil in the north. Thus did the northern limit of the plant's range gradually move south toward its present position.

ACKNOWLEDGMENTS

The pollen analyses utilized in the study were made by Miss Ester Uussaari, Mag. Phil., the diatom determinations by Miss Kyllikki Salminen, Lic. Phil., and the drawings by Mrs. Lyyli Orasmaa, all members of the staff of the Geological Survey's Department of Surficial Deposits. The English translation was done by Paul Sjöblom, M. A. I wish to thank them all, as well as everyone who participated in the field investigations or furnished information on hazelnut finds.

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