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Cultural Landscape Development through 5500 Years at Lake Skånsø, Northwestern Jutland as Reflected in a Regional Pollen Diagram

by BENT ODGAARD

INTRODUCTION

This paper presents the main conclusions on cultural landscape development drawn from a pollen analytical investigation of lake sediments from Skånsø. This lake is one of a series of sites chosen to elucidate cultural landscape development within the framework of a cooperation between the Office of Cultural History at the National Agency for Protection of Forests and Sites and the Geological Survey of Denmark. Skånsø was chosen for both archaeological and geological reasons. The lake is situated in an area with a high density of burial mounds, it has an appropriate size for a site of a regional pollen diagram and – very importantly – the sediments are non-calcareous and hence datable by the radiocarbon method.

The results presented here concentrate on cultural history while a detailed report of the entire investigation including the history of the lake and the early postglacial vegetational development will be published in the series of the Geological Survey.

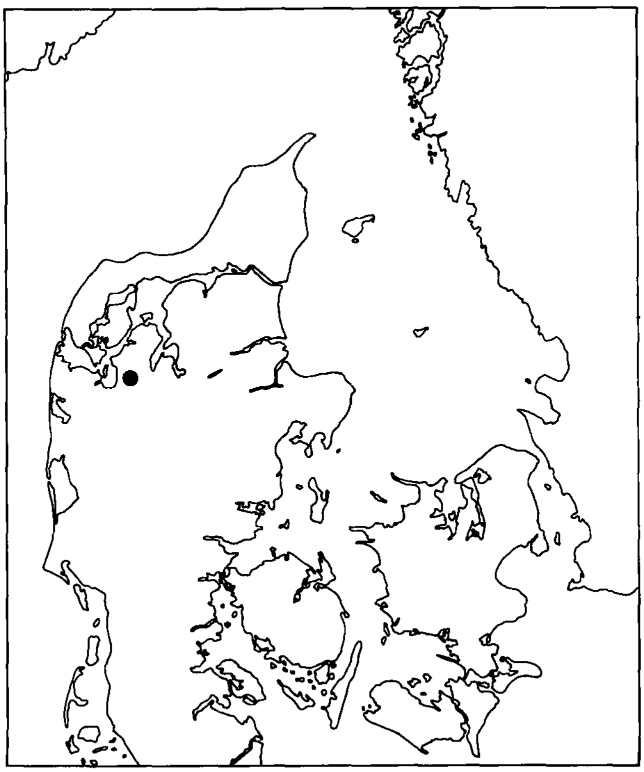


Fig. 1. The location of lake Skånsø.

SITE

Lake Skånsø is situated in northwestern Jutland (Fig. 1) on an outwash plain just north of the main stationary line of the Weichselian ice (last glaciation). The meltwater sand of the outwash plain was deposited during the ablation of the ice. The flat plain is interrupted by numerous kettle holes, formed after the melting af dead ice blocks buried by meltwater sand. Some of these depressions are dry today but several are filled by bogs or lakes like Skånsø.

Skånsø is about 11 ha. (Fig. 2) and has no natural inlet or outlet. It is situated about 2 km from the nearest Weichselian till areas and the pollen diagram can be assumed mainly to reflect the regional vegetational history of the outwash plain.

Radiocarbon dates of the late-glacial lake sediments show that by 10.900 before present (BP) the dead ice had already melted sufficiently for lake Skånsø to come into existence.

35 corings with Hiller and russian peat samplers have revealed an uneven distribution of post-glacial sediments. The distribution along the profile A crossing the middle of the lake from west to east shows this clearly (Fig. 3). In periods of strong winds the local wind is mainly northwestern (Frydendahl 1971). Waves and surface currents induced by strong winds cause deep currents

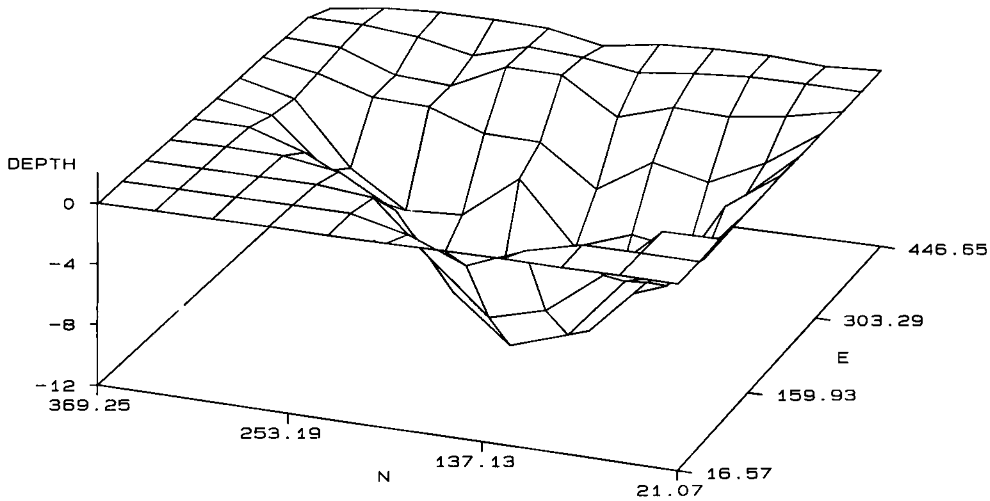


Fig. 2. The morphology of the Skånsø lake basin at the end of the late-glacial period seen from WSW, tilted 40% around the northaxis. Distances in meters.

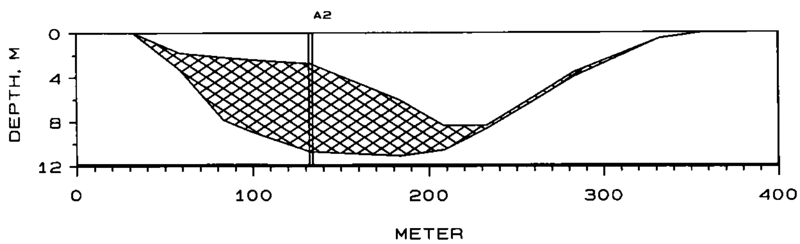


Fig. 3. Cross-section of the post-glacial gyttja (cross-hatched) from west to east through the middle of the lake. The double line marks coring A2.

along the eastern exposed coast of lake Skånsø, which resuspend previously sedimentated material. Along the western coast on the other hand, conditions are quiet during heavy northwestern winds, and sediments are not disturbed. Another effect of this wind-governed sedimentation pattern is that the coring at A2, the main coring point (Fig. 3), only include sediments from the last 7000 years, while older sediments have been located closer to the western shore.

An age/depth relationship at coring A2 has been established from 26 radiocarbon dates by joining mean values of every two dates. From this curve (Fig. 4) a C-14 age has been ascribed to each pollen sample. At a few levels the reliability of the dating curve can be checked by palynological markers. The elm-decline is dated to 5200 BP which is one or two centuries older than expected. The first appearance of rye (Secale) pollen grains seems to be a good chronological marker in Danish regional pollen diagrams. Thus this event has been radiocarbon dated to 2200 BP in four widely spaced diagrams: Holmegård, Zealand; Abkær, South Jutland; Fuglsø, Djursland and Solsø, West Jutland (Aaby 1986, 1988, Odgaard unpublished). At Skånsø rye also appears at 2200 BP.

The dating at 432 cm has not been used in constructing the curve, since it is older than the dating below, and as explained later, probably influenced by older redeposited material in connection with retting of hemp (*Cannabis*). The three other datings in the stage of retting (488 cm, 464 cm, 410 cm) may also be influenced by redeposition to some extent and may therefore give an overestimation of the age of the pollen samples in this part of the sediment.

Generally the age/depth curve seems to give reasonably accurate datings of the pollen spectra. The esti-

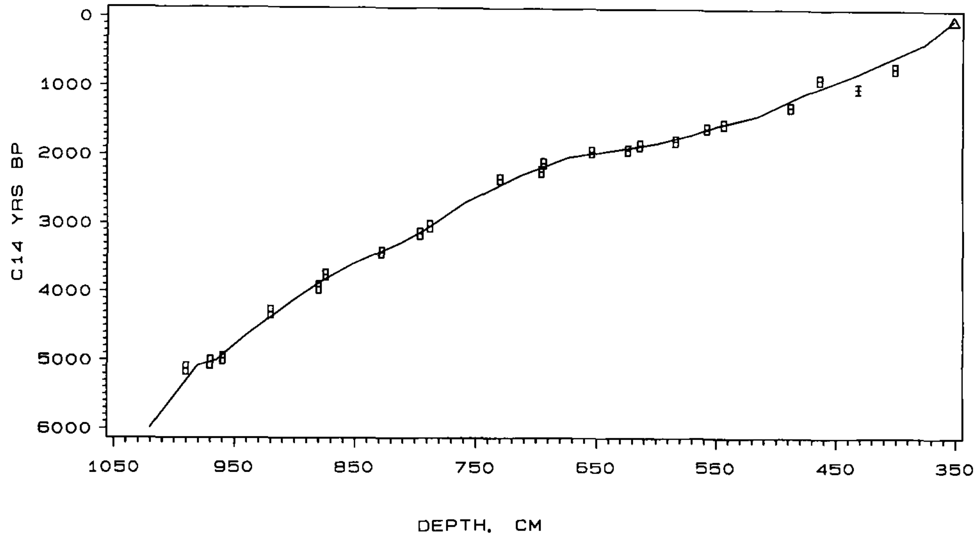


Fig. 4. Uncalibrated radiocarbon dates of coring A2 showing dates with standard deviation. The curve is drawn by joining mean values of two neighbour dates. The dating at 432 cm has not been used in the curve drawing since it is older than the one below and therefore obviously influenced by redeposited material. The surface sample (triangle) has been ascribed the age of 0.

mated ages for the older spectra and those of the last 1500 years might, however, be a few centuries too old.

Skånsø is situated in the crosspoint of two bands of burial mounds, one in the direction SE-NW another SW-NE. Thus about 40 burial mounds have been registered within a radius of 2 km from the lake (Brøndsted 1966).

According to the map by the Royal Danish Academy of Sciences and Letters (1800) and later topographic maps Skånsø was surrounded by heath until the beginning of the 20'th century, after which much of the heathland was reclaimed and conifers planted. Due to the isolated location of Skånsø and the buffering of the heath and plantations the lake has remained rather uninfluenced by modern urban and agricultural eutrophication. Today Skånsø presents one of the finest examples of Danish oligotrophic lakes. This nationally rare lake type harbours an interesting flora of endangered species, which by pollen analysis have been shown to have very long continuity at Skånsø, e.g. Quill-Wort (*Isoetes lacustris*), Water Lobelia (*Lobelia dortmanna*) and Marsh Clubmoss (*Lycopodium inundatum*).

ANALYSIS OF POLLEN AND CHARRED PARTICLES

76 samples of coring A2 have been analysed for pollen, dark-coloured hypha fragments and microscopical charcoal. In each sample at least 1000 land plant pollen grains were counted and the percentages are calculated in relation to the land plant pollen sum or to the corrected tree pollen sum (Andersen 1970). Cereal pollen types (*Hordeum* type, *Triticum* type, *Avena* type) have been identified statistically according to Andersen (1979). Hemp includes *Cannabis/Humulus* type pollen grains with raised pores (French & Moore 1986, Whittington & Gordon 1987).

Brown coloured hyphae are remains of terrestrial fungi, which take part in the biological degradation of soil organic matter. The amount of dark hyphae is thus an indication of the amount of terrestrial material brought into the lake by erosion. The area of hyphae in each pollen slide has been analysed in the microscope by an eyepiece grid permitting a calculation of the area of hyphae relative to the number of land plant pollen grains. The results of the hypha analysis are not shown here but are used in the interpretation of the charcoal curve.

Microscopical charred particles have been analysed along with the hyphae and are likewise expressed in area pr. pollen grain. Microscopical charcoal can be brought into the lake by wind or by water and the amount of charred particles can be expected to reflect the intensity of fires in the area. In tracts with exclusively deciduous forest natural fires are usually regarded as unsignificant. As indicated by the pollen diagram conifers have been

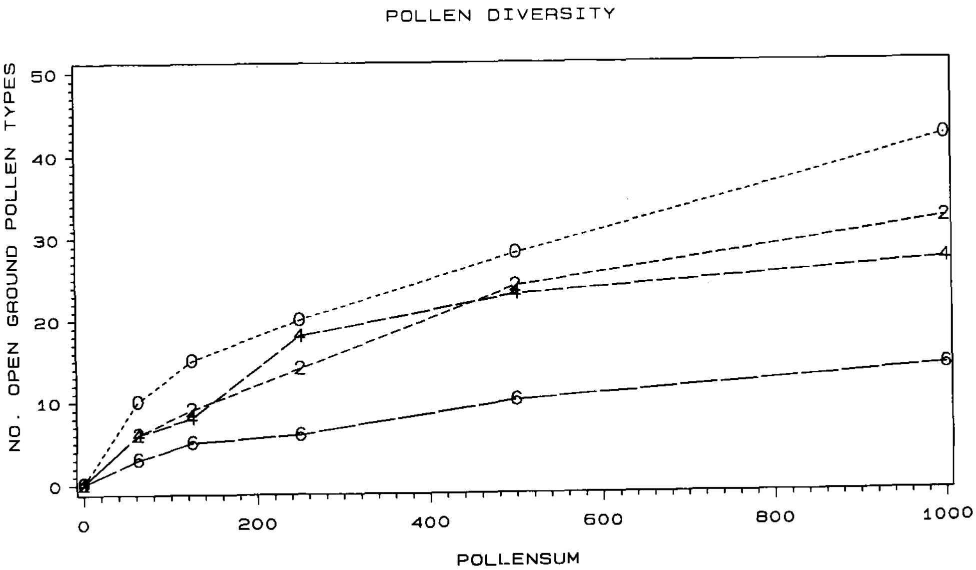


Fig. 5. The number of open ground land plant pollen types at increasing pollen sums in 4 different pollen spectra from Skånsø A2. The number used as a plotting symbol in each graph gives the age of the spectrum in thousands of radiocarbon years BP.

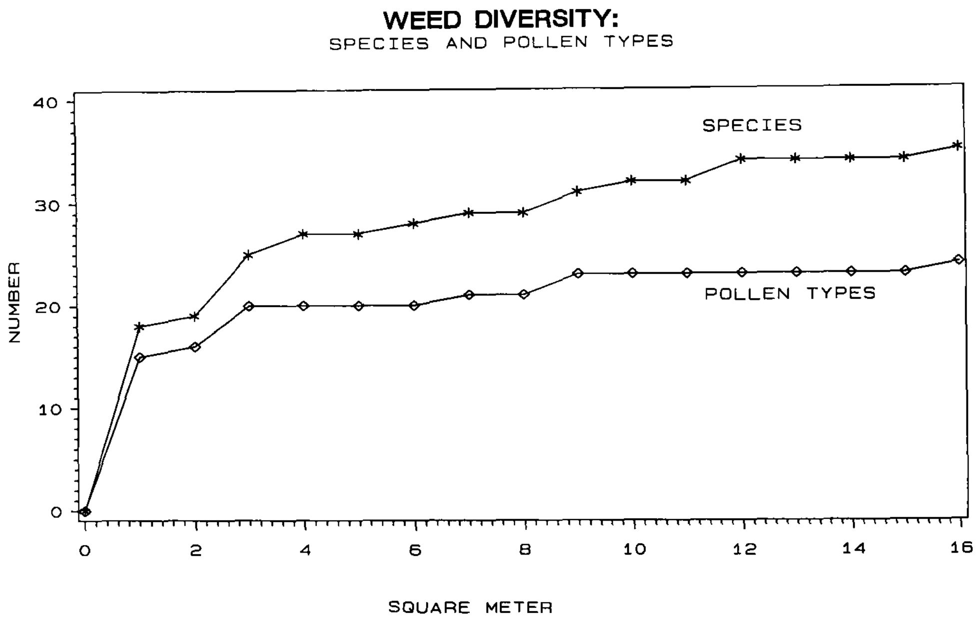


Fig. 6. Cumulative curves of number of plant species and pollen types produced by these at increasing area in garden weed vegetation at Allerød, Denmark.

absent from the Skånsø area through the last 6000 years except perhaps for scattered pine (*Pinus silvestris*) and juniper (*Juniperus communis*) but a field layer of heather (*Calluna*) may have acted both as ignition points for lightning and carrier for surface fires as it does today in the boreal zone (Engelmark 1987). Thus the curve of charred particles can be expected to reflect the sum of both natural and anthropogenic fires.

Fig. 7 displays besides the pollen diagram and the charcoal curve also a diversity graph. The term diversity is here used to denote the number of different pollen types of open ground dry soil plants in each pollen sample. Since the number of pollen types increases as the number of counted pollen grains rises (Fig. 5) the pollen types have been counted at a fixed sum of 1000 land plant pollen grains. The number of different pollen types which can be produced by a vegetation is related to the number of species present, but since several plant species produce identical pollen types a rise in species diversity is not necessarily followed by an increase in pollen diversity especially not in species-rich communities (Fig. 6). Generally, however, there is a good correlation between species richness in modern plant communities and pollen diversity (Birks 1973). Species diversity is of ecological and archaeological interest since this parameter usually rises with increasing anthropogenic influence. Natural woodland communities are not rich in species while especially rough pasture is known to be very rich. Furthermore boundaries between plant communities are very diverse and since anthropogenic influence tends to lead to an increase in the "patchiness" of vegetation, it also increases diversity (Birks et al.1988). A very strong human impact as today, however, favours a few species adapted to continuous disturbance and hence decreases diversity.

Besides species richness pollen diversity in regional pollen diagrams also depends on the effectivity of pollen dispersal and hence the physical structure of the vegetation. In closed woodland windspeed in the trunk space is low (e.g. Andersen 1974, Tauber 1977) and the pollen of woodland herbs has a low chance of escaping the trunk space and tree canopy and eventually of settling in a large lake. In more open vegetation types wind velocities near the ground are higher and herb pollen is more efficiently dispersed and the probability of fossilisation in larger bogs or lakes is higher. Accordingly woodland clearances can be expected to increase pollen diversity in regional pollen diagrams, even if species diversity was actually unchanged. Thus pollen diversity is directly – as a measure of species diversity – or indirectly – reflecting changes in vegetation structure – an important indicator of human influence on the vegetation.

CULTURAL LANDSCAPE DEVELOPMENT

The pollen diagram (Fig. 7) is drawn on a scale of uncalibrated radiocarbon years by means of the age/depth relationship established by the C-14 datings (Fig. 4). Only curves for the important pollen types are shown. Solid lines divide the diagram into one thousand year segments and dotted lines into 10 landscape development phases (l.d.p.) mainly based on the relationship between tree pollen and open ground pollen.

L.d.p. 1. Before 5200 BP.
Sum trees, lime (*Tilia*) and elm (*Ulmus*) high, sum herbs, sorrel (*Rumex acetosella* type), diversity and heather (*Calluna*) low, ash (*Fraxinus*) and oak (*Quercus*) increasing, pine (*Pinus*), hazel (*Corylus*) and charcoal decreasing, ribwort (*Plantago lanceolata*) and types from cultivated species absent.

This segment of the pollen diagram mirrors a virgin forest stage where no unequivocal anthropogenic impact on the vegetation can be traced. The forest types reflected are open with lime and hazel as regional dominants, while alder (*Alnus*), birch (*Betula*), oak and elm are also important. The considerable amounts of pollen of grasses, herbs and heather are typical features of western Danish pollen diagrams (Odgaard 1985, 1988) while the changes of the tree pollen curves through the last part of the Atlantic period are common to the entire country. The extremely high amounts of charcoal in the lowermost analysis is unexpected since there is no other evidence of possible human impact. However, a maximum of terrestrial fungal hyphae at the same level (curve not shown here) suggests that the high concentration of charred particles may be due to increased inwash of terrestrial soil material.

L.d.p. 2. 5200–5100 BP.
Sum trees, ash, oak, lime and charcoal high, herbs and heather low, alder and hazel increasing, elm decreasing, ribwort and pollen types from cultivated species absent.

The elm decline is not very well marked due to the low elm values in the Atlantic. The elm seems to be replaced by oak, alder and hazel. There is no unambiguous evidence of human impact but the high amount of charcoal and slightly raised diversity might suggest forest clearances by fire.

L.d.p. 3. 5100–4800 BP.
Heather, hazel, oak, sorrel, ribwort and charcoal high, sum trees and ash low, diversity increasing, lime decreasing, barley (*Hordeum* type) present.

The first definite evidence of human impact is found in this phase. Shortly after the first appearance of ribwort a minimum in the tree pollen curve and maxima of heather and charcoal indicate forest clearances by fire and a temporary heather expansion. The heather curve, however, quickly drops down almost to the level of the previous zones and here the first cereal pollen grains appear. In the tree pollen diagram weak indications of a classical landnam (Iversen 1941) are seen: a small maximum of birch synchroneous with a minimum in oak, followed by an increase of hazel. Hazel thus seems to be especially important in the forest regeneration phase after the heather expansion.

L.d.p. 4. 4800–4200 BP.
Sum trees, oak and ash high, ribwort and charcoal low, bracken (*Pteridium*) and diversity increasing, heather and lime decreasing, beech (*Fagus*), barley and oat (*Avena* type) present.

In this period the vegetation is quite stable. The forest has regenerated somewhat after the clearances of the previous period, but it is still more open than in the Atlantic. Heather has almost decreased to the pre-elm-decline level. As a whole human impact in this period seems slighter than in phase 3, especially fires are notably more infrequent. The presence of oat is unexpected since macro-remains of *Avena sativa* are only known from Denmark from the Bronze Age onwards (Jensen 1985). This suggests that the pollen grains identified statistically as oat are merely small wheat (*Triticum* type) grains.

L.d.p. 5. 4200–3900 BP.
Grasses, ribwort, sum weeds, mugwort (*Artemisia*), barley, bracken and diversity high, sum trees and charcoal low, oak and ash increasing, hazel and lime decreasing, beech present.

This is a new forest clearance period, this time apparently without much use of fire and heather does not expand. Instead the increase of ribwort, grasses and bracken seems to indicate expanding pastures. The small maximum of barley might also suggest increasing arable farming. This period is probably contemporaneous with the Single Grave Culture.

L.d.p. 6. 3900–3700 BP.
Sum trees, birch, oak and ash high, hazel, sum cultivated, ribwort, sum weeds, bracken and charcoal low, lime decreasing, beech present.

A forest regeneration stage where especially birch is important. Cultural indicators are not as prominent as in the previous period and anthropogenic influence seems slighter.

L.d.p. 7. 3700–2500 BP.
Ash, ribwort and charcoal high, heather, pine, beech, sorrel, sum weeds, grasses, tormentil (*Potentilla* type), buttercup (*Ranunculus acris* type) and diversity increasing, sum trees and oak decreasing, barley, wheat, oat, spurrey and sweet gale (*Myrica*) present.

This is a long period of forest destruction where fires have been frequent. The rising pine value is probably the result of increasing importance of far distance transported pollen as the regional pollen production decreases along with the forest destruction.

The rising beech curve may have the same explanation but the presence of scattered beech trees in the area by the end of the period cannot be excluded. There is no indication of rising importance of arable farming whereas the increasing curves of grasses, heather, sorrel and buttercup as well as the high ribwort values suggest an expansion of nutrient-poor grass-dominated pasture.

L.d.p. 8. 2500–2300 BP.
Birch, pine, buttercup and charcoal high, hazel, lime and ash low, sum trees, beech, barley and sweet gale increasing, grass, sorrel and sum weeds decreasing, rye (*Secale*) absent.

A short stage with some forest regeneration in which especially birch is important. Pastures seem to decrease somewhat, while fields are still present, perhaps even increasing.

L.d.p. 9. 2300–800 BP.
Barley, diversity and charcoal high, pine and buttercup low, heather, birch, sweet gale, crowberry (*Empetrum*), rye, hemp (*Cannabis* type, raised pores) and sorrel increasing, sum trees and oak decreasing, buckwheat (*Fagopyrum*), flax (*Linum usitatissimum*) and cornflower (*Centaurea cyanus*) present.

This long period is generally characterized by forest destruction, interrupted by short periods with slight regenerations of birch. The increase in heather pollen is now not accompanied by the grass curve but by the crowberry and billberry type (*Vaccinium*, not shown) curves, which indicate that heatherheaths are now spreading and reach their maximum at about 800 BP. It is noteworthy that the pine curve drops down to a minimum at about 1600 BP even though the sum trees still decreases. This must reflect a change in the composition of far distance transported component of the pollen rain, which is obviously connected to the broadleaf forest regenera-

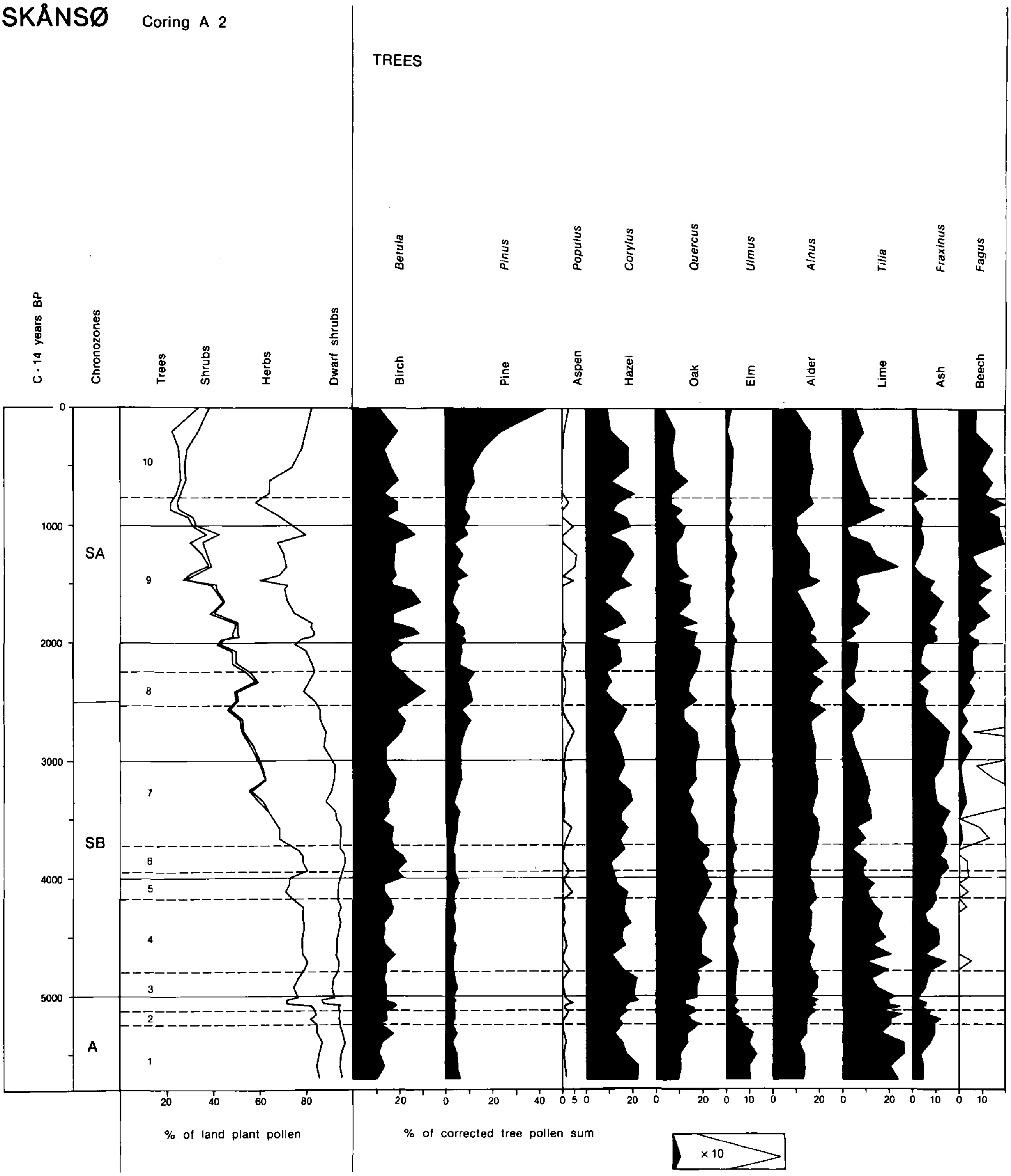
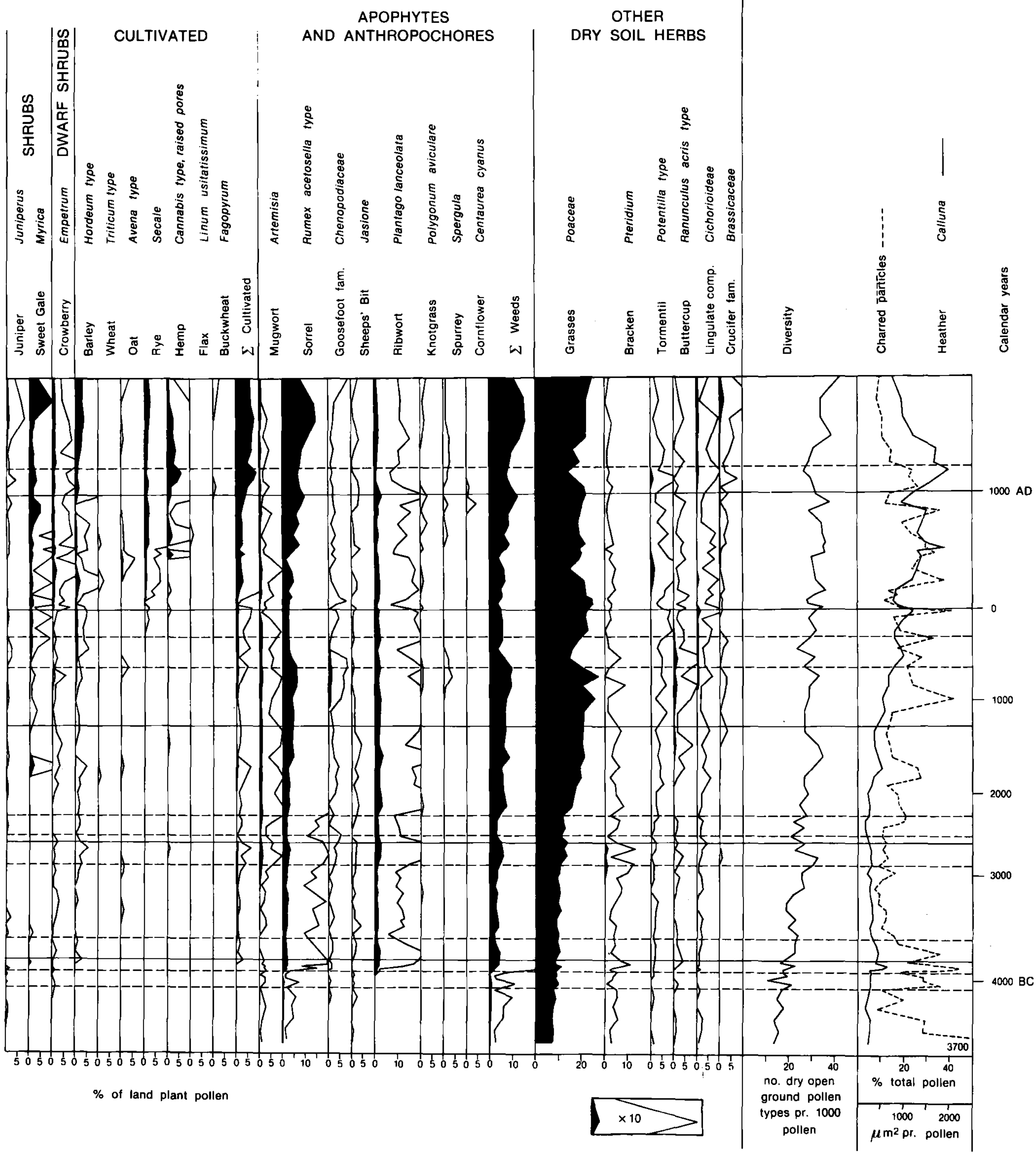


Fig. 7. Pollen diagram from Skånsø A2 drawn on a radiocarbon time scale. From the left is seen a survey diagram giving the main pollen groups. The numbers refer to the landscape development phases delimited by dotted lines. The tree pollen diagram is shown as transformed percentages, which take into account the differential pollen production of the tree species (Andersen 1970). Selected herb pollen types are shown in ecological groups. For explanation of the curves of diversity and charred particles see text.



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tion in eastern Denmark in the German Iron Age known from many pollen diagrams (e.g. Aaby 1986, 1988).

The maximum of beech around 1000 BP is characteristic of pollen diagrams from western and northern Jutland (e.g. Jessen 1935, Odgaard 1985). Much unlike the forested conditions in eastern Denmark at the time of the arrival of beech (Aaby 1986) the landscape in western Jutland was already then very open and heavily exploited. It is not possible to assess how much of the beech pollen in the Skånsø diagram which is transported from till areas and hence to determine whether beech actually grew on the outwash plain. The nearest forest with natural beech today is at Rydhave on boulder clay 7 km SSW of Skånsø.

Judging from the pollen types of cultivated species arable farming increases in importance in the period. Especially barley and rye are cultivated, the latter at least from about 1400 BP.

The high values of hemp pollen from 1500 BP onwards suggest that the lake has been used for retting hemp plants to macerate the stems for disengaging the fibers. To check this possibility samples from the interval 1350–850 BP have been analysed for plant macrofossils. The search was negative as far as hemp remains are concerned but instead many remains of seed-capsules of flax were found in sediments from 1050 BP and younger. Accordingly, the lake has been used for retting of flax at least. The almost total absence of flax pollen is due to the fact that flax is an insect-pollinated plant with a small pollen production. The absence of identifiable hemp macrofossils does not, on the other hand, support the conclusion that hemp was not retted in the lake. Actually seeds of hemp have never been located in Danish prehistoric or medieval deposits (Jensen 1985) although, judging from pollen diagrams (e.g. A. Andersen 1954, S. T. Andersen 1984) the activity of retting seems to have been quite widespread in the Roman Iron Age and later. At Skånsø the retting caused a eutrophication of the lake, which manifested itself by an increase in green and blue-green planktonic algae (not shown here). The retting may also account for the aberrant date at 432 cm (Fig. 4), since retting inevitably causes introduction of soil organic matter (at least in historical times plants with roots were retted, Brøndegaard 1979) and disturbance and re-deposition of near-shore lake sediments.

L.d.p. 10. 800–0 BP.
Rye high, sum trees and ash low, pine, barley, sorrel, crucifer family (*Brassicaceae*) and diversity increasing, heather, beech, hemp and charcoal decreasing, buckwheat and spurrey present.

By the start of this period a completely open landscape had come into existence. Fires were not frequent in this phase and heathland decreased. Arable farming, on the other hand, seems to increase. Especially barley and rye are cultivated and retting of hemp (and flax?) probably continues albeit at decreasing intensity. Crumpling of cereal pollen grains have in many cases impeded the identification and some rye pollen grains inevitably have been classified as barley. Thus the barley values are probably exaggerated and the rye percentages underestimated. The high percentages of sorrel, which thrives very well in winter cereal fields cultivated with fallow years, is most likely connected with the growing of rye.

The increase of pine in the top of the diagram reflects the afforestation by conifer plantations and probably also a changing composition of the far distance transported component of the pollen.

DISCUSSION

The Skånsø pollen diagram reflects without interruptions the broad-scale dynamics of a cultural landscape through 5500 C-14 years. The diagram is of typical west Jutish type and therefore has many similarities but also some important dissimilarities with the Solsø diagram (Odgaard 1985, 1988). Solsø is situated about 50 km SSW of Skånsø in an area of sandy till and meltwater sand from the Saalian (last-but-one) glaciation.

At both sites the late Atlantic forest is very open and has much more birch and less elm and lime than is known from sites on Weichselian till in eastern Denmark. However, the Solsø diagram is slightly more extreme than the one from Skånsø indicating that the soil at Solsø was less fertile. Common to both sites is also a Subboreal heathland expansion, but there is a strong difference in timing and vigour. Although new radiocarbon dates have shown that the heather expansion at Solsø starts at 4300 C-14 years BP rather than at the 4800, which is indicated on the published diagram (Odgaard 1985, 1988) this is still 1000 years earlier than the first weak rise in the heather curve at Skånsø. Furthermore the expansion at Solsø is much quicker. At 3500 BP heather has reached 25% whereas at Skånsø this level is not achieved until 2000 years later. So when the forest destruction starts at

Skånsø at 3700 BP the forest is not replaced by heathland but by grass-dominated poor pasture, whereas heath follows immediately upon the forest clearances at Solsø. This difference could be explained as an effect of a more fertile soil at Skånsø which could endure a longer period of grazing before degradation was sufficient for heather to expand. However, the relationship between the heather and charcoal curves at Skånsø indicates that the frequency of fires were also important. Thus before or synchronous with a rise in the heather curve there is almost always an increase of the charcoal values suggesting that heather expanded after vegetation fires. From modern heaths it is well known how vigorously heather spreads after a fire (e.g. Hansen 1976). The temporary heather expansion at 5000 BP when there is a peak in the charcoal curve can be taken as further support for this hypothesis.

A very important common feature of regional pollen diagrams from East Denmark is the forest regeneration period starting around late Roman/early German Iron Age. Studies of the deposition of dust from cultivated fields on the raised bog Fuglsø bog (Aaby 1985) indicates a slight reduction of arable land at this time, if any. The decrease of ribwort which accompany the rise in tree pollen in eastern Danish pollen diagrams at this level suggests that pasture was replaced by forest.

In the Skånsø diagram as well as other regional pollen diagrams from western Jutland (Iversen 1941: Bølling Sø, Andersen 1954: Tinglev Sø, Jonassen 1950: Krag Sø, Jonassen 1959: Fiil Sø, Odgaard 1985, 1988: Solsø) an Iron Age forest regeneration phase is absent. A decline of pastoral farming seems to be completely lacking here. This feature is important in order to understand the history of beech in western Jutland. Admittedly, the predominantly sandy soils of west Jutland do not present optimal edaphic conditions for beech but today the tree thrives as well here as on infertile soils in northern Jutland and northern Zealand where beech is unquestionably indigenous. Lindquist (1959) drew a line through Jutland to delimit the westernmost stands of natural beech. This line coincides with the border between areas with an Iron Age forest regeneration and those without. The German Iron Age forest expansion in eastern Denmark is exactly the period when beech became a dominant tree here, but beech never had the same opportunity in western Denmark. It may thus be argued that the line of Lindquist (1959) is primarily caused by differences in cultural history rather than by edaphic or climatic factors. As a modern parallel Worsøe (1980, 1981) has documented how local presence or absence of beech in Central Jutland is determined by the historical use of the woodlands.

Until now heathland expansions in western Jutland have only been radiocarbon dated at Skånsø and Solsø. At a few other sites along the main stationary line, however, the first heath expansions can be dated to the Subatlantic period by correlation of the pollen diagrams (Iversen 1941: Bølling Sø, Andersen 1954: Tinglev Sø). The tentative scheme that emerges from these investigations is that the first heath expansion is oldest (early Subboreal) on leached sandy till in the central part of western Jutland, while considerably younger (late Subboreal or early Subatlantic) on outwash plains close to the main stationary line of the Weichselian glaciation. This scheme is, however, very crude and needs further testing. To check the timing of forest destruction on an outwash plain situated quite far from the main stationary line a pollen diagram is now being prepared from Lake Kragsø near Karup. Preliminary results indicate that forest destruction and heath expansion are rather late here like at Skånsø. Thus more and more the strong and early anthropogenic impact at Solsø stands out as unique and striking.

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