



# Hunter-gatherer farming during the first millennium BCE in inland, boreal landscapes: new pollen analytical and archaeological evidence from Dalarna, central Sweden

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## Abstract

The archaeological evidence of a sedentary hunter-gatherer society during the early metal ages, i.e. the first and second millennia BCE, in the central Scandinavian boreal inlands has previously been overlooked. In order to gain a deeper understanding of these past societies we have combined archaeological data with landscape-scale changes based on pollen records. The combined record clearly indicates landscape use characterized by domestication strategies that started during the Late Bronze Age ca. 1000 BCE and further intensified during the Early Iron Age. Indications of cultivation of plants, as well as possible burning practices to clear shrub and forest, clearly show that arable farming and grazing were practiced in the area earlier than had previously been assumed. The farming economy seems to have involved mainly small scale arable farming. Fishing and hunting continued to be important, but the investment in the landscape shown by both pitfall systems and agriculture also express a domestication that would have required settled presence.

**Keywords** Sweden · Pollen analysis · Archaeology · Boreal forest · Arable farming

## Introduction

During the final stages of the Neolithic in Scandinavia, arable farming was well established in the southern and central parts, and also further north on the Atlantic and Baltic coastlines. The transition to the Bronze Age, which occurred at ca. 1700 BCE, is regarded as the end of the Neolithic period. The following Nordic Bronze Age (1700–500 BCE) is described as a homogeneous cultural period with a

hierarchical chiefdom society, based on control over metal trade and supported by farming (e.g. Kristiansen 1999, 2015; Ling et al. 2014).

The categorization of a Bronze Age cultural sphere relies heavily on the occurrence of metalwork and farming. As a result, areas where bronze objects and traces of farming are absent (such as the northern inland areas of Scandinavia) are seen as separate from those with strong evidence for farming. Associated sites are categorized as belonging to an ‘Arctic Bronze Age’ related to mobile hunter-gatherer groups. These are assumed to have had little or no connection to the southern farming sphere (see Bolin 1999; Prescott and Melheim 2017; Oma 2018; Ojala and Ojala 2020 for a contrary view). The dualistic division of Nordic Bronze Age societies as being either farmers or hunter-gatherers (HG), or by reference to the northern ‘farming limit’, are not supported by the archaeological record. Recently, researchers have focused on the heterogeneous character of the societies inhabiting areas north of the so-called ‘farming limit’ (e.g. Anfinset and Wrigglesworth 2012; Skandfer and Wehlin 2017). This paper similarly discusses evidence of settlement and landscape changes in the central Scandinavian inland landscapes. By comparing the results of pollen analysis with

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the archaeological record, we address movements, settlement, material-culture expressions and landscape transformation during the last two millennia BCE, to better evaluate the gradual neolithisation of the region. We also qualify

this process in terms of its different elements. There is a complexity related to patterns of movement and subsistence that is not captured by the categorizations provided by the archaeology of south Scandinavian farming societies, but which involve clear elements that relate to agricultural practices.

The study is based on analyses of the spatial distribution and categories of archaeological sites and associated material culture in the area around Tisjön in the western part of Dalarna, located in the Fennoscandian Mountain range (Figs. 1 and 2). The majority of sites were located through archaeological surveys, as well as rescue excavations carried out in the period 1958–1960 in connection with the building of hydroelectric dams (Östberg 1972; Ekman and Iregren 1984; Hyenstrand 1987). The archaeological material is discussed in relation to pollen, charcoal, and dung fungal spores from a lake-core near Tisjön and two cores collected earlier from two different fen basins in the valley along the river Västerdalälven in the county of Dalarna, central Scandinavia.



**Fig. 1** Location of the study area in western Dalarna, Sweden. In the detailed map, Lake Tisjön and the Natura 2000 nature reserve Tandövala are indicated, and the location of the pollen coring sites, Lomtjärnen, Heden and Brofästet, are indicated by an asterisk. Graphics: J. Wehlin

**Fig. 2** View to the north-west (at 750 m a.s.l.) of the low alpine area of Tandövala with Lake Tisjön in the background. Photo: M. Klarström; 03/06/2011



## In between farming and hunting

Farming settlements are typically defined based on the occurrence and control of domesticated animals and/or cultivation of crops (Welinder et al. 1999, pp. 44–47). Archaeologically, such agricultural practices are generally identified from a variety of evidence including house remains, animal bones, pottery, fossilized fields, pollen grains of cereals, clearance cairns and so forth. These indications of farming are mostly absent in northern inland areas. The absence of direct evidence of farming has led researchers to assume that domestication of plants and animals did not play a significant role in these parts during the Bronze and Early Iron

Ages, and hence that farming was unimportant (Forsberg 1985; Baudou 1995). However, as stated above and as we shall see further on in this paper, archaeological material and palaeoecological evidence from our study give witness to a domestication of both plants and animals that is not captured by categorizations based on southern source materials.

Archaeological evidence in southern Scandinavian areas shows that farming was combined with use of wild resources. Excavations of the Bronze Age settlement Apalle have revealed large quantities of bones from fish and small game, indicating a substantial exploitation of non-agricultural resources. The use of a wide range of wild plants and domesticated plants also suggests heterogeneous subsistence patterns (Ullén 2003; Vretemark 2010). At the same time, lipid analyses of Bronze Age pottery show that the use of cooking vessels mainly involved preparations of dairy-products, suggesting a primary role of animal husbandry as a provider of secondary products (Isaksson 2018).

Farming communities in the past can be traced through interactions with landscapes in terms of settling, human-animal relations, and conceptions of death and the afterlife that are manifested in graves and monuments (cf. Bradley 1998, 2000). These interactions and material traces can be distinguished from a HG way of life. Still, studies of the early Neolithic show a gradual and much-varied integration of farming that did not replace subsistence sources such as hunting, fishing and gathering. More obvious features of the neolithisation process include the occurrence of graves, monuments and ceremonial sites, and broader landscape practices and transformations (Tilley 1996; cf. Cummings and Harris 2011).

A recent study of north Scandinavian inland Sami communities from the period 500–1500 CE reveals cultivation of Sami cultural plants in abandoned pens for reindeer corraling that had been fertilized by the manure and trampling of reindeer (Bergman 2018). Another example is thinning out or burning vegetation in order to create environments that favour desirable plants, wild or domesticated. Such cultivation of the natural environment is not necessarily connected to settlements in the traditional form of farmsteads, but may still be characterized by other features of agricultural life, such as strong connections to ceremonial sites and territorial control over resources (Popov and Tabarev 2014).

Connections between permanent settlements and farming activities cannot be taken for granted. Mobility has, in fact, been an essential part of farming even in later times (e.g. Costello and Svensson 2018). Moving livestock to outlands during the summer time was an essential part of animal husbandry up until at least the nineteenth century. We argue that a permanent or rotational settlement is expressed through landscape features, such as the construction of large structures aimed at controlling resources, for example pitfall systems, or transformations of the environment.

By analysing the gradual change connected to mobility, material culture, subsistence, burial practices and human-environment relations we are able to address aspects of domestication and settlement during the early metal age in central Scandinavian boreal inlands that have been previously overlooked.

## Study area

The study is centred in the area around Lake Tisjön in the western part of Dalarna, which lies in the southernmost reaches of the Fennoscandian Mountains (Figs. 1 and 2). Lake Tisjön is located 482 m above sea level (a.s.l.) and extends over about 27 km<sup>2</sup>. The area around Lake Tisjön is topographically diverse with mountains (highest 775 m a.s.l.), some of which are forested and some with open vegetation. These elevated areas are interspersed with river valleys and several marshlands, bogs and small lakes (at about 450 m a.s.l.). Vegetation is characterized by alpine flora with open, herb-dominated plant communities on the higher peaks. In recent years, birch shrub and forest have encroached upon the open mountain vegetation, threatening unique bryophyte and lichen communities (County Administrative Board 2016). At lower elevations, pine, spruce and birch are the most common forest trees. Historically, the area was used for so-called shielings, i.e. summer grazing and outland natural resource extraction, such as for example coaling and big-game hunting. The summer shieling and outland practice in this area were first documented in the 17th century, but probably have origins further back in time (County Administrative Board 2016).

Archaeologically almost 40 prehistoric sites that are interpreted as settlements or settlement areas connected to a hunter-gatherer way of life, are known from around Tisjön. Three sites in the northern part of the lake have been archaeologically excavated, and the archaeological material indicates typological dates from ca. 7000–200 BCE (Östberg 1972). More recently, <sup>14</sup>C analyses have been carried out on bone material from the old excavations, and the results indicate that there is a wide age range represented (6600–2100 BCE) (Wehlin 2017; Manninen et al. 2023). In addition, there are some previously recorded iron production sites, systems of hunting pitfalls and an early Iron Age grave field indicating a rich variety of activities. The date for onset of iron production in the area has not yet been clarified, but a dozen remains from bloomery hearths have been recorded.

## Materials and methods

This paper presents a combined study of three dated pollen cores from different locations together with a compilation of archaeological data. The archaeological data originate

exclusively from the Tisjön area. The palaeoecological study is based on analyses of pollen, charcoal and spores carried out on a sediment core from Lomsjön, beside Lake Tisjön. This record is complemented by two other cores from Heden and Brofästet, situated 20 km east of the study area (Fig. 1). These cores were analysed in 1998, but have not previously been published. The Heden and Brofästet cores are here re-analysed.

## Pollen record Lomtjärnen

### Coring

Lake Lomtjärnen (60° 57' 7.99" N, 12° 54' 9.93" E) was selected as a sample location because it is situated north of Lake Tisjön and in close proximity to several archaeological sites dated to 2000 BCE–500 CE. Lake Lomtjärnen has a surface area of about 8,600 m<sup>2</sup> and it is therefore likely to have both a local and regional pollen source area (Jacobson and Bradshaw 1981; Prentice 1985; Sugita 1998, 2007a, b). Therefore, we expect the pollen signal from the archaeological sites and human activity at the landscape level to be discernible in the data.

Fieldwork to retrieve sediment core C was carried out on 1st April 2020. A 92-cm-long core was retrieved from a depth of about 2 m using a 7.5 cm diameter Russian corer. The coring site Lomtjärnen is located about 500 m from the northern end of Lake Tisjön where several known prehistoric sites are located.

### Sub-sampling and analysis

The core was subsampled for pollen analysis with a focus on the first two millennia BCE. Pollen samples were prepared using standard methods with 10% HCl, 10% NaOH, acetolysis (Moore et al. 1991) and density separation (Björck et al. 1978; Nakagawa et al. 1998). Pollen, pteridophyte spores, fungal spores and charcoal particles were recorded. Charcoal particles were measured and divided into size categories < 50 and ≥ 50 µm. Percentages were calculated based on the sum of terrestrial pollen; charcoal percentages were calculated based on the sum of charcoal and terrestrial pollen. Samples were divided into pollen assemblage zones (PAZs) using a CONISS analysis performed by the software Tilia (Grimm 2016). A total of 24 samples were counted (every 2 cm between 36.5 and 68.5 cm and every 4 cm between 16.5 and 36.5 cm, and 68.5 and 76.5 cm). A minimum of 500 terrestrial pollen grains were counted per sample. The samples were mounted in silicone oil. Grain and annulus diameters of Poaceae pollen were measured to identify potential cereal pollen grains, as specified by Andersen (1979). Pollen of *Cannabis* and *Humulus* have been merged into one category (*Cannabis*-type) as these pollen types are

not easily distinguished. Organic matter (OM) was measured by combusting samples that were taken every 1 cm at 550 °C for 4 h (Aaby and Berglund 1986). For <sup>14</sup>C dating the Tandem Radiocarbon Laboratory, Uppsala University, was used and dates were calibrated using Oxcal 4.4 (Bronk Ramsey 2009) and the IntCal20 calibration curve (Reimer et al. 2020). A Bayesian age-depth model was produced in R (R Core Team 2021) using the package Bacon (Blaauw et al. 2022).

## Pollen records at Heden and Brofästet

### Coring

Fieldwork to retrieve two sediment cores for pollen analysis was carried out on 25th August 1998 in a small pond near Heden (60° 52' 47.19" N, 13° 23' 40.59" E) and in a fen near Brofästet (60° 52' 52.78" N, 13° 23' 37.72" E), west of Västerdalälven in Lima. The Heden pond is part of a smaller marshland in close proximity (100 m) to Västerdalälven. The marshland is cut off from the river flood but receives water during floods and high stands. The sampling locations were selected because of their proximity, 500 and 600 m respectively, to an excavated archaeological site L2001:7831 that was part of a rescue excavation (Eriksson 1991). Both cores were retrieved with a Russian corer and were 200 cm long and 5 cm in diameter. The pond at Heden has a surface area of about 650 m<sup>2</sup> and the fen at Brofästet has a surface area of about 2800 m<sup>2</sup>, which suggests that their pollen source areas are local and regional, respectively (Jacobson and Bradshaw 1981; Prentice 1985; Sugita 1998, 2007a, b). Here we also expect the pollen signal from the archaeological site, or activities nearby, to be discernible in the data. Pollen diagrams were generated in R, using the Rioja-package (version 0.9–26; Juggins 2020).

### Sub-sampling and analyses

The cores from Heden and Brofästet were subsampled every 5 cm and treated using 10% HCl, 10% NaOH and acetolysis (Berglund and Ralska-Jasiewiczowa 1986). Charcoal particles > 25 µm were registered while counting pollen. A total of 37 levels were counted at about every 5 cm in the Heden core. In the Brofästet core 19 levels, mostly at 10 cm intervals, were counted. Percentage curves were constructed and the pollen profile was divided into PAZs using the vegan-package in R (version 2.5-7; Oksanen et al. 2020). Grain and annulus diameters of Poaceae pollen were measured to identify potential cereal pollen grains as specified by Andersen (1979). For <sup>14</sup>C dating the Tandem Radiocarbon Laboratory, Uppsala University, was used and dates were calibrated using Oxcal 4.4 (Bronk Ramsey 2009) and the IntCal20 calibration curve (Reimer et al. 2020). Age-depth

models have been produced in R (version 4.0.5; R Core Team 2021) following the linear-interpolation model in the clam-package (version 2.4.0; Blaauw 2010).

### The archaeological record at Tisjön

Archaeological surveys and excavations around Tisjön were carried out between 1958 and 1960 in the context of a hydroelectric project. Excavations were carried out at a small grave field and three prehistoric sites were interpreted as Stone Age settlement areas (Hyenstrand 1987; Fig. 3). In the late 1960s, both the stone (Östberg 1972) and bone material (Ekman and Iregren 1984) were reported on in more detail. In more recent years  $^{14}\text{C}$  analyses have been carried out on bone material from the settlements and the grave field towards improving the chronology of the sites (Wehlin 2017; Manninen et al. 2023).

After the 1960s, the amateur archaeologist Martin Rosén carried out surveys that more than doubled the number of known settlements around the lake. Roséns collection is kept and managed by Dalarnas museum and has recently been studied in detail with the aim of locating settlements from the first two millennia BCE (Wehlin and Lindblad 2023).

In addition to settlements and a grave field, there are a number of iron production sites and also four extensive pitfall systems for big-game hunting located around Tisjön. None of the iron production sites has been excavated, and the

pitfall systems are not dated, with the exception of  $^{14}\text{C}$  dating of two of the pitfalls in the largest system located south of Tisjön (Hyenstrand 1987).

This study builds on the compilation of sites and material registered and reported in the Swedish National Heritage Board's database for archaeological sites and monuments (KMR, Kulturmiljöregistret, <https://app.raa.se/open/fornsok/>), the museum collections at the Swedish history museum (Inventory Numbers SHM 26482, 26483, 26484, 25979) and the Martin Rosén collection at the county museum of Dalarna (inventory numbers DM 18785–18836, 18839–18886, 18888–18903). Sites are both typologically and  $^{14}\text{C}$  dated.

## Results

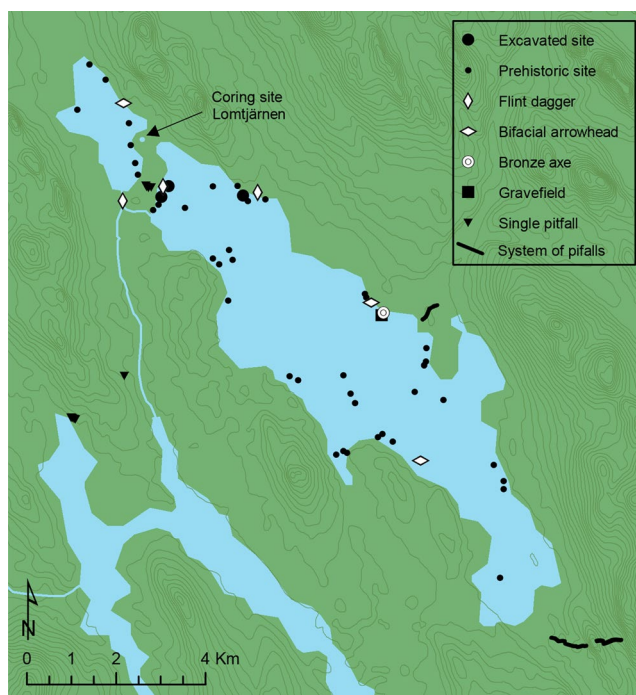
### Palaeoecological record at Lomtjärnen

The core consisted of dark-brown, coarse detritus gyttja. The results of  $^{14}\text{C}$  dating of four terrestrial plant macrofossil samples are given in Table 1. These and other  $^{14}\text{C}$  dates presented here have been calibrated using Oxcal 4.4 (Bronk Ramsey 2009) and the IntCal20 calibration curve (Reimer et al. 2020). Figure 4 shows the Bayesian age-depth model for the Lomtjärnen core. The CONISS zonation recognised three main PAZs (Fig. 5) that are briefly summarized below.

**PAZ 1 (76.5–50.5 cm, ca. 6000–4000 BCE)** This oldest pollen assemblage zone (PAZ) is characterized by high values for arboreal pollen (AP), i.e. *Betula* (45–63%), *Pinus* (21–38%), *Alnus* (7–13%) and *Ulmus* (0.5–2%). *Corylus/Myrica*-type is also relatively common. There is one record of *Cannabis*-type pollen in the uppermost part of the PAZ, and herbs such as *Urtica* and *Artemisia* are also occasionally recorded. Values of dwarf shrub *Calluna* are low but higher within this PAZ than in the rest of the core (0–1%). Single spores of coprophilous fungi, *Podospora* sp. and *Cercophora* sp., are recorded. Microscopic charcoal levels are relatively high, 0–1% for particles  $\geq 50\ \mu\text{m}$ , and 1–6% for particles  $< 50\ \mu\text{m}$ . OM is at 95–96%.

**PAZ 2 (48.5–36.5 cm, ca. 4000–1300 BCE)** *Alnus* decreases (6–9%) within this PAZ, along with *Corylus/Myrica*-type (1–2%). *Picea* pollen occurs occasionally. The PAZ shows a small increase in *Sphagnum* spores. Two *Cannabis*-type pollen grains, a single pollen grain of other herbs (*Artemisia*, *Rumex* spp. and *Urtica*) and a spore of the coprophilous fungus *Sporormiella* are recorded. OM decreases slightly at 45.5 cm, but is not accompanied by noticeable changes in the pollen record. Microscopic charcoal decreases relative to PAZ 1.

**PAZ 3 (32.5–16.5 cm, ca. 1300 BCE–600 CE)** *Picea* begins to increase, particularly from 32.5 cm depth (ca. 900 BCE).



**Fig. 3** Main study area of Tisjön with known prehistoric sites and finds. The pollen coring site at Lomtjärnen is marked. Contours at 5 m intervals are shown. Graphics: J. Wehlin

**Table 1** Results of  $^{14}\text{C}$  dating of plant macrofossil and bulk samples from the Lomtjärnen, Heden and Brofästet cores

Lab. code	Sample	Depth (cm)	Material dated	$\delta^{13}\text{C}$ (‰)	$^{14}\text{C}$ age (BP)	Calibrated age (2 $\sigma$ )
Lomtjärnen (macrofossils)						
Ua-70386	T28	28.5	Conifer seed scale	-27.6	2,440 ± 30	751–684 BCE (22.3%) 668–634 BCE (9.8%) 622–613 BCE (1.1%) 591–408 BCE (62.3%)
Ua-70387	T61	61.5	Piece of wood	-26.8	5,961 ± 34	4941–4770 BCE (88.9%) 4761–4727 BCE (6.5%)
Ua-73046	L31	31.5	<i>Pinus</i> bud scales, <i>Betula pubescens</i> 2 fruits, 1 bud scale	-26.1	2,578 ± 30	810–751 BCE (81.7%) 685–667 BCE (4.6%) 635–588 BCE (8.4%) 579–572 BCE (0.7%)
Ua-73047	L43	43.5	Conifer seed scale	-28.8	4,404 ± 32	3314–3297 BCE (1.4%) 3286–3240 BCE (5.1%) 3105–2913 BCE (89.0%)
Heden (bulk)						
Ua-14549	H50	50	Peat/moss	-27.2	1,010 ± 85	776–785 CE (0.6%) 833–849 CE (0.9%) 876–1221 CE (93.9%)
Ua-14550*	H80	80	(Peat/moss)	-29.8	2,895 ± 80	1375–1351 BCE (1.4%) 1301–897 BCE (92.9%) 868–846 BCE (1.2%)
Ua-14551	H110	110	(Peat/moss)	-27.4	2,785 ± 85	1198–1172 BCE (1.9%) 1163–1143 BCE (1.6%) 1131–801 BCE (91.9%)
Ua-14552	H130	130	(Peat/moss)	-29.3	3,060 ± 85	1500–1106 BCE (93.1%) 1099–1078 BCE (1.4%) 1071–1055 BCE (1.0%)
Brofästet (bulk)						
Ua-14553	B71	71	Peat/moss	-27.7	1,320 ± 60	606–628 CE (2.6%) 635–779 CE (81.0%) 786–835 CE (8.8%) 848–877 CE (3.1%)
Ua-14554	B99	99	Peat/moss	-25.3	1,660 ± 60	250–295 CE (11.6%) 311–547 CE (83.8%)

\*Outlier in the age-depth model (Fig. 6)

There is a relative decrease in *Betula*, and *Corylus/Myrica* pollen grains are either absent or present in low numbers. *Tilia* and *Ulmus* decrease, as *Picea* becomes more important. *Cannabis*-type pollen is recorded more frequently in the lower part of this PAZ. A few other herb pollen types are recorded, such as *Rumex acetosella*, *Polygonum*, Chenopodiaceae and *Artemisia*. No coprophilous fungal spores are recorded in this PAZ. OM decreases to <95% at 28 cm (ca. 500 BCE).

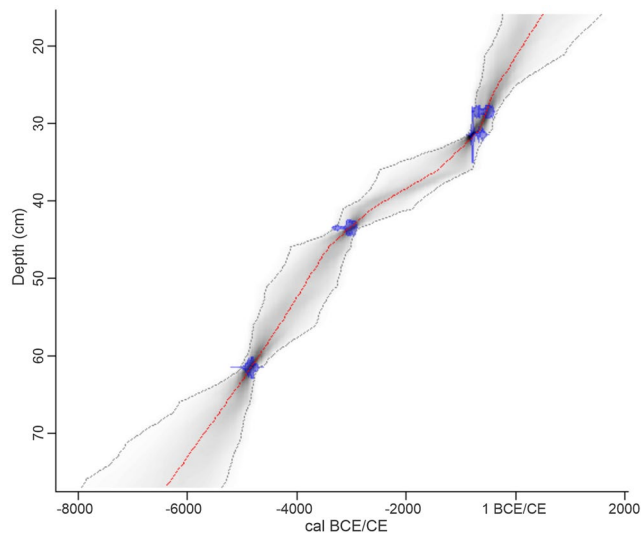
### Palaeoecological record at Heden

The core from Heden consisted of homogenous peat. Four bulk samples of *Sphagnum* peat were sent for  $^{14}\text{C}$  dating (Table 2). The date at 80 cm depth proved older than the underlying date at 110 cm and is treated as an outlier.

Figure 6 shows the age-depth model of the core. The CONISS zonation (Fig. 7) separated three main pollen assemblage zones that are summarized below.

**PAZ 1 (200–160 cm, ca. 2500–1800 BCE)** The bottom zone is mostly constituted by *Pinus*, *Betula* and *Alnus*. There is a relatively high presence of Poaceae and Cyperaceae and several other NAP taxa are recorded. There is a continuous representation of deciduous trees (*Populus*, *Ulmus*, *Quercus*, *Tilia* and *Fraxinus*), although with low values.

**PAZ 2 (150–36 cm, ca. 1640 BCE–1320 CE)** The second pollen assemblage zone covers a relatively long period, where no major changes are recorded. *Pinus* increases compared to PAZ 1. *Betula* values decrease, but the taxon is still relatively well represented. *Alnus* and *Quercus* are present at values similar to those in the previous zone, but



**Fig. 4** A Bayesian age-depth model for the Lomtjärnen core, produced in R using the package Bacon (Blaauw et al. 2022). In the model, the calibrated  $^{14}\text{C}$  dates are shown in blue. The red line shows the mean age/depth values, and the grey and outer stippled lines suggest the margin of error and the minimum and maximum age ranges (95% confidence) at the particular depth, respectively

*Ulmus*, *Fraxinus* and *Populus* are only sporadically recorded. Poaceae and Cyperaceae dominate the herb taxa.

The first cereal-type (*Triticum*-type) pollen is recorded at 135 cm (ca. 1380 BCE). From 115 cm upwards (ca. 1040 BCE), *Triticum*-type appears regularly throughout the core; there are only a few levels where it is not recorded. *Hordeum*-type is first recorded at 130 cm (ca. 1300 BCE) and subsequently 125 cm (ca. 1200 BCE). From 95 cm upwards (ca. 460 BCE), *Hordeum*-type occurs regularly. *Secale cereale* makes an appearance for the first time at 70 cm depth (ca. 371 CE). From 65 cm upwards (ca. 540 CE), pollen of cultivars increases, especially *Hordeum*-type. *Avena*-type is recorded at 80 cm (ca. 40 CE). This taxon may include pollen of non-cultivated *Avena* that may have been present as a weed. From 55 cm upwards (ca. 870 CE), *Avena*-type is continuously recorded, together with other cereal-type pollen. These taxa are accompanied by an increase in shrubs, especially *Juniperus* and *Calluna*, starting at 80 cm (ca. 40 CE).

**PAZ 3 (30–14 cm, ca. 1420–1700 CE)** The uppermost PAZ indicates an opening in the forest canopy. *Pinus* especially decreases but *Picea* and *Betula* also decrease slightly. *Juniperus* and *Calluna* are still well represented. Herbs, especially Poaceae, Cyperaceae, *Rumex longifolius* and *R. acetosa/acetosella* increase especially towards the top of the zone. The range of cultivars is similar to that in the upper part of PAZ 2 but with increased values towards the top.

## Palaeoecological record at Brofästet

The Brofästet core consisted of homogenous *Sphagnum* peat. As no terrestrial macrofossils were identified, two bulk peat samples were  $^{14}\text{C}$  dated (Table 1). The age-depth model (Fig. 8) presented for this core is tentative. The CONISS zonation (Fig. 9) separated four main pollen assemblage zones. The zones are briefly summarized below.

**PAZ 1 (190–135 cm, ca. 550 BCE–50 CE)** The pollen signal in the first zone indicates a forested landscape, mostly made up of *Pinus* and *Betula*. *Picea*, *Alnus* and *Quercus* are also present in low values. *Juniperus*, Poaceae and Cyperaceae are present at fluctuating levels.

**PAZ 2 (135–45 cm, ca. 50–1,200 CE)** The composition of the forest alters at the beginning of this zone as *Picea* increases while *Betula* decreases. Apophytes, e.g. Poaceae, *Rumex* and *Achillea*-type, increase at some levels, even if the presence is fluctuating. *Hordeum*-type is recorded at 100 cm depth (ca. 439 CE). In the uppermost part of the zone *Hordeum*-type is recorded together with *Triticum*, *S. cereale* and *Avena*-type. Microscopic charcoal particles increase in this zone, especially towards the upper end.

**PAZ 3 (45–25 cm, ca. 1200–1550 CE)** In this zone, the forest signal decreases while the agrarian indicators increase. *Juniperus*, Poaceae and several herbs (e.g. Asteraceae, *Rumex*, *Achillea*-type and *Ranunculus* type) increase. Cultivated plants also increase, where *Hordeum* being the most dominant type.

**PAZ 4 (25–5 cm, ca. 1550–1900 CE)** This upper zone appears to indicate a change in land use. *Betula* increases sharply, possibly due to birch colonizing areas that had previously been utilized as pastures. There is still a signal of cereals (mostly *Hordeum*- and *Avena*-types). Charcoal particles decrease sharply compared to the previous zone.

## Archaeological record

### Site findings and chronology

Three prehistoric sites have been archaeologically excavated in the northern part of lake Tisjön (KMR L2000: 976, 1555 and 1556), but they contained no visible structures apart from a few hearths. The archaeological material consisted mainly of fire-cracked stones, cores, blades, flakes and stone-tool production waste material, and also included some artefacts and a small amount of burnt bone. The artefacts consisted mainly of scrapers, but a number of dateable finds were found, of which the majority were arrowheads (Fig. 3; Tables 2, 3, 4). The majority of the dateable artefacts show human presence around Tisjön from 7000 BCE with continuity more or less until 2000 BCE. Though there are no later  $^{14}\text{C}$  dates available, a specific type of small, nail-shaped flakes from stone knapping indicates a later date, 1700–500

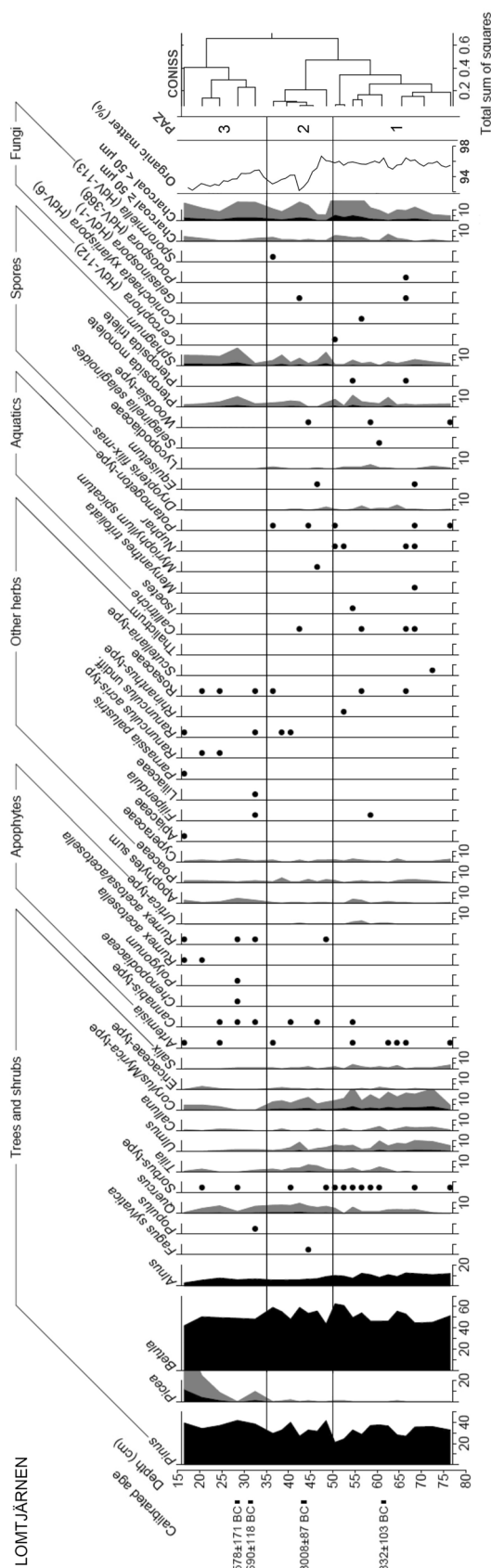
**Fig. 5** Percentage pollen diagram, Lomtjärnen. Silhouettes show percentage values  $\times 5$ . Dots signify percentages  $< 1\%$

BCE. This material is very similar to archaeological material found further north where there is a connection between a high frequency of these small nail-shaped flakes and the manufacture of bifacial arrowheads demonstrated at several other sites. This stone material has been interpreted as part of the new bifacial, stone knapping technology that generates a higher frequency of small nail-shaped flakes than the bipolar and unifacial stone knapping technologies used earlier (e.g. Baudou 1978; Forsberg 1985).

Most of the small nail-shaped flakes found at the sites around Tisjön are made from flint and the rest are mainly quartz or quartzite. The number of flint flakes is very high, about 5,000 (Östberg 1972). The amount of flint at the sites is conspicuous considering that flint is not found naturally in the area and is very uncommon in settlement materials throughout the region. Possibly there is a connection here with the number of flint daggers found in the region around Tisjön. Flint daggers are typical artefacts for the Scandinavian Late Neolithic, 2350–1700 BCE. Most of all known flint daggers in Dalarna are found near Tisjön. Flint daggers are made using bifacial technology which, based on the large quantity of flint flakes found at the excavated sites, suggest local production. Just a few other finds of flint artefacts made using the same stone technology are known from Dalarna. However, a large number of arrowheads and possibly spearheads have been recovered from the region. These are made with a similar bifacial stone technique as the flint artefacts but in other materials, mainly quartzite (Wehlin and Lannerbro Norell 2016). Around Tisjön, four such arrowheads have been found and one of these was recovered from an excavated settlement site. Remarkably, the bifacial arrowhead was found at the settlement with the least amount of rejections from this type of stone knapping technique. The other three bifacial arrowheads are stray finds (Östberg 1972).

The excavated site L2000:1555 at Tisjön with a high frequency of the bifacial type of stone technology differs from the two other excavated sites in several respects. The site was clearly divided in two sections where the stone rejections were found almost exclusively in the west section. This site is located only 1 km from the Lomtjärnen core.

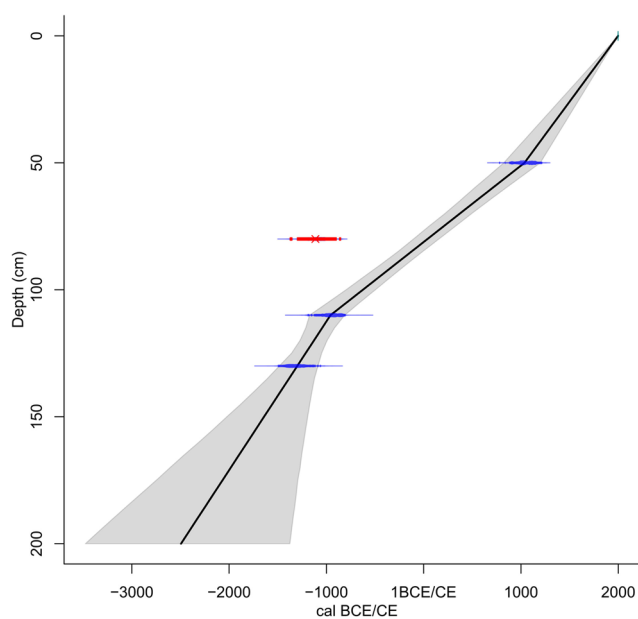
In addition to the stone material, a small number of burnt bones were excavated at the sites. Identified mammal species were elk (*Alces alces*) and beaver (*Castor fiber*). Furthermore, several fish species were found including pike (*Esox lucius*), perch (*Perca fluviatilis*) and bream (*Abramis brama*). The bream indicates that the sites were used during the summer months because bream lies passive in deep water during winter (Ekman and Iregren 1984). Eight  $^{14}\text{C}$  dates are available from burnt bones collected at the three excavated sites. The results more or less confirm the typological dates with





**Table 2** Typological dateable artefacts from the archaeological excavated sites at Tisjön. Dates are generally based on the established Scandinavian typology

Type	Site no. (KMR)	Quadrat no.	Inventory no.	Material	Typological age
Handle core	L2000:976		SHM 26482	Flint	7000–5400 BCE
Arrowhead	L2000:976	J49	SHM 26482	Slate	3300–2000 BCE
Transverse arrowhead	L2000:1555	D32	SHM 26483	Flint	5500–4000 BCE
Tanged arrowhead	L2000:1555	L47	SHM 26483	Flint	7000–3000 BCE
Pendant	L2000:1555	F34	SHM 26483	Slate	2350–1700 BCE
Transverse arrowhead	L2000:1556	R42	SHM 26484	Flint	5500–4000 BCE
Transverse arrowhead	L2000:1556	S42	SHM 26484	Flint	5500–4000 BCE
Tanged arrowhead	L2000:1556	T45	SHM 26484	Slate	3300–2000 BCE
Tanged arrowhead	L2000:1556	V56	SHM 26484	Slate	3300–2000 BCE
Grooved hammerstone	L2000:1556	L41	SHM 26484	Porphyry	2350–1100 BCE
Bifacial arrowhead	L2000:1556	U46	SHM 26484	Quartzite	1500–200 BCE

**Fig. 6** Age-depth model for the Heden core. This was generated in R (R Core Team 2021) using Clam (Blaauw 2010). The  $^{14}\text{C}$  dates are shown in blue, the uppermost point is the year of coring (in green), and the outlying  $^{14}\text{C}$  date is shown in red. Other conventions followed are similar to those in Fig. 4. In the older part the error margin is large because of lack of dates

a predominance of  $^{14}\text{C}$  dates falling between 7000 and 2000 BCE, but none fell within the last two millennia BCE (Table 2).

East of lake Tisjön an undated pitfall system (L2000:1522–1524, 1777) is located (Fig. 3), and should probably be interpreted as contemporary with the settlement sites nearby. However, south of lake Tisjön there is a partially excavated system of pitfalls (L2000:1851). Three  $^{14}\text{C}$  analyses have been carried out on two of the pitfalls in the 800 m long system of pits. In one of the pits there were two horizons that were dated with different results (Hyenstrand

1987). All in all, the results from the excavated pitfalls show that they were used for a long time, ca. 3000 BCE–1000 CE.

The latest date from the pitfall system corresponds to the dates of the excavated grave field at Örviken (L2000:981). The grave field consisted of five stone settings and was excavated in 1960. Only one of the graves contained dateable artefacts and these dated the grave to 400–550 CE (Hyenstrand 1987). A  $^{14}\text{C}$  date from one of the other graves proved to be earlier 50–200 CE (Wehlin 2017).

### Stray finds

A number of archaeological stray finds have been found around Lake Tisjön. These types of collected artefacts are difficult to interpret because they lack context information, but they still tell us quite a bit about human presence in the area. At present, we know of nine typologically dateable artefact types that have been found in various contexts around Tisjön (Fig. 10; Table 5). These include a stone adze of the Lihult type, three flint daggers, three bifacial arrowheads and a celt in bronze. The most notable find is a bronze celt axe-head dated to 900–700 BCE (Fig. 10a). The celt is the only example from the region that has not been found in direct connection to the river Dalälven.

The typological dating of stone adzes and daggers fit well into the proposed chronology of the excavated settlements. The stray finds of the bifacial arrowheads and the bronze celt suggest a continued presence around Tisjön during the period 1500–200 BCE.

## Discussion

How do we understand the evidence from pollen analysis and the archaeological record that indicate changes in the use of landscape around Tisjön starting at about 2000 BCE? In the following discussion we will address this question by

**Fig. 7** Percentage pollen diagram for the Heden core, showing a selection of the more frequently appearing species; silhouettes are  $\times 20$

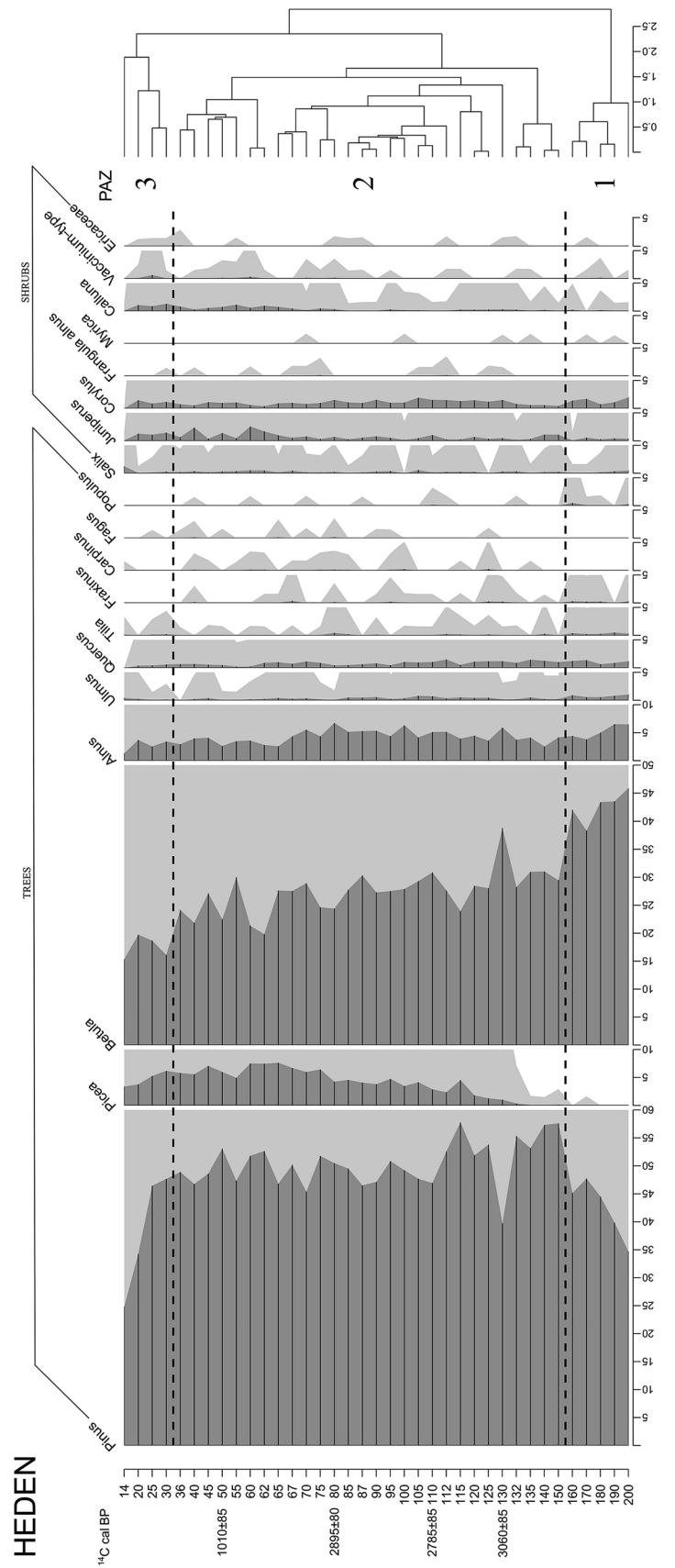
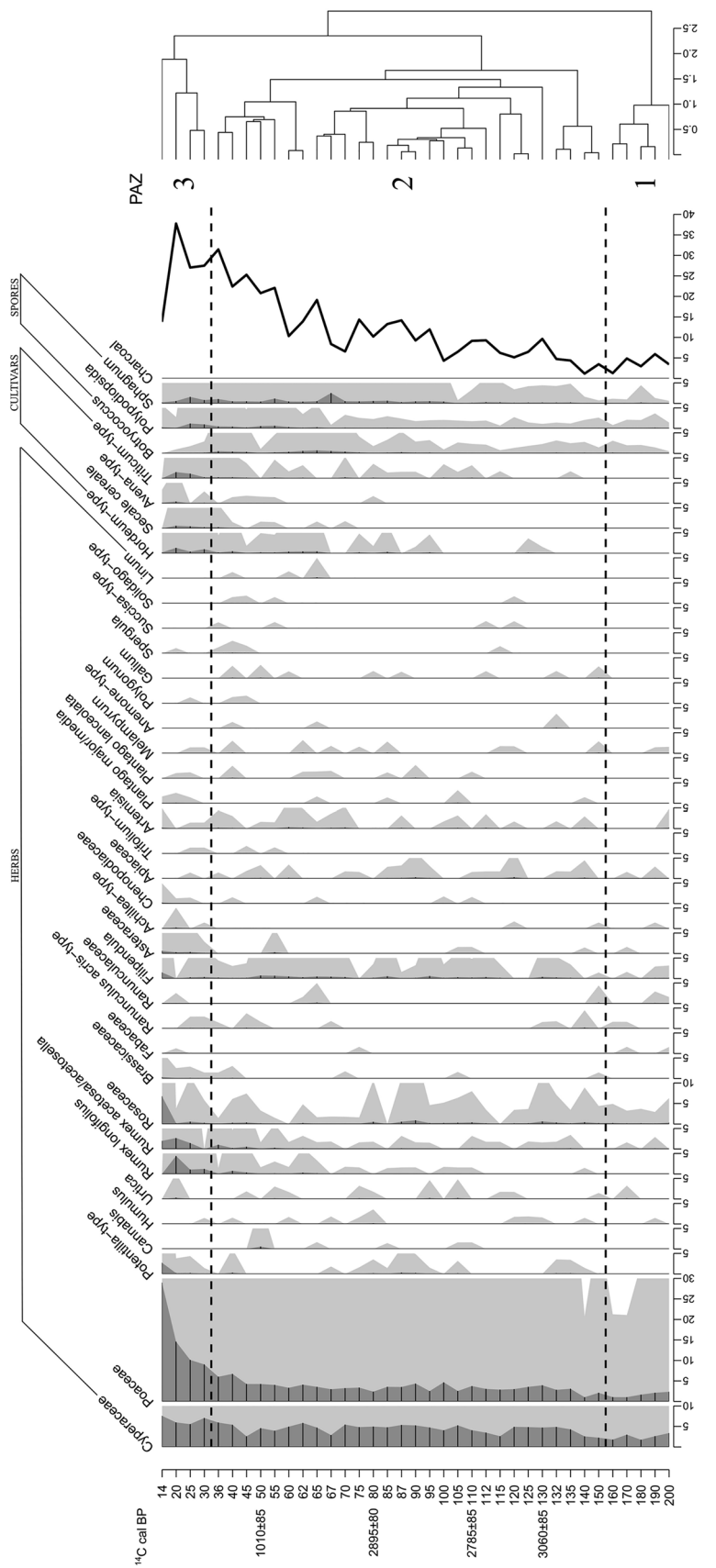


Fig. 7 (continued)



focusing on the period 2000 BCE–500 CE. Parts of the presented pollen and archaeological records stretch further back in time, so we will begin by discuss the first 5,000 years of human presence around Lake Tisjön.

### Hunting in the natural forest (7000–2000 BCE)

The archaeological source material shows human presence in the study area from around 7000 BCE. However, there is nothing in the pollen records indicating any significant effect on the landscape caused by human activities during the period under consideration. The archaeological sites contain a large amount of stone artefacts and burnt animal bones, and may be seen as dwellings and activity areas connected with smaller groups of people who probably had a continuous presence in the lake Tisjön area. The animal bones, deriving mainly from fish, elk and beaver, are connected with hunting and fishing. The lithic assemblages are made up of considerable amounts of flint. Flint does not occur naturally in the region and is rarely found on other prehistoric sites in the study area. In this period, the Tisjön sites appear to be used for continuous, possibly seasonal, hunting and fishing activities connected to highly mobile groups. Notably, there are no occurrences of settlement traces characteristic of areas further north during the same time, such as asbestos ceramics, schist stone technology or semi-subterranean houses (e.g. Baudou 1978, 1995; Forsberg 1985; Bolin 1999). This suggests a less intense presence in the landscape around Tisjön in comparison with both northern and southern areas during this time interval.

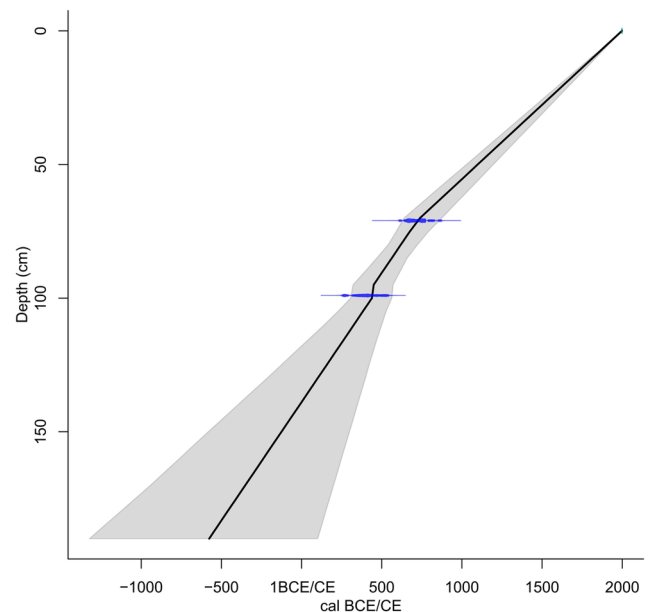
### Environmental impact and changes in landscape use (2000–1000 BCE)

From 2000 BCE, the character of the archaeological material and site distribution patterns changes. The most distinct change is related to the production of stone artifacts, which from this point onwards involves the use of locally occurring minerals, preferably a type of quartzite characterized by material qualities similar to flint and processed with bifacial stone technology. The typologically most reliable artefacts are bifacial arrowheads, usually dated to the first two millennia BCE. The typology of the lithics at one of the three excavated settlement sites (L2000:1555) suggests that the site was used relatively extensively for stone tool production between 1700 and 500 BCE. The archaeological material from the other two excavated settlement sites, i.e. L2000:976 and L2000:1556, indicates use as dwelling sites with stone production activity dated to between 7000 and 200 BCE, but with less intensity after 2000 BCE (Östberg 1972). This idea is supported by the  $^{14}\text{C}$  dates from site L2000:1555 (Tables 2 and 3). Generally, there are changes in how sites were used around Tisjön during this period. Older settlement areas

and activity zones were abandoned and less extensively used after 2000 BCE. This chronological pattern is similar to what can be seen throughout Dalarna (Wehlin and Lannerbro Norell 2016). This is possibly caused by new movements and interactions with the landscape.

Taken together, the occurrence of a new stone technology based on local raw materials and the changes in site distribution around Tisjön suggest new patterns of movement in the region, possibly connected to intensification of other activities compared with those represented on the older hunting sites. A further indication of change during this period is the distinct increase of hunting pitfalls throughout present-day northern Dalarna. A chronological study of all dated pitfalls indicates that they were much more frequent from ca. 1800 BCE and that there was a major increase at ca. 400–500 BCE (Hennius 2020). The same pattern appears in reindeer hunting in the alpine areas in Norway, which increases during the same period (Pilø et al. 2018). The extensive pitfall hunting systems are interpreted as the material representation of a possible neolithisation process in boreal woodland areas. This argument is based on the idea that the large pitfall systems must have demanded intensive and collective work efforts, dependent on a social organization that can be compared with that of early farming societies (cf. Lindholm et al. 2013). Hence, the extensive pitfall systems may indicate a more settled way of life.

Interestingly, the results of the pollen analyses support the argument of a gradual change towards a more permanent human presence in the landscape. During the late



**Fig. 8** Age-depth model (ADM) of the Brofästet core generated by Clam (Blaauw 2010). The same conventions are followed as in Fig. 6

**Fig. 9** Percentage pollen diagram for the Brofästet core, showing a selection of the most frequent pollen taxa; silhouettes are  $\times 20$

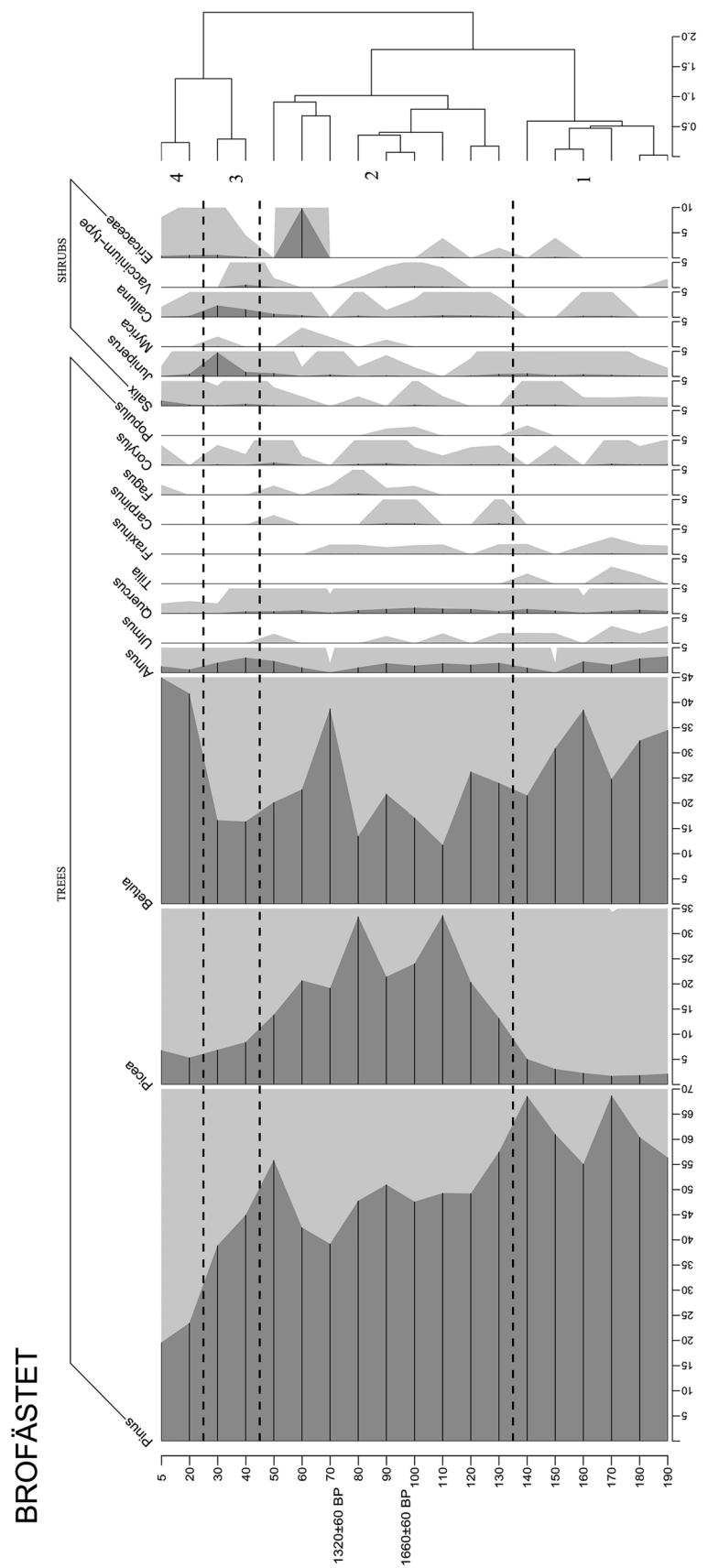
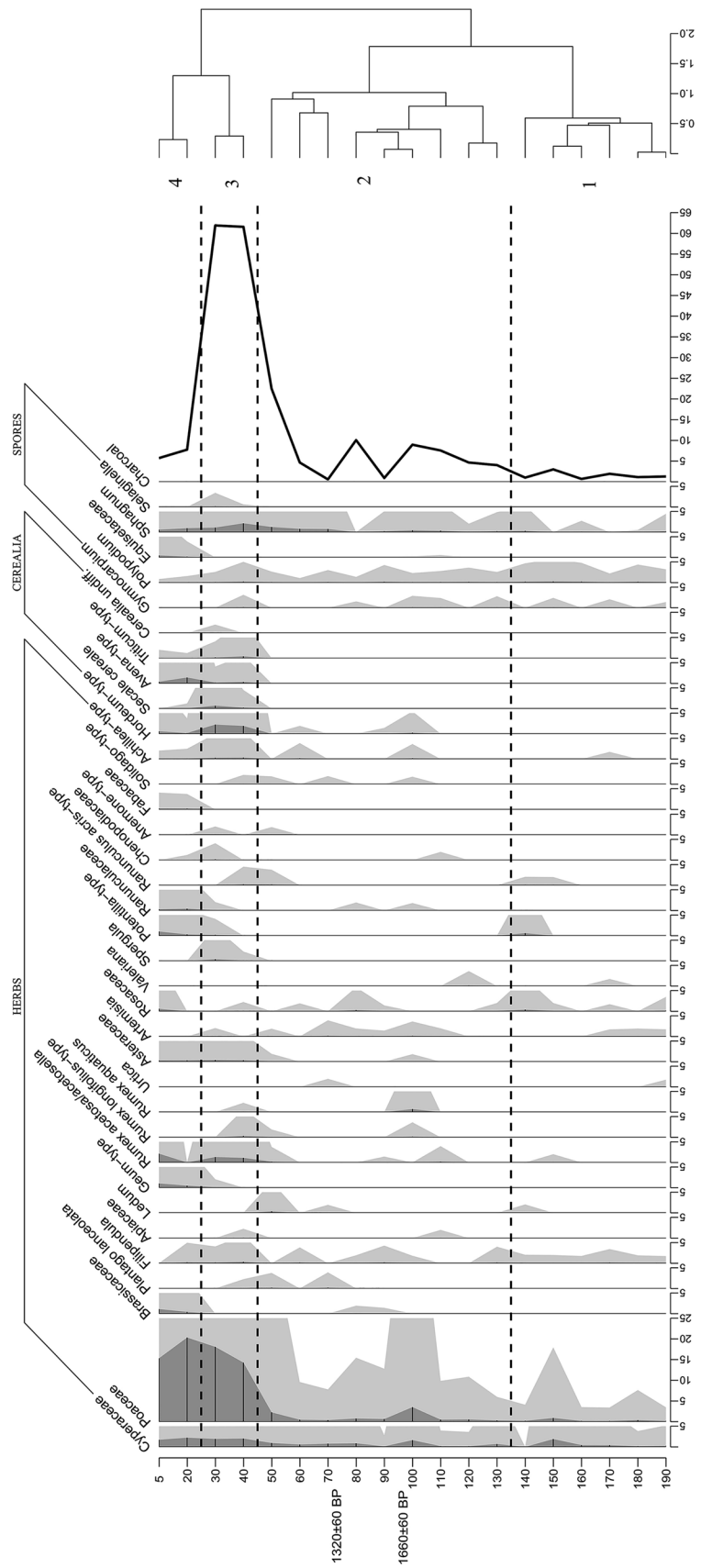


Fig. 9 (continued)



**Table 3** Excavated archaeological sites in the Lake Tisjön area. Age ranges are based on the results in the report by Östberg (1972) and additional <sup>14</sup>C dates (see Table 4)

Type	Site no.	Excavation*	Age
Settlement	L2000:976	1960 (400 m <sup>2</sup> )	7000–2000 BCE
Settlement	L2000:1555	1960 (300 m <sup>2</sup> )	5500–1700 BCE 1700–500 BCE
Settlement	L2000:1556	1960 (425 m <sup>2</sup> )	7000–200 BCE
Pitfall system	L2000:1851	1984	3000 BCE–1000 CE
Grave field	L2000:981	1960	50–550 CE

\*Year of excavation and area excavated are indicated

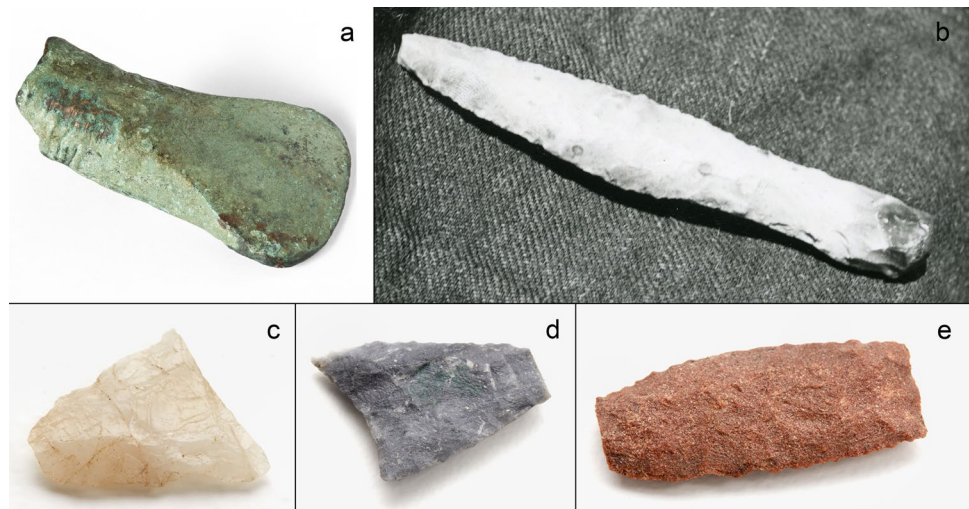
half of the second millennium, human impact on the environment is traceable in the pollen record. At Lomtjärnen, an increase in NAP associated with land use, such as *Rumex acetosella*, *Polygonum*, *Chenopodiaceae* and *Artemisia*, is observed from ca. 1300 BCE, and at the end of the period under discussion (ca. 1000 BCE) plants associated with open ‘disturbed’ land are detected in the pollen signal. *Triticum*-type pollen is consistently recorded in

the Heden pollen profile. Cereal pollen does not disperse far from fields (Vuorela 1973) and is often underrepresented or absent from pollen records, even at sites located close to fields (Høeg 2011; Overland and Hjelle 2013). Given the severe underrepresentation of pollen of wheat (*Triticum*)—indeed all cereals with the exception of rye (*Secale cereale*)—in pollen records generally, the continuous presence of *Triticum*-type pollen at Lomtjärnen points to local wheat being grown and processed, and arable farming generally. At Heden, in the same period (ca. 1000 BCE), species associated with open disturbed land are frequently detected in the pollen signal (*Plantago major/medica*, *P. lanceolata*, *Chenopodiaceae*, *Asteraceae*, *Rumex longifolius*, *R. acetosacetosella*, *Urtica*), which may be linked to grazing by domesticated animals. Landscape reconstructions in northern Europe have shown that open land, such as pastures and meadows, is generally represented by a weak pasture signal in pollen records (e.g. Åkesson et al. 2015), so that even small indications of grazing and arable activity may signify substantial anthropogenic modification of the vegetation.

**Table 4** Results of <sup>14</sup>C dating carried out at archaeological sites in the Tisjön area

Lab. code	Sample	Material dated	δ <sup>13</sup> C (‰)	<sup>14</sup> C age (BP)	Calibrated age (2 σ) (%)
L2000:976 (settlement)					
TRa-3156	Square J47	Burnt bone (mammal)	−27.2	4,335 ± 30	3024–2892 BCE (95.4)
L2000:981 (grave field)					
Ua-50453	Grave 1	Burnt bone (human)	−24.4	1,906 ± 35	27–47 CE (3.6) 57–224 CE (91.9)
L2000:1555 (settlement)					
Ua-50452	Site 1095	Burnt bone (mammal)	−26.9	3,822 ± 37	2454–2418 BCE (4.9) 2409–2371 BCE (6.9) 2364–2192 BCE (75.7) 2179–2143 BCE (7.9)
TRa-3157	Square J38	Burnt bone (beaver)	−26.2	3,885 ± 30	2466–2285 BCE (93.8) 2248–2236 BCE (1.7)
L2000:1556 (settlement)					
TRa-3163	Square T45	Burnt bone (mammal)	−25.3	6,250 ± 45	5316–5202 BCE (59.4) 5184–5057 BCE (36.1)
TRa-3160	Square S41	Burnt bone (mammal)	−21.9	7,365 ± 35	6369–6301 BCE (18.9) 6268–6083 BCE (76.6)
TRa-3161	Square R41	Burnt bone (mammal)	−18.2	7,610 ± 35	6565–6553 BCE (1.7) 6506–6401 BCE (93.7)
TRa-3158	Square O39	Burnt bone (mammal)	−23.9	7,625 ± 35	6570–6545 BCE (5.5) 6534–6418 BCE (90.0)
TRa-3162	Square P41	Burnt bone (mammal)	−19.9	7,665 ± 45	6596–6431 BCE (95.4)
L2000:1851 (pitfall system)					
St-9805	A (lower)	Charcoal	n/a	4,035 ± 240	3332–3215 BCE (2.8) 3189–3150 BCE (0.8) 3134–1940 BCE (91.9)
St-9806	A (upper)	Charcoal	n/a	2,000 ± 135	366 BCE–255 CE (93.2) 285–326 CE (2.2)
St-9807	B	Charcoal	n/a	1,405 ± 140	363–900 CE (93.1) 918–973 CE (2.4)

**Fig. 10** **a** Bronze celt [~ 7 cm] (DM 22844), photo: H. Sjöstrand; **b** Flint dagger [21.5 cm] (Private), photo: Dalarna Museum Archives; **c** Bifacial arrowheads (DM 18799-3 [1.2 cm]; **d** DM 18856-3 [2.6 cm]; **e** DM 18867-1 [3.2 cm]). Photos c–e: P. Eriksson, Dalarna Museum



**Table 5** Known typologically datable stray finds from the Tisjön region. Dates are generally given based on the established Scandinavian typology

Type	Site no.	Inventory no.	Material	Typological age
Lihult type adze	L2000:1154	Private	n/a	6000–4000 BCE
Dagger	L2000:8167	Private	Flint	2350–1500 BCE
Dagger	Not registered	DM 6877 (copy)	Flint	2350–1500 BCE
Dagger	Not registered	Private	Flint	2350–1500 BCE
Arrowhead	L2000:1780	DM 18865:1	Slate	3300–2000 BCE
Bifacial arrowhead	L2000:1613	DM 18856:3	Quartz	1100–200 BCE
Bifacial arrowhead	L2000:1866	DM 18867:01	Quartzite	1500–200 BCE
Bifacial arrowhead	L2000:1840	DM 18799:3	Quartz	1600–1 BCE
Celt	L2000:1612	DM 22844	Bronze	900–700 BCE

### First agricultural indications (1000 BCE–500 CE)

There are some indicators that grazing may have occasionally taken place at Brofästet during this period as *Calluna* starts to occur more regularly in the pollen signal from ca. 45 CE. From ca. 440 CE, there is no sign of cultivation of *Hordeum* in Brofästet, and it was subsequently absent until medieval times. Around 900 BCE, *Triticum* was cultivated at Heden and there are also a few earlier records of *Triticum*-type pollen. *Triticum* continues to be cultivated in the area up until the early modern period, with a few gaps. Cultivation increases steadily from its introduction, and around 370 CE *S. cereale* is introduced but it remains unimportant. The indications of cereal cultivation are also accompanied by an increase in charcoal particles, which indicates that fire may have been used to clear forests and perhaps also to increase the quality of pastures (cf. Karlsson et al. 2010; Westin et al. 2022). Although cereal-type pollen is not recorded in the Lomtjärnen profile, the presence of *Cannabis*-type along with occasional occurrences of apophytes, such as *Chenopodiaceae* and *Polygonum*, suggest active cultivation. *Cannabis*-type potentially includes pollen of *Cannabis sativa* and *Humulus lupulus*. Pollen of *C. sativa* is likely,

especially given that hemp seems to have been cultivated at other outland locations during the Iron Age (cf. Eddudóttir et al. 2021).

Although the pollen records indicate arable farming and grazing after 1000 BCE, there are no clear changes in the material culture of archaeological sites discussed earlier. The exception is the presence of a bronze celt axe-head found at the shore of Lake Tisjön, which can be typologically dated to ca. 900–700 BCE. At the transition BCE/CE it seems that the grave field at Örviken was established. The construction of these lakeside grave fields in the region started around 500 BCE and they were continuously used over a long period of time, up to ca. 400–500 CE. The archaeological data from a larger geographical area in boreal inland Dalarna indicate that there is a chronological relationship between the lakeside grave fields, like the one at Örviken, and the hunting pitfalls. Recently carried out studies indicate that the number of pitfalls increased at the same time as the establishment of the first grave fields (Hennius 2020).

The construction of grave fields is an important sign of a new way of conceptualizing the landscape in line with



the discussion on a settled way of life presented initially in this paper. We argue that both the graves and the pitfall systems are the result of a shift towards a farming mentality that, beside strategies of domesticating the landscape (pitfalls), also involved manifestations of ancestry (graves) in the landscape. It is worth pointing out that in areas further north, where HG settlements occur in the form of hut constructions, ceramic technology etc., similar grave fields are absent at this time. Placing graves at specific, marked points in the landscape does not necessarily mean that people built houses, but rather that their interaction with the landscape involved a settled state of mind.

## Conclusion: settled hunters

The pollen analytical and archaeological records indicate a landscape use characterized by a gradual neolithisation-type process, starting during the Late Bronze Age period and further intensified during the Early Iron Age. The results of pollen analyses provide information on changes in vegetation possibly caused by domestication in the form of different scales of grazing and land clearances, but also other cultivation practices not associated with traditional agriculture. Taken together, the results indicate a new way of life in inland boreal Scandinavia 3,000 years ago where the landscape was domesticated through a combination of cultivation, landscape alteration and systematic large-scale pitfall hunting within what we suggest was a semi-sedentary lifestyle.

The palynological investigations show clear anthropogenic signals even if these are rather weak. There are sparse early finds of cereal-type pollen that suggest small-scale arable farming. There are also indications of grazing in the pollen signals that, in combination with archaeological data, suggest a human presence. The spores, in combination with ruderal plants, are interpreted as originating from domesticated grazing. There are also indications in the pollen signal that forest may have been cleared by human-induced fires to generate better pastures. Altogether, the combined indications of various types of land use suggest an earlier human influence on these forested landscapes and the vegetational composition within them than previously had been known.

The increasing number of hunting pitfalls is connected to a more stable human presence in the landscape and a general ambition to domesticate the landscape. Still, there is no direct evidence of livestock at this point, and settlement features of a southern character, such as longhouses, are absent. What we see instead is a form of agriculture possibly practised on a small horticulture scale. Fishing and hunting would still have been important, but the investment in the landscape shown by both pitfall systems and land clearances express practices that would have required settled presence.

The construction of lakeside grave fields, starting around 500 BCE, is of special importance when considering a sedentary settlement pattern. Even though traces of agriculture and pitfall hunting occur several hundred years prior to the grave fields, the graves express a new mind-set. The people inhabiting these landscapes started to conceptualize their environment in genealogical terms, and the dead were given fixed places manifesting connections between their past and the present. In this sense, the graves had probably little to do with hunting grounds, which is unexpected given the Swedish terminology for these features, i.e. *fångstmarksgravar* ('hunting ground graves'). The introduction of grave fields consisting of groups of stone settings is something that we commonly associate with well-established farming contexts and as strong manifestations of a settled, genealogical affinity with the landscape.

The people inhabiting the central Scandinavian forests in the period under consideration are portrayed in a very different light to the way they have been portrayed in earlier research. They are not simply mobile hunter-gatherer groups as previously imagined. Our data show how the negotiation between hunter-gatherer and farmer ways of life was a gradual process where different elements were incorporated and adapted to the local context. The elements and practices of neolithisation in and around around Lake Tisjön differ from those found in farming communities further south. Still, the practices of Lake Tisjön dwellers involved agriculture and extensive, well-planned landscape transformations, possible also pastoral activities, but lacked ceramic technologies and, instead, continued to pursue lithic production.

By way of overall conclusion, our study leads us to conclude that it is beneficial for archaeologists to carry out re-evaluation of what have been regarded as fundamental categorizations, so as to fully understand the intersections between mobile and settled ways of life, and between farming and hunting.

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