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THE BALTIC IN THE BRONZE AGE

Regional patterns, interactions and boundaries

edited by

Daniela Hofmann, Frank Nikulka
& Robert Schumann

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A publication of the Institute for Pre- and Protohistoric Archaeology (Institut für Vor- und Frühgeschichtliche Archäologie) of the University of Hamburg.

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Stone Age-Early Metal Period transition in the southern Finnish lake district

Incipient forest grazing and temporary burning practices

Kerkko Nordqvist, Teija Alenius, Chiara Molinari

Introduction

In the mid-third millennium BC, coastal areas of southern Finland were occupied by Corded Ware groups and the inland was inhabited by local hunter-fisher-gatherers generally identified through Pöljä Ware. A few centuries later, the Kiukainen culture appeared on the coast, whereas much of the inland lake district is archaeologically poorly defined at this time. Only centuries later do archaeological materials become visible again, but in an altered form and scarcer than before.

The decrease in the number of archaeological sites and finds in the Finnish inland areas during the late third millennium BC occurred simultaneously with deteriorating climatic conditions (see Heikkilä and Seppä 2003; Helama and Oinonen 2019; Salonen *et al.* 2014). This scarcity is explained either by diminishing population sizes, even depopulation (Lavento 2001, 141-42; see also Sundell 2014; Tallavaara *et al.* 2010), or by a shift to a more mobile lifestyle and archaeologically less visible material culture (Lavento 2001, 183-84; 2015, 125; Mökkönen 2011, 65). At the same time, palaeoecological records evidence an increasing anthropogenic impact on the environment. This contrast between palaeoecological and archaeological data has been pointed out in studies of land use and settlement history in inland areas (e.g. Alenius and Laakso 2006, 146; Alenius *et al.* 2009, 152; 2013, 15; 2020, 1632), and it forms the starting point for this study. Our goal is to combine palaeoecological and archaeological results from the southern lake district of Finland (Figure 1, Table 1) in order to discuss vegetation and land use changes during the transition from the Late or Final Stone Age to the Early Metal Period (i.e. the Bronze and Early Iron Ages; for terminology, see Nordqvist 2018, 53-54). In absolute years, the focus is roughly between 2500 and 1500 BC (see Table 2).

Long and continuous cores from lake sediments serve as rich archives for palaeoenvironmental reconstructions. They preserve records of past environmental changes and can provide information about the development of anthropogenic activities

Table 1. Lakes with analysed sediment pollen and/or charcoal* sequences discussed in this article (in cases where samples were obtained from a bay, the area of the bay is indicated in parenthesis; archaeological materials include the following categories: settlement/cairn/rock art site. † two of the sites overlap).

	Lake Kirkkolampi*	Lake Orijärvi*	Lake Nautajärvi	Lake Katajajärvi	Lake Huhdasjärvi*	Lake Ahvenainen*
Location	61°47′N 30°00′E	61°40′N 27°14′E	61°48′N 24°41′E	61°90′N 26°50′E	61°10′N 26°35′E	61°02′N 25°07′E
Area (ha)	72 (4)	29	19	17	107 (27)	7
Reference	Alenius and Laakso 2006	Alenius *et al.* 2008	Ojala and Alenius 2005	Alenius *et al.* 2009	Alenius *et al.* 2013; 2017a	Tolonen 1978
Number of archaeological sites at different radiuses	<1 km 0 (0/0/0) <2 km 0 (0/0/0) <5 km 1 (1/0/0) <10 km 3 (1/0/2) *Total 4 (2/0/2)*	<1 km 0 (0/0/0) <2 km 0 (0/0/0) <5 km 2 (2/0/0) <10 km 6 (5/0/1) *Total 8 (7/0/1)*	<1 km 0 (0/0/0) <2 km 0 (0/0/0) <5 km 0 (0/0/0) <10 km 6 (3/3/0) *Total 6 (3/3/0)*	<1 km 3 (3/0/0) <2 km 6 (4/1/1) <5 km 5 (3/1/1) <10 km 6 (5†/1/0) *Total 20 (15/3/2)*	<1 km 1 (1/0/0) <2 km 0 (0/0/0) <5 km 1 (1/0/0) <10 km 12 (6†/2/4) *Total 14 (8/2/4)*	Not studied

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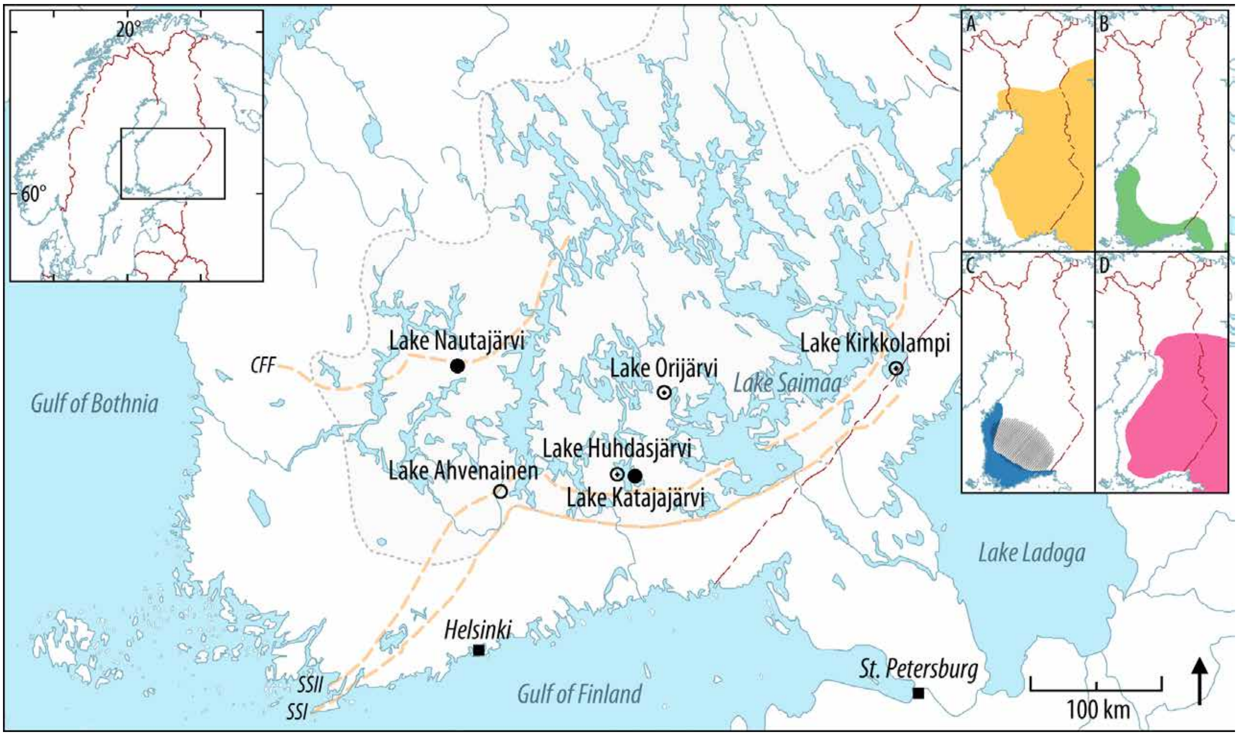

Figure 1. Locations of lakes with pollen (filled symbols) and charcoal (open symbols) data discussed in this article. The smaller maps show the main archaeological areas mentioned in the text: A – Pöljä Ware, B – Corded Ware, C – Kiukainen Ware and the "Middle Zone" (hatched), D – Textile Ware. The approximate border of the inland lake district (dotted line) and the major ice-marginal formations are also marked (SSI and SSII – Salpausselkä I and II, CFF – central Finland formation) (map by K. Nordqvist based on public domain data from Natural Earth (https://www.naturalearthdata.com/)).

through time. We analysed palaeoecological data from five previously published case studies using CONISS cluster analysis (Grimm 1987; 1991) with the aim to identify and date different vegetation phases (clusters) in the pollen sequences. To assess the impact of fire as a possible indicator of land use, we collected charcoal data from four previously published sites and reconstructed the main fire dynamics in the studied region. Finally, we combined the data with archaeological material from the surroundings in order to explore land use during the period that marks the change from the Stone Age to the metal periods.

Changes in social and economic conditions during the period under review are also more widely reflected in land use patterns in the northern and eastern Baltic Sea region (see for example Lang 2007 for Estonia). It is noteworthy, however, that despite indications of food-producing livelihoods found in various parts of the area (e.g. Cramp *et al.* 2014; Piličiauskas *et al.* 2017; Vanhanen 2019), the hunter-gatherer lifestyle in no way disappeared, and nowhere did societies emerge that relied solely on food production; the latter developed in the area only starting from the Bronze Age, or even much later. Development is typically slow in pace and, above all, highly variable. The area, disguised by such terms as "eastern Baltic region" or "north-east Europe", is geographically huge and includes a patchwork of cultural and natural environments, each of which provided local populations with particular resources and restrictions. In this context, our article presents one view based on a specific dataset from a particular area in the southern lake district of Finland.

Materials and methods

Five well-dated, high-resolution pollen records and four charcoal records obtained from sediments of lakes Kirkkolampi, Orijärvi, Nautajärvi, Katajajärvi, Huhdasjärvi and Ahvenainen (Figure 1) were selected for this study. Fieldwork, laboratory analyses and dating of the sediment sequences are described in the respective previous publications (see Table 1).

These records were chosen because they belong to the same geo-cultural context of the southern Finnish lake district. All lakes are situated between 61°20' and 61°90' latitude in the southern boreal vegetation zone. The bedrock of southern Finland belongs to the Svecokarelic unit, where microcline granite dominates. The studied lakes are located in

Figure 2. The rugged and steep shorelines of lake Katajajärvi, covered by bedrock and moraine, are not at first glance the preferred habitat for hunter-fisher-gatherers – nor the later farmers. The dominance of moraine soils is often seen as making the lake district less suited for cultivation. View from the southern end of the lake, from where the sediment core was obtained (photo: K. Nordqvist).

the vicinity of major ice-marginal formations (the Salpausselkä I-II and central Finland formations), and the rolling topography is often covered with Quaternary till, sand, silt, clay and organic deposits, which commonly fill the depressions of crystalline bedrock (Figure 2).

The lakes or basins (bays) selected for sampling vary between 4 and 29 ha in size and, therefore, also in the relevant source area of pollen (RSAP; Sugita 1994). In general, large sedimentary basins collect pollen from larger areas than small basins (Jacobson and Bradshaw 1981; Prentice 1985) and reflect a more regional vegetation cover (and human impact on vegetation). According to computer simulations (Sugita 1994), the RSAP in a fully forested environment is c. 300-400 m from the lake edge for small lakes (radius c. 50 m, lake Katajajärvi has a radius of 80 m) and 600-800 m for medium-sized lakes (radius c. 250 m, the other studied lakes).

To best identify periods of similar vegetation composition and ultimately observe possible changes in land use, a stratigraphically constrained cluster analysis (CONISS; Grimm 1987; 1991) was conducted for each site except lake Ahvenainen (due to the unavailability of raw pollen data) using land taxa. Cluster analysis helps to group pollen samples that differ from each other. *Picea, Pinus, Betula* and *Alnus* were omitted from the analyses to avoid the dominance of the major tree species. For each site, four major clusters were identified (Figure 4). To understand the main variations in vegetation composition and explore whether the vegetation actually changed during the Early Metal Period, the CONISS analyses were extended beyond this temporal interval, to between 3000 BC and AD 800. The lower limit was selected because, from this time onwards, all species typical of modern boreal forests (including *Picea*) are present. In contrast, the upper limit was chosen because until c. AD 800, no large-scale human impact on the landscape profoundly changed the forest structure.

For the study of fire dynamics at the regional level, charcoal data (microcharcoal concentrations, i.e. number of fragments/cm^3) from lakes Kirkkolampi, Orijärvi, Ahvenainen and Huhdasjärvi were transformed and standardised according to a protocol described by Power *et al.* (2008). The smooth composite curve (Figures 5 and 6) was produced by determining fitted values at 100-year intervals, and the data were expressed as transformed charcoal influx (hereafter referred to as tCHAR) Z-scores around the long-term mean, using the method implemented in the R (R Core Team 2016) package “paleofire” version 1.2.4 (Blarquez *et al.* 2014).

Figure 3. The cairn of Piikinperse A (southern lake Saimaa area) is a picturesque example of the "Lapp cairns", often described as rounded and low settings of unworked stones, located in the interior of Finland and built on bedrock in a prominent position along a lakeshore or on an island. Still, despite a long research history, there is no unambiguous definition for them, and the extremely few finds keep their dating and function open to interpretation (photo: K. Nordqvist).

Pöljä Ware	3300-2600/1900 BC
Corded Ware	*2900-2200/2000 BC*
("Middle Zone ceramics"	third millennium BC)
Kiukainen Ware	*2300-1800/1500 BC*
Textile Ware	1900-100 BC
Coastal Bronze Age Wares	*1500-500 BC*

Table 2. Dating of pottery types which, in the Finnish scholarly tradition, define the archaeological phases used in this paper. Coastal phenomena are in italics (the traditional dualistic coast-inland division of the Bronze Age in Finland associates the inland areas with the so-called eastern (i.e. non-Scandinavian) Bronze Age or Early Metal Period (c. 1900 BC-AD 400)).

To understand the archaeological micro-environment around the five lakes studied for pollen, information about all the surrounding material was collected and plotted on a map. This was done radially, first at a distance of less than 1000 m from the coring location. Keeping in mind the small size of the basins and their small RSAP, this distance should register relevant local human activity. To provide a broader context, finds at distances of 2000, 5000 and 10,000 m were also included (Table 1 and Figure 7). Information was extracted from the register of ancient monuments, maintained by the Finnish Heritage Agency (www.kyppi.fi), and amended using published literature (e.g. Alenius *et al.* 2013; Lavento and Lahelma 2007; Miettinen 1998). The register is primarily a tool for cultural resource management, and therefore its classifications are not accurate enough for research purposes (generic find categories and approximate dates). For example, "Settlement sites" (Table 1) include all find locations that are dated to the "Early Metal Period", but also to the "Stone Age" and "Prehistory". Almost all of them are locations identified based on only a handful of survey finds (mostly chipped quartz) without any datable attributes, and thus their potential age covers several millennia (dating based on shore displacement cannot be effectively used

Cluster	Lake Kirkkolampi	Lake Orijärvi	Lake Nautajärvi	Lake Katajajärvi	Lake Huhdasjärvi
1	**3000 -2120 BC** Trees: 93 % Thermophilous Deciduous trees: 3.5 % Herbs: 3.1 % *Juniperus:* 0.1 %	**3000-1860 BC** Trees: 93 % Thermophilous Deciduous trees: 4.5 % Herbs: 1.8 % *Juniperus:* 0.6 %	**3000-1520 BC** Trees: 92.4 % Thermophilous Deciduous trees: 4.8 % Herbs: 2.1 % *Juniperus:* 0.6 %	**3000-2560 BC** Trees: 91.7 % Thermophilous Deciduous trees: 5 % Herbs: 2.7 % *Juniperus:* 0.6 %	**3000-2060 BC** Trees: 91.4 % Thermophilous Deciduous trees: 5.4 % Herbs: 1.5 % *Juniperus:* 0,7 % Cereals: single 2160 BC
2	**2120-985 BC** Trees: 94.9 % Thermophilous Deciduous trees: 2 % Herbs: 2.4 % *Juniperus:* 0.5 %	**1860-90 BC** Trees: 94.4 % Thermophilous Deciduous trees: 2.9 % Herbs: 1.7 % *Juniperus:* 1 %	**1520-1180 BC** Trees: 93.6 % Thermophilous Deciduous trees: 3.7 % Herbs: 1.5 % *Juniperus:* 1.2 %	**2560-1950 BC** Trees: 92.3 % Thermophilous Deciduous trees: 4.4 % Herbs: 3 % *Juniperus:* 0.4 % Cereals: single 2220 BC	**2060-730 BC** Trees: 92.9 % Thermophilous Deciduous trees: 3.3 % Herbs: 1.6 % *Juniperus:* 1.3 %
3	**985 BC-AD 540** Trees: 96 % Thermophilous Deciduous trees: 1.3 % Herbs: 2.1 % *Juniperus:* 0.6 % Cereals: sporadically from AD 335 onwards	**90 BC-AD 720** Trees: 95.5 % Thermophilous Deciduous trees: 1.9 % Herbs: 1.8 % *Juniperus:* 0.8 % Cereals: single AD 620	**1180-30 BC** Trees: 94.2 % Thermophilous Deciduous trees: 2.5 % Herbs: 2.2 % *Juniperus:* 1.1 %	**1950-1660 BC** Trees: 92.3 % Thermophilous Deciduous trees: 3.5 % Herbs: 2.4 % *Juniperus:* 1.8 %	**730 BC-AD 660** Trees: 94.4 % Thermophilous Deciduous trees: 1.9 % Herbs: 1.9 % *Juniperus:* 0.9 % Cereals: 280 BC, AD 270, AD 620
4	**AD 540-800** Trees: 92 % Thermophilous Deciduous trees: 0.6 % Herbs: 6.4 % *Juniperus:* 1 % Cereals: continuously, 0.5 %	**AD 720-800** Trees: 95 % Thermophilous Deciduous trees: 2.4 % Herbs: 1.7 % Cereals: continuously from AD 740 onwards	**30 BC-AD 800** Trees: 94.8 % Thermophilous Deciduous trees: 1.9 % Herbs: 2.5 % *Juniperus:* 0.7 %	**1660 BC-AD 800** Trees: 94 % Thermophilous Deciduous trees: 1.7 % Herbs: 2.9 % *Juniperus:* 1.4 % Cereals: continuously between AD 280-670	**AD 660-800** Trees: 93.9 % Thermophilous Deciduous trees: 1.3 % Herbs: 2.7 % *Juniperus:* 1.5 % Cereals: AD 660, AD 775

Table 3. The four major clusters (3000 BC-AD 800) defined by the CONISS analysis, with a description of the main vegetation.

in most cases either). Only sites with typologically characteristic finds (pottery) from other periods, as well as sites with the remains of pithouses (housepits), which generally become less common from c. 2500 BC onwards (see Mökkönen 2011, 41-44; Okkonen 2003, 172), are excluded. "Cairns" include both the cairns directly dated to the Early Metal Period in the register and all "Undated" stone settings that, based on their description, meet the common criteria for Early Metal Period "Lapp cairns" (the building of which began at the very end of the third millennium BC; Saipio 2015, 126; Taavitsainen 2003, 29) (Figure 3). Finally, although mostly affiliated with the preceding Stone Age (starting c. 5000 BC), rock art sites are included here, as there are indications of their prolonged use or recontextualisation during the Early Metal Period (Lahelma 2008, 37-41; Saipio 2015, 129).

Results

The descriptions of the four major clusters identified by CONISS are presented in Table 3 and in Figure 4.

The regional reconstruction of fire dynamics oscillated during the period 3000 BC to AD 800 (Figure 5). Despite uncertainties, the composite charcoal curve shows values above the long-term mean (i.e. positive tCHAR Z-scores compared to the base period, i.e. the Early Metal Period, 1900 BC-AD 400) at 2800 BC, during the periods 2400-2200 BC, 2000-1800 BC, 1300-1000 BC, 700-400 BC, around 0 and 200 AD, and between AD 500 and 700. The maximum value is registered at 600 BC. Values below the long-term mean are instead recorded between 3000 and 2900 BC, 2700 and 2500 BC, around 2100 BC, during the periods 1700-1400 BC, 900-800 BC, 300 BC-AD 400 (peak in negative tCHAR Z-scores at AD 400) and around AD 800.

The number of archaeological sites located close to the sampling locations, while acknowledging the possible research biases, is quite low (Table 1 and Figure 7). Sites within the RSAP are only found at lakes Katajajärvi and Huhdasjärvi. When the radius increases (5 km or more), sites are found also around the other coring locations. Still, basically none of the nearby (small and short-term) settlement or camp sites can be securely associated with the time horizon discussed in this paper. The same applies to the unexcavated stone cairns. Rock art sites are found in the vicinity of all locations, excluding lake Nautajärvi, which already lies outside the main distribution area of rock paintings.

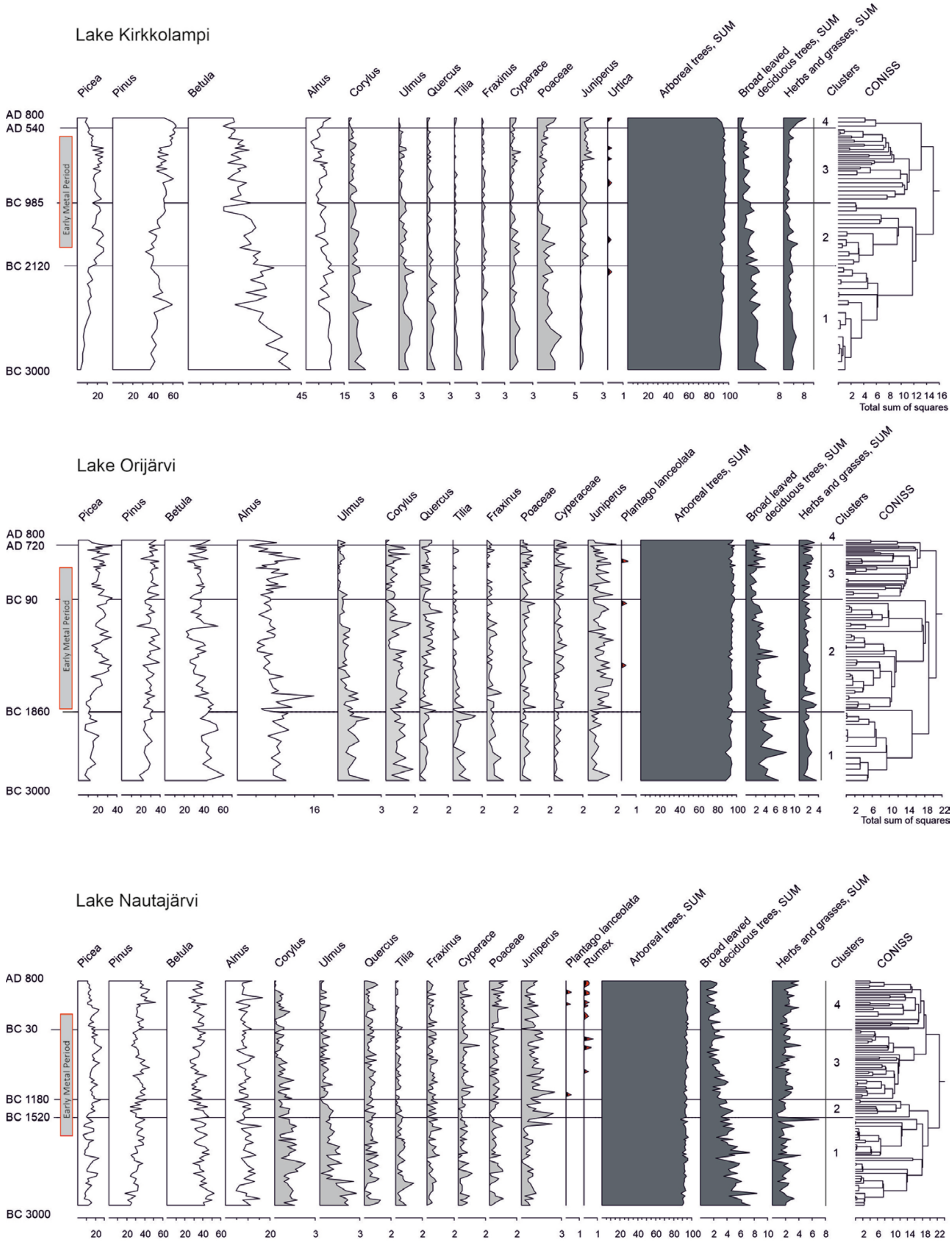

Figure 4. Pollen percentage diagrams with selected taxa plotted for the time interval 3000 BC-AD 800. The CONISS zonation and main clusters (defined by CONISS) are shown on the right.

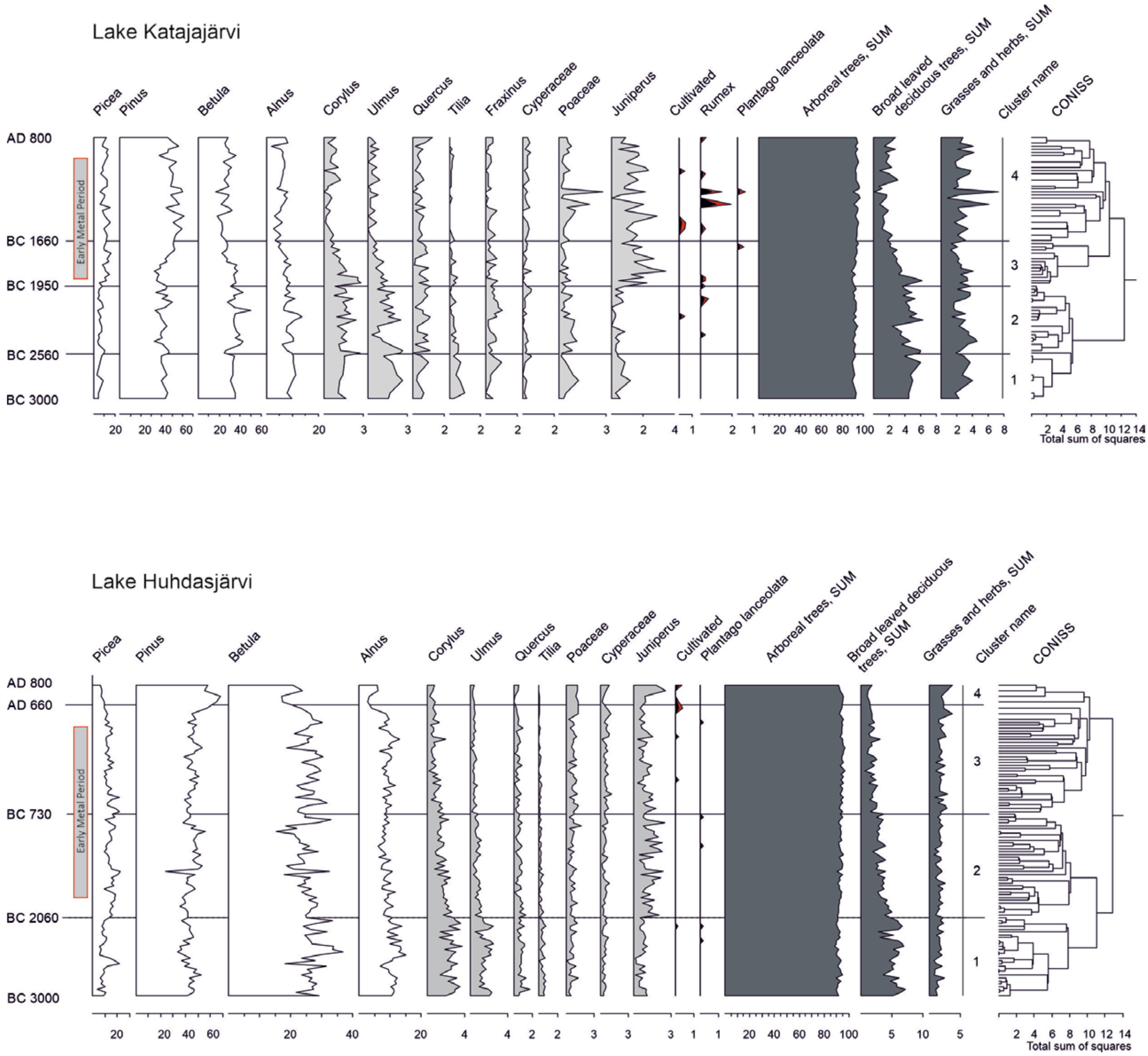

Figure 4 (continued).

Discussion

Incipient forest grazing and slash-and-burn cultivation

At lakes Kirkkolampi, Orijärvi, Nautajärvi and Huhdasjärvi, the analysed transition period coincides with the beginning of cluster 2 and at lake Katajajärvi with the start of cluster 3. In all five lakes, this period begins at c. 2120-1520 BC, and it is characterised by a variation in forest structure. The most distinct change in each place is a slight increase in *Juniperus* (juniper) pollen values. At the same time, a clear decrease in *Betula* (birch), *Alnus* (alder) and other broadleaved deciduous trees (*Ulmus, Corylus, Quercus, Tilia, Fraxinus*) is recorded. *Rumex*, *Urtica* and *Plantago lanceolata* are present sporadically, and even some *Hordeum*-type pollen grains have been dated to c. 2160 BC in lake Huhdasjärvi (at the end of cluster 1) and c. 2220 BC in lake Katajajärvi (in cluster 2).

The decrease in broadleaved trees and the simultaneous increase in *Juniperus* (a species with special light requirements and generally connected to forest disturbances) indicate grazing pressure (e.g. Behre 1981; Hæggström 1990; Pykälä 2001). During the era of traditional animal husbandry, livestock grazed and trampled freely in the forests (Soininen 1974) and helped preserve heterogeneous habitat mosaics and plant diversity

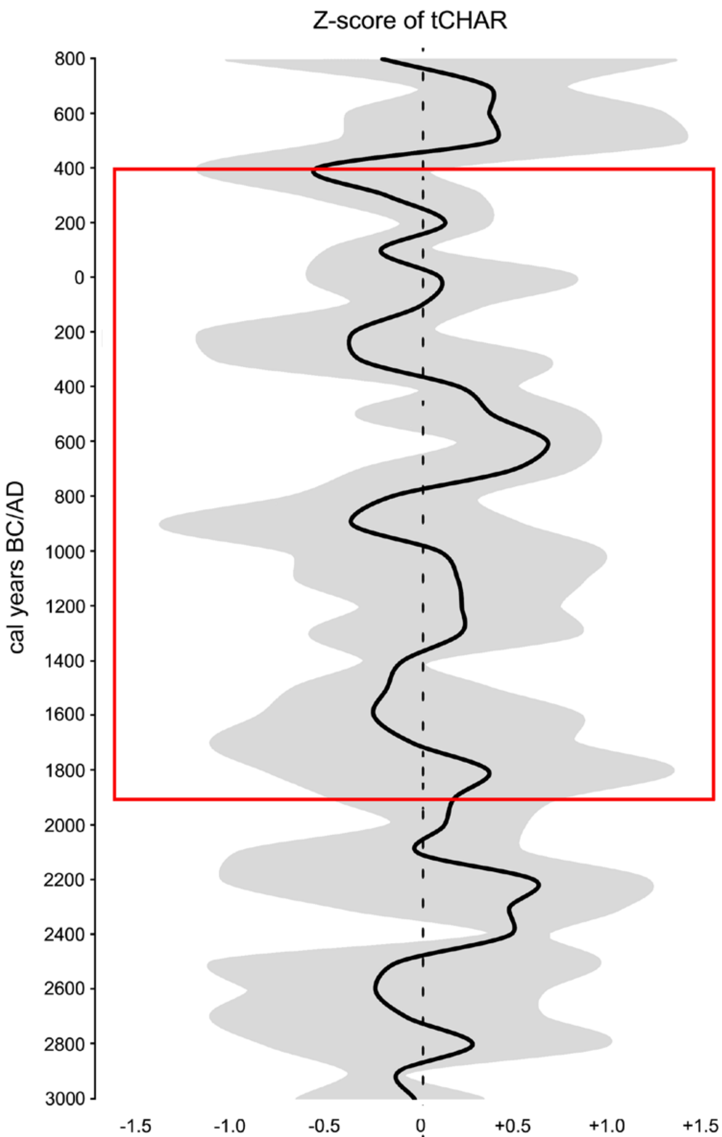

Figure 5. Reconstruction of regional fire activity (tCHAR Z-scores) for the time interval 3000 BC-AD 800 based on charcoal data from lakes Ahvenainen, Huhdasjärvi, Kirkkolampi and Orijärvi. The composite charcoal curve has a base period between 1900 BC and AD 400 and has been smoothed using a 150-year window half width. Grey shading represents the 95 % CI calculated using the bootstrap procedure. The Early Metal Period is marked with a red rectangle.

in the landscape (Luoto *et al.* 2003). The medieval shieling system in Dalarna (central Sweden) can be used to demonstrate the pre-industrial influence of animal husbandry on forest structure (Emanuelsson and Segerström 1998; Segerström and Emanuelsson 2002). Shieling areas that were established in the forests at some distance from the permanent settlements and used to pasture domesticated animals had a strong impact on local vegetation development: broadleaved trees like *Quercus*, *Tilia* and *Ulmus* disappeared locally, and *Betula* and *Picea* diminished. *Juniperus*, *Pinus*, Poaceae and other herbs (such as Caryophyllaceae, *Rumex* and *Urtica*) increased and cereals were introduced (Segerström and Emanuelsson 2002). Changes in vegetation in Dalarna correspond closely to what we see in the pollen data from the southern Finnish lake district.

Thus, it can be hypothesised that the vegetation dynamics observed at our studied sites are mostly the result of the introduction of incipient animal husbandry in the forests. However, the variations in pollen data are quite discreet. Starting from 2120-1520 BC onwards, *Juniperus* percentages increase but still remain low (c. 1.2 %). In previous pollen analyses carried out at lake Hannusjärvi, near Helsinki, *Juniperus* proportions accounted for close to 10 % of vegetation between AD 1550 and 1750, at a time when animal husbandry was already a widely established part of subsistence. According to cadastral and tithes records from AD 1571, lake Hannusjärvi was surrounded by ten farms, with a total of 12 horses, 39 cattle, 44 sheep and one pig (Alenius *et al.* 2017b). Based on these previous results, it can be speculated that only a few sheep would have been enough to cause the slight change in *Juniperus* proportions recorded by our data.

Archaeological and osteological evidence of domesticated animals for this time period is meagre (all material is burnt, as unburnt bone does not generally preserve in the soil conditions of Finland). The earliest sheep/goat bone comes from the context of the coastal Kiukainen culture (end of the third millennium BC), while cattle and horses are found only later in the Bronze Age in south-western Finland (Bläuer and Kantanen 2013, 1651-53). Lipid biomarker analyses of pottery are few, and no material dating to the studied period has been published from the inland parts of Finland. On the coast, the presence of dairy lipids has been established from the Corded Ware period onwards (Cramp *et al.* 2014, 3-4; Pääkkönen *et al.* 2020, 9-11). Despite this evidence, animal husbandry did not yet alter the basic subsistence, and the fragmentary osteological assemblages show that hunting and fishing also retained their importance during the transition to the Early Metal Period in southern Finland (Bläuer and Kantanen 2013, 1655; Mökkönen 2001; Seitsonen *et al.* 2017; Ukkonen 1996). The rapid expansion of animal husbandry in northern Europe has recently been genetically dated to the Middle and Late Iron Age (AD 400-1000; Niemi 2018).

The earliest macrofossil evidence of a domesticated plant from the Finnish mainland is a barley grain from a Kiukainen culture context, coastal south-western Finland, dated to the second half of the third millennium BC (Vuorela and Lempiäinen 1988, 40-41). In the southern lake district, the oldest macrofossil identification (barley) comes from a Textile Ware context dated to the second half of the second millennium BC (Lavento 1998, 50). However, archaeobotanical studies are quite limited in Finland (Vanhanen 2019, 15-20). No artefacts undisputedly related to cultivation exist from these early contexts.

Pollen data from different parts of the country testify to the incipient growing of domesticated species from c. 2300 BC onwards, but signs of cultivation remain scarce throughout the Early Metal Period (see Vuorela 1999; Vuorela and Hicks 1996 for reviews). Judging by the sporadic and low occurrence of cereal pollen, cultivation during this time must have been an episodic, small-scale activity, with no major subsistence value. Pollen data indicate that cultivation started to gain importance in many places in the Middle and Late Iron Age. Even then, farming often remained a subsidiary subsistence strategy.

We are aware of the fact that variations in vegetation composition in our study region could have been driven by purely environmental factors, including climate (Marquer *et al.* 2014; 2017). Recent research shows that the greatest proportion of variation in vegetation composition in Finland is explained by climate during the pre-agricultural period (c. 8000 BC-AD 1000; Kuosmanen *et al.* 2018). Furthermore, other studies support the hypothesis that land use became a primary driver of vegetation dynamics in northern Europe and Fennoscandia only during the last 2500 years (Kuosmanen *et al.* 2018; Marquer *et al.* 2017; Reitalu *et al.* 2013). Nonetheless, changes in the five pollen diagrams analysed here are abrupt (yet small-scale), while climate-driven alterations in vegetation are usually more gradual over a long time period and probably would affect a larger area. The assumption of human-driven change in vegetation composition is further supported by the sporadic occurrence of apophytes (i.e. *Rumex, Plantago lanceolata* and *Hordeum*), which are normally favoured by anthropogenic activities.

Incipient farming, particularly slash-and-burn cultivation, is an element associated in archaeological narratives with the Early Metal Period (Carpelan 1982; 1999, 268; Lavento 2001, 139-41; 2012a, 9-11). The regional charcoal curve from south-east Finland (Figure 5) seems to partially support the idea of the introduction of slash-and-burn cultivation during this time. In fact, even if the trend oscillates throughout the recorded time period (3000 BC-AD 800), with respect to the Early Metal Period the

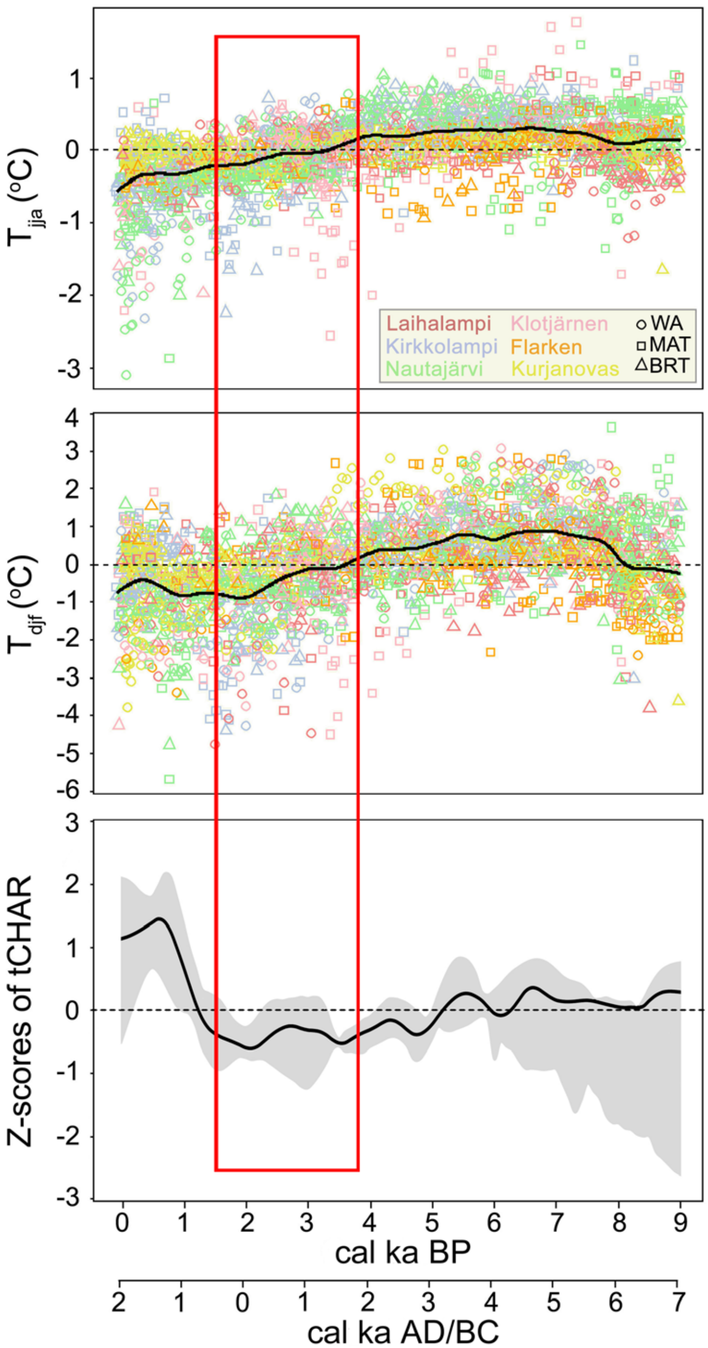

Figure 6. Comparison between pollen-based palaeoclimatic reconstructions for Tjja (June-to-August mean temperature) and Tdjf (December-to-February mean temperature), based on work by Salonen *et al.* (2014), and regional fire activity over the past 9 ka. A total of 18 reconstructions are included for each climatic parameter, prepared from six lakes with three methods: weighted averaging regression and calibration (WA), the modern analogue technique (MAT) and boosted regression trees (BRT). For details, see Salonen *et al.* (2014). For this comparison, both paleoclimate and biomass burning trends were expressed as deviations from the reconstruction-specific 9-ka mean, and the composite charcoal curve was smoothed using a 500-year window half width. Grey shading represents the 95 % CI calculated using the bootstrap procedure. The Early Metal Period is marked with a red rectangle.

intervals 1900-1800 BC, 1300-1000 BC, 700-400 BC and approximately AD 0 and AD 200 are characterised by charcoal values above the long-term mean (in this case, charcoal data have been expressed as deviations from the base period of 1900 BC-AD 400; Figure 5). The comparison of regional fire dynamics with reconstructions of Holocene summer and winter temperatures in northern Europe (taken from Salonen *et al.* 2014) indicates a rise in forest fires during the intervals 1500-700 BC and AD 0-400, two periods characterised by a general decrease in temperatures, especially mean summer values (Figure 6). Despite values below the long-term mean for both temperature and charcoal Z-scores (to be comparable with palaeoclimate reconstructions, in this case charcoal data have been expressed as deviations from the base period 0-9000 BP), these opposite trends during the Early Metal Period could suggest the occurrence of human-induced fires more than variations driven by natural disturbances (unlike the ones characterising earlier periods when the palaeoclimate and charcoal trends were synchronous).

Effects and scale of past human disturbance and modern research activities

Studies searching for the beginning of food-producing economies are often tuned to identifying the phases when cultivation and/or animal husbandry are already more or less established, providing a certain level of subsistence and transforming the structure and socio-demographic development of societies. However, this can be preceded by a lengthy introductory – or “trial-and-error” – period when the signs of new livelihood(s) may be weak and sporadic (Smith 2001). These incipient phases have usually received less scholarly attention (see also Alenius and Laakso 2006, 146; Alenius *et al.* 2021; Mökkönen 2010).

Inconsistencies between the archaeological and palaeoecological material are also not unknown in Finnish inland areas during the later phases of prehistory, and in several cases signs of cultivation or grazing are not backed up by archaeological finds (Alenius *et al.* 2004; 2008, 180; 2009, 141; 2013, 15; 2020, 1632). Lake Kirkkolampi can serve as an example here: despite indications of human activities and food production dated from the Bronze Age and Early Iron Age onwards, archaeological signals appear only in the Middle Ages (Alenius and Laakso 2006, 160). In this particular case, the lack of finds is not related to a lack of fieldwork: due to the adjacent and well-studied Papinniemi Orthodox village and cemetery (Laakso 2014), the lake shore and other surrounding areas have been thoroughly surveyed for Iron Age and later sites. These studies have not produced Stone Age or Early Metal Period finds. However, part of the adjacent area (radius >3 km) is located on the Russian side of the present-day border, and thus remains completely unstudied (Figure 7:4).

Of the other analysed locations, the area surrounding lake Nautajärvi remains practically unexplored, while in the area around lake Orijärvi numerous Iron Age excavations, but no basic surveys, have been conducted (Figure 7:2 and 7:3). The sites next to the coring locations in the lake Huhdasjärvi and lake Katajajärvi area (the two lakes are situated less than 14 km apart; Figure 7:1) were largely identified during targeted intensive archaeological surveys conducted in connection with palynological studies (Alenius *et al.* 2013, 7-8; Lavento and Lahelma 2007). Furthermore, the rather small number of finds in relation to the research efforts highlights the scarcity of sites and the sparse nature of land use. They also illustrate the problems connected to finding sites that are often (especially around lake Katajajärvi) situated in settings that diverge markedly not only from the stereotypical positions expected for Stone Age hunter-fisher-gatherer locations, but also from later agropastoral settlements (Alenius *et al.* 2009, 150; Nordqvist 2007, 107) (Figure 2). The absence of typologically diagnostic finds and radiocarbon dates prevents proper dating and emphasises the unclassifiable nature of the material.

The implications of limited research on and the potentially reduced archaeological visibility of such sites must be acknowledged. The changes suggested for settlement patterns and material culture in general (Ikäheimo 2005, 773-76; Lavento 2001, 137-39; Mökkönen 2011, 65) would markedly weaken the archaeological signals. However, since

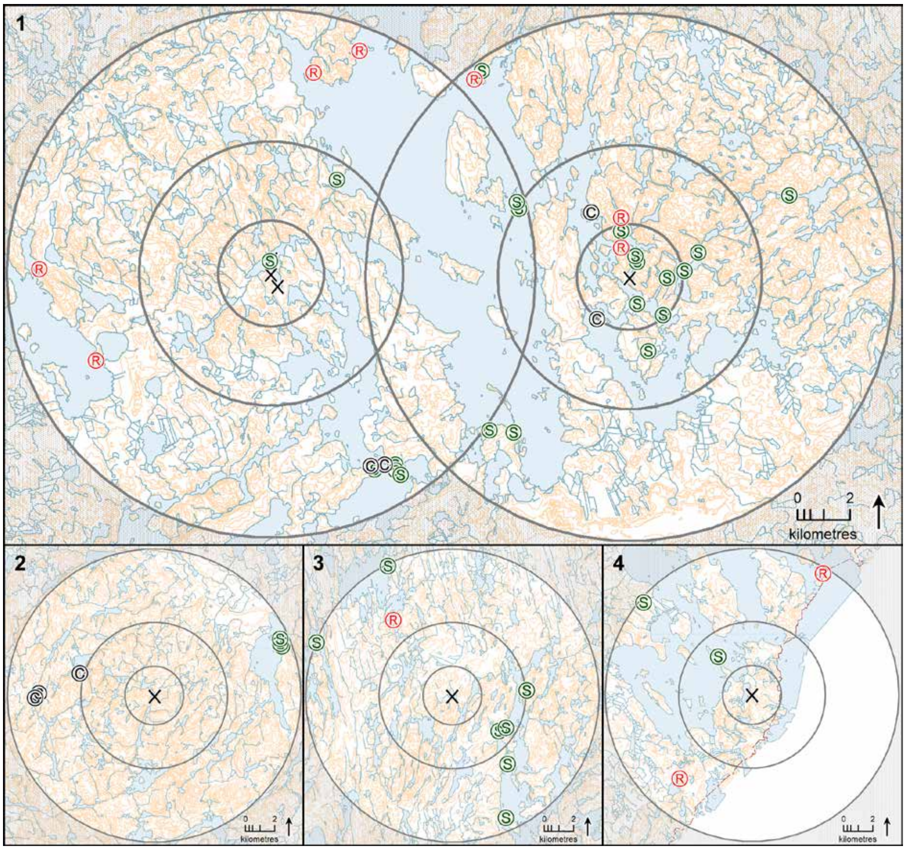

Figure 7. Archaeological sites located in the vicinity of the sampling locations (x): 1 – lake Huhdasjärvi (left) and lake Katajajärvi (right), 2 – lake Nautajärvi, 3 – lake Orijärvi, 4 – lake Kirkkolampi (white uncharted area is in the territory of the Russian Federation); C – cairn; R – rock art, S – settlement. Concentric circles mark 2-, 5- and 10-km buffer zones around the coring sites (map by K. Nordqvist, based on CC-BY data from the National Land Survey of Finland Topographic Database 10/2020).

only a handful of properly studied Early Metal Period sites and micro-areas are known (*cf.* Lavento 2001, 135-37; 2012b, 159-61), this must remain just one of several hypotheses. Even if we noted a contradiction between the archaeological and palaeoecological data, both sets of data still show a change in land use and settlement patterns and indicate the limited magnitude of anthropogenic activities during the last centuries of the Stone Age and the beginning of the Early Metal Period.

It has been demonstrated (Broström *et al.* 2004; Sugita 1994) that small vegetation patches cannot be recorded in pollen data from very large lakes because substantially large amounts of pollen come from more distant sources. Vegetation appears homogeneous in the pollen record, and therefore very large lakes are well suited for reconstructing regional vegetation, but less for studying small-scale (local) forest composition and human activities. At the same time, *Juniperus communis* and *Plantago lanceolata* have high pollen productivity estimates (Broström *et al.* 2004; Hjelle 1998), accounting for the significant influence of background pollen coming from an area beyond the immediate RSAP. This suggests that the light increase in *Juniperus* in all studied sites from 2120-1520 BC onwards does not necessarily indicate local pastoral activity, but might instead, given the lack of archaeological finds near most sampling locations, represent human activities (i.e. grazing) on a regional scale; alternatively, if grazing did take place beside these lake basins, it was not connected with the settlements.

The low human presence close to the sampled sites could be explained through sparse habitation and the (also historically documented) practice of clearing cultivated plots further away from the settlements (Alenius *et al.* 2009, 150; 2013, 15; Lavento 2012a, 15, 32; see also Taavitsainen *et al.* 1998). The earliest cultivated plant pollen originate from autogamous and insect-pollinated species (such as *Hordeum, Avena* and *Triticum*), which release very little pollen into the air (Fægri and Iversen 1989). *Hordeum* pollen are poorly represented even in the immediate vicinity of the fields (Bakels 2000; Hall 1989;

Vuorela 1973), and therefore, the picture provided by cultivated plant pollen types is likely distorted. Wind-pollinated *Secale*, on the other hand, produces substantial amounts of pollen, and as a result the onset of slash-and-burn cultivation with rye as the main species is more clearly visible in the sediments relative to the cultivation of barley even in small permanent fields.

Farewell to the Stone Age

The palaeoecological data summarised here suggest changes in land use in the southern Finnish lake district during the Stone Age-Early Metal Period transition, including incipient forest grazing and even sporadic cultivation attempts in some areas (Figure 4). Still, the overall changes in the forest structure remain quite small (yet visible) and indicate that the human-driven activities causing these changes must have been of limited magnitude. The question is how to contextualise these observations in archaeological terms.

Much of the material related to the inland hunter-fisher-gatherers, generally epitomised by Pöljä Ware (see Meinander 1954, 161-67; Nordqvist and Mökkönen 2021), disappears during this time. Even if some continuity is often assumed between the Stone Age and the Early Metal Period, actually very little material has been reliably dated to later than 2500 BC (including Pöljä pottery/food crusts; see Nordqvist and Mökkönen 2021, 34; Pesonen 2004, 92), and the few dated contexts evidence changes in settlements, dwellings and other material culture (Mökkönen 2011, 64). Levels in sediment cores containing *Cerealia* pollen dating to the third millennium BC have previously been connected with groups living in the so-called Middle Zone (Carpelan 1982, 268; 1999, 268), which is seen as a contact area in southern Finland where hybridisation of the coastal and inland populations took place (Carpelan 1979, 15; 1999, 267). However, the “Middle Zone” remains a vaguely defined concept with similarly unclear dating (*cf.* Mökkönen 2011, 53; Nordqvist 2016, 59-61; see also Lavento 2012b, 153-54) and lacking full explanatory value. Thus, in the presence of only insufficiently recognised archaeological materials, these early indications of cultivation remain rather “stray pollen finds” without clear origins and context.

Changes in forest structure, visible from 2120-1520 BC onwards and likely caused by forest grazing, partially pre-date but largely overlap with the occurrence of Textile Ware. Characterising the inland Bronze Age, its appearance most likely resulted from external influences from the (south-)east, possibly with some local inputs (Lavento 2001, 176; see also Carpelan 1999, 268-70; Meinander 1954, 180-95). Textile Ware populations were probably familiar with slash-and-burn cultivation (Lavento 2001, 139-41; 2015, 132; also Carpelan 1999, 268) and, although their main subsistence still came from foraging (Lavento 2001, 141), they may also have engaged in animal husbandry on a quite limited scale (Lavento 2015, 133). Although some caution is warranted with our data interpretation, both temporary burning practices and forest grazing are supported by the present results. In conclusion, the change in land use does not indicate a large-scale spread of agriculture during this time. Both cultivation and animal husbandry were known, but they only had, at best, a minor subsidiary role in subsistence. The transition to fully productive livelihoods was a gradual process in Finland, and their introduction did not lead to an immediate population increase or obvious increase in social complexity. Finally, the present data do not indicate a total break (long-lasting hiatus) or depopulation in the studied area as a whole, but, at the same time, they do not support full-scale continuity either.

The duration of the Stone Age has intrigued Finnish archaeologists for over a century (e.g. Ailio 1913; Äyräpää 1935; Tallgren 1914). Even if the Stone Age-like nature of settlements and subsistence during the Early Metal Period has been repeatedly stressed (cf. the Arctic Bronze Age; Tallgren 1937, 12-14), the period of time discussed in this article covers the disappearance of many populations following a hunter-fisher-gatherer way of life in the traditional Stone Age sense of the word (see also Lang 2007, 33). The character of the archaeological data changes in many fields of life (settlements and settlement patterns, material culture, belief systems), indicating the alteration of society in general. Nevertheless, we are forced to conclude that, at present, we can neither sufficiently identify the role of local communities behind such developments nor name all the populations or directions of impact responsible for particular changes in archaeological terms. This gap in our knowledge regarding the cultural and demographic developments of the late third and the early second millennium BC still requires heavy interdisciplinary research input, not only in Finland but also on a north-east European scale.

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