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Getting Back to the Lake: A New Look into the Mesolithic and Neolithic Settlement and Subsistence Strategies at the Wetland Site of Järvensuo 1, Southwest Finland

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ABSTRACT
Hunter-gatherer wetland sites in boreal Fennoscandia are rare, deeply buried, and difficult to detect, making them a still critically underutilised archaeological resource. However, the moist anoxic conditions of waterlogged contexts preserve organic materials that are typically lost on boreal drylands, thus offering unique tools to explore the past. Small-scale excavations in 2020–2021 at the wetland site of Järvensuo 1, southwest Finland, uncovered a stratified lakeshore archive spanning over five millennia and a rare assemblage of organic artefacts, structures, faunal remains, and environmental data. The discoveries, characterised by sustained and repeated utilisation of freshwater resources, reveal long-term human occupation and activities by a small lake from the Late Mesolithic to the Final Neolithic (c. 6000–2000 cal BCE). This paper synthesises the fieldwork results, contextualises the findings, and examines the significance of similar lake environments in understanding hunter-gatherer subsistence, landscape use, and cultural practices in Fennoscandia and northeast Europe.

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Introduction

Increasing land use pressure and accelerating climate change have rendered wetland archaeology a globally more topical and urgent field than ever before (e.g. Boethius et al. 2020; Gearey et al. 2026; Matthiesen et al. 2022). The immense scientific importance of archaeological sites buried in wetlands – such as pile dwellings, bog bodies, wooden causeways, ritual deposits, organic artefacts, and archaeo-environmental remains – is unparalleled (e.g. Gearey, Fletcher, and Fyfe 2014; Menotti 2015; van Beek et al. 2023). Despite their huge relevance for northern Europe, wetland archaeology in the boreal biogeographic region of Fennoscandia, i.e. the conifer-dominated taiga belt encompassing

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Finland, most of Sweden, and parts of Norway and Russia, remains a still underutilised yet critically important field of research. This is striking, given the millions of hectares of mires and tens of thousands of lakes in the area. Consequently, relatively few wetland sites have been identified, excavated, and studied in detail to date (e.g. Hallgren 2023; Koivisto 2017; Lozovskaya et al. 2020). The scarcity of research is by no means due to any lack of potential site locations; rather, it reflects a long-standing research focus on dryland archaeology and the inherent methodological challenges associated with fieldwork in demanding wetland habitats.

In boreal Fennoscandia, the shore-bound settlement pattern of the Mesolithic (c. 9500–5200 cal BCE; e.g. Manninen et al. 2021) and Neolithic (c. 5200–1800 cal BCE; e.g. Nordqvist 2018; Pesonen 2021) communities resulted in extensive utilisation of coastal, riverine and lacustrine landscapes (e.g. Bergsvik et al. 2021; Ekholm 2016; Siiriäinen 1980). It is worth noting that in the Finnish archaeological research history, the Neolithic period is also known as the 'Pottery Mesolithic' or 'Forest Mesolithic', as well as the 'Sub-Neolithic', indicating pottery-producing hunter-gatherer societies that adopted certain Neolithic innovations while maintaining a non-agricultural economy (e.g. Meinander 1961; see also critiques by Nordqvist (2018) regarding the terminology). Human activity was not confined to dryland areas; rather, waterfronts, shallow waters, and shoal zones formed integral components of the living space. Waterlogged environments were utilised for a wide range of activities, including resource procurement, water supply, transportation, waste disposal, and even for ritual practices (e.g. Ahola and Koivisto 2025; Bergsvik and Ritchie 2020; Mjærum and Mansrud 2020; Molin, Hagberg, and Westermark 2018). Throughout the Holocene, boreal lakes provided especially resourceful habitats for hunter-gatherer subsistence and settlement. Nevertheless, the buried lake edge sites remain an underrepresented resource in northern archaeology, as many lakes have later overgrown and transformed into mires (e.g. Korhola 1995), rendering archaeological horizons invisible to conventional survey methods (e.g. Bergman et al. 2003; Koivisto, Latvakoski, and Perttola 2018). Nevertheless, such sites likely represent a fairly common, rather than exceptional, type of hunter-gatherer settlement in the region, which have not yet been comprehensively identified and investigated.

Järvensuo 1, southwest Finland, is a rare example of such a site. First exposed through drainage works in the 1950s (Aalto, Siiriäinen, and Vuorela 1985; Siiriäinen 1983), this paludified lake edge site has yielded exceptional organic artefacts and palaeo-environmental remains in a northern context. However, unreported trial excavations in the 1980s initiated decades of debate concerning the site's actual character, chronology, and significance (see Koivisto 2021). Our renewed excavations in 2020–2021 enable a reassessment, by providing new evidence for human activity, technology, seasonal use, and landscape development from the Late Mesolithic to the Final Neolithic (c. 6000–2000 cal BCE).

This paper reviews the 2020–2021 excavation results, incorporating the site's stratigraphy, dating, finds, and their archaeological interpretation. We aim to illuminate the characteristics of the hunter-gatherer groups that occupied Järvensuo 1, who utilised local resources and adapted to a changing lakeshore environment over the long term. Within this analysis, we address three core research questions:

- What is the stratigraphic and chronological history of Järvensuo 1?
- What activities took place at the site, and how did these change over time?

- How does Järvensuo 1 contribute to our understanding of Mesolithic and Neolithic hunter-gatherers and lake sites in boreal Fennoscandia, and, more broadly, in northeast Europe?

Study Area and Research History

Järvensuo 1 is located in the Häme region in southwest Finland, on the edge of the now drained Lake Rautajärvi (Figure 1(A and B)) – a small basin isolated from the Baltic Sea during the Ancylus regression, c. 7800 cal BCE (Hokkanen 2005). Over subsequent millennia, the lake level was transgressive, up until the Late Neolithic (c. 2500 cal BCE), when it abruptly dropped, exposing a wide shoal zone on the southern shore (Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021; Vuorela 2002). This appears to have been a sudden event, initiated by the formation of a new outflow channel in the west, indicated by a

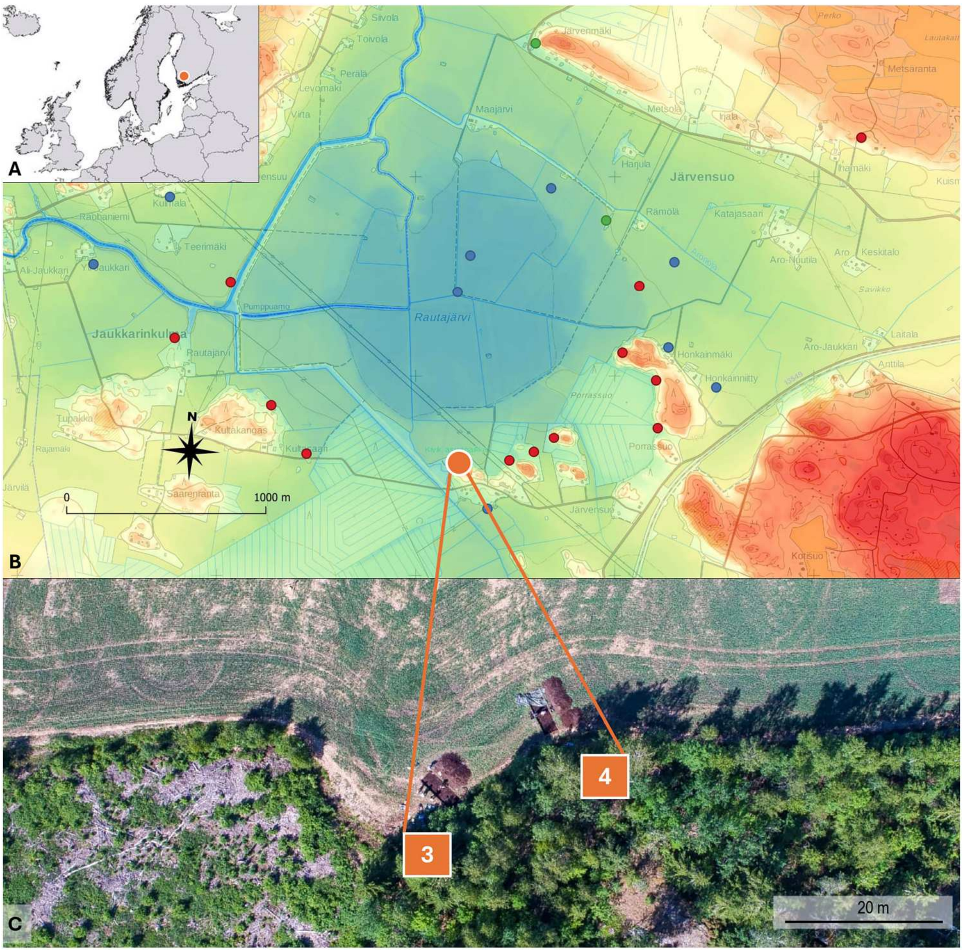


Figure 1. A. Location of Järvensuo 1; B. Reconstruction of the drained Rautajärvi Lake with known archaeological sites (red dots) and artefact find spots (blue dots); C. Drone photo of the study area with two evaluation trenches in 2020–2021.

clear boundary between gyttja (eutrophic mud) and peat in the lake area (see Koivisto 2021). The site is situated on the southern edge of this lake, amidst a wide peatland plateau, used today for agriculture and forestry. Due to the flat topography and overgrown shores, the lake was drained from the 1800s CE onwards to increase farmland. However, the nearby Koenjoki River in the west and the flat relief of the terrain hampered land reclamation, making the area prone to flooding until a pumping station and systematic subsurface drainage network were established in the area in the 1950s.

Järvensuo 1 was a chance discovery during drainage operations. In the 1950s, a wooden paddle was discovered in one of the ditches, later 14C dated to the Middle Neolithic (c. 2900 cal BCE; Edgren 1984; Koivisto 2021). A few decades later, a fragmentary wooden scoop, along with organic fishing gear and pottery sherds, was discovered during the maintenance of the same ditch. This triggered an archaeological inspection, palaeo-environmental sampling, and small-scale trial excavations in the main find area between 1982 and 1985 (Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021; Siiriäinen 1987).

The investigations identified two cultural horizons in the find-rich ditch area, containing wooden and bark artefacts, pottery, and animal bones (Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021; Siiriäinen 1987). However, incomplete documentation, limited dating, and disturbance of stratigraphy by drainage works left major interpretive gaps in the archaeological knowledge of the site. The pottery was (typologically) dated to the late 4th and early 3rd millenniums BCE (Siiriäinen 1982; 1987), whilst the palaeobotanical studies revealed well-preserved remains of edible and wild plants (Aalto, Siiriäinen, and Vuorela 1985; Vuorela 2002). The site was preliminarily interpreted as containing evidence from a pile dwelling or a raft haven, with a water chestnut procurement area located on the shallow shore of a transgressive lake during the Neolithic (Siiriäinen 1987; see also Koivisto 2021). However, due to unreported fieldwork and a lack of publications, many questions concerning the site remained unanswered for over three decades.

Materials and Methods

Wetland Excavations and Sampling in 2020–2021

Renewed fieldwork at Järvensuo 1, conducted as part of the wetland archaeological project 'Perish and Fade Away: Sedimentation and Preservation of Organic Archaeological Remains in Wetland Landscapes' (University of Turku, 2019–2022), aimed to refine the uncertainties about the site by documenting representative stratigraphy across the former lakeshore, assessing the current state of preservation of organic materials, acquiring new 14C dates, and contextualising the findings.

In the summers of 2020 and 2021, two small evaluation trenches (both 6 by 2 m) were opened, intersecting the overgrown lakeshore at the transitional zone between the mineral soil and the peatland farmland (Figure 1(C)). Continuing the trench numbering of the 1980s (see Koivisto 2021), Trench 3 was positioned next to the drainage ditch, where most of the earlier finds had been recovered, and Trench 4 was placed c. 20 m northeast of it, at the foot of a rocky slope ascending Kuoppanummi Hill, where a prehistoric dryland site is located (Pohjakallio 2005). Excavation proceeded by following the natural layers of peat and the underlying gyttja and lakebed sand using shovels and trowels, with intensive documentation through total station mapping, photography, and 3D modelling. Wooden platforms, buckets, and pumps were used to manage the groundwater, which remained a challenge in deeper sediments. All the organic artefacts were documented in detail during the lifting, packed in sealed plastic tubes, and stored in cool (c. 8 degrees Celsius) dark storage before being transported to the Conservation and Collection Facility of the National Museum (Vantaa). Non-organic finds were handled in accordance with standard archaeological fieldwork practices in Finland (Finnish Heritage Agency 2020).

A systematic sampling strategy was designed and implemented to maximise the exceptional availability of organic materials – an extraordinary occurrence in the boreal Fennoscandian context. Several hundred samples of soil and organic sediments were collected from peat, gyttja, and lakebed sand deposits to facilitate a range of analyses (see section 3.2 below). At least three series of samples were taken per trench from each documented layer and, where necessary, from intermediate layers. In addition, natural pieces of wood, bark, plants, fruits, seeds, fibres, and insects were collected for reference material.

Analyses

Plant macrofossil Analysis

The first stage of plant macrofossil identification carried out as part of this study consists of 12 approximately two-litre soil samples that were wet-sieved using a 0.25 mm mesh. The plant taxa were grouped according to their presumed use and modern ecological habitats in Finland (Lempiäinen 1989 with references). The nomenclature of scientific names followed the World Checklist of Vascular Plants (WCWP) database (Govaerts 2024). Plant remains were identified using the reference collection of the University of Turku (Herbarium) and literature (e.g. Birks 2001; Cappers, Bekker, and Jans 2006). Fruits, seeds, and other plant remains were handpicked from the residue using a stereomicroscope (x1.5), and the material was preserved in 99.5% ethanol. All identifiable fruits and seeds were recorded. When a taxon exceeded 50 identifiable remains in a sample, counting was truncated at 50 remains to standardise quantification across samples. The only exception was *Lythrum salicaria*, for which up–100 remains were counted because of its exceptional abundance. The number of fruit and seed macrofossils was counted, whereas the relative abundances of mosses and ferns were estimated due to the exceptionally large quantities of preserved remains in the peat.

Zooarchaeological Analysis

The zooarchaeological analysis conducted as part of this study concerns a preliminary examination of all burnt and unburnt animal remains recovered in 2020–2021. After the fieldwork the unburnt remains were kept in a wet state at the conservation facility, most still covered in sediment, hindering detailed examination. Bones underwent species identification using the reference collection at the Zoological Museum (Helsinki). Fractures and surfaces were examined with the naked eye, and the age of the mammal mandible individual was roughly estimated based on teeth and tooth wear using the teaching collection of the archaeology laboratory, University of Helsinki.

Artefact Analysis

The artefact analysis integrates the entire collection of find materials, of both durable and organic materials, recovered in 2020–2021. Here, we present only an overview of the organic artefacts, as they were examined still non-conserved, in the wet state. As with unburnt bones, this hindered detailed examination of certain characteristics, such as tool marks, use wear, and surface processing. More detailed studies of the conserved organic artefacts, the treatment of which with polyethene glycol (PEG) and freeze-drying will be completed soon, are underway and will be published at a later date. For previous publications on specific organic artefacts from the fieldwork, see Koivisto and Lahelma (2021), Koivisto, Suomela, and Lempiäinen-Avci (2024), and Suomela, Suhonen, and Koivisto (2025).

AMS 14C Dating

The new AMS 14C dating samples (n = 17) from the 2020–2021 materials are from organic artefacts, nutshells, wood, food crusts (adhered on pottery sherds), and bone. Samples were selected from both trenches to reliably date the artefacts and the archaeological horizons observed in peat, fine detritus gyttja, and coarse detritus gyttja/lakebed sand. In addition, two organic compound samples (Ua-81471 and Ua-81470) were selected from earlier found pottery sherds from the ditch area. The AMS 14C dating was performed at the Tandem Laboratory of Uppsala University (Sweden), and all dates presented in this paper are calibrated using OxCal v4.4 (Bronk Ramsey 2009) with the IntCal20 calibration curve (Reimer et al. 2020).

Results

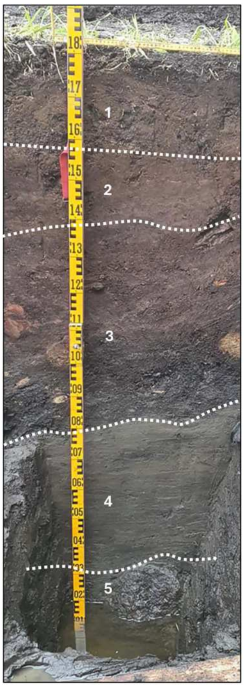
Stratigraphy and Dating

The excavation of the two trenches revealed detailed stratigraphy, reflecting varying lakeshore environments and episodes of human activity, extending to a maximum depth of c. 200 cm, reaching the hard, impenetrable rocky lakebed (Figure 2).

In Trench 3, below the surface, a thin, peaty plough zone (Layer 1) was encountered, which overlaid a moist *Carex* peat (Layer 2) with some charcoal and well-preserved plant remains. Below was a thick sequence of peat (Layer 3; sublayers 3A–3D), containing an abundance of wood, tree trunks, stumps, twigs, and decomposed *Sphagnum* and *Carex* mosses, suggesting repeated flooding, episodic tree stands, and shoreline accumulation after the lake receded (see Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021). The presence of well-preserved plant remains, including almost intact cranberries (*Vaccinium oxycoccos*), water chestnuts (*Trapa natans*), and hazelnuts (*Corylus avellana*), and the preservation of organic artefacts (e.g. wooden posts, laths and bark floats; see section 4.2 for details on the finds), suggests that the remains were rapidly buried in an anoxic environment.

Beneath the peat, a distinct layer of fine detritus gyttja (Layer 4) was identified, which revealed a few more wooden artefacts, including two vertical posts and a paddle. In addition, the layer contained two pebbles wrapped in birch bark, a few quartz flakes, and fragments of (unburnt) bone.

The lowest coarse detritus gyttja/lakebed sand horizon (Layer 5), which corresponds to the 'older cultural horizon' previously identified by Aalto, Siiriäinen, and Vuorela (1985; see also Koivisto 2021), yielded rather abundant finds near the drainage ditch section,



LAYER	DATING	UNIT	DESCRIPTION
1	Modern	Level 0	Surface of farmland
		Layer 1	Peaty plow-zone
2	<1500 BCE	Level 1	Surface of *Carex* peat
		Layer 2	Undecomposed *Carex* peat
3	2470-1460 BCE	Level 2	Surface of wood layer in tough *Carex* peat
		Layer 3	Decomposed tough, soapy dark *Carex* peat; large quantity of wood and some charcoal
		Level 3	Surface of *Sphagnum* peat
		Sublayer 3A	Tree stumps and roots in crumbly, loose, cleavable *Sphagnum* peat; abundant plant remains; first wooden finds: surface of the "younger cultural horizon" (Aalto et al. 1985); average depth in Trench 3: c. 65 cm from the surface; Trench 4: c. 70 cm
		Sublayer 3B	Plant layer with bark floats, laths (drifted to the shore) and hazelnuts; wood finds in Trench 3 c. 110 cm depth
		Sublayer 3C	Dense, tearable layer of plant matter at the bottom of peat; 'net float level'; some wooden finds (intermediate layer to gyttja nearly findless in Trench 3)
		Sublayer 3D	Trench 3: branch/stone concentration packed near waterfront
4	4450-3040 BCE	Level 4	Surface of fine detritus gyttja
		Layer 4	Gray homogeneous gyttja layer; erosion near the shore; series of sand layers especially in Trench 4 area; Trench 3: paddle, long conical artefact and post struck vertically to the lakebed sand; dozens of net floats in both areas
5	6010-3100 BCE	Level 5	Surface of coarse detritus gyttja mixed with lakebed sand, the "older cultural horizon" (Aalto et al. 1985)
		Layer 5	Layered gyttja-mixed sand; erosion and wave energy, especially near the shore; archaeological finds moved from their original locations; 'normal' dryland materials (quartz, burnt and unburned bone, pottery)
6	-	Level 6	Bottom stratum of the lake, coarse rocky, "inaccessable"

Figure 2. Part of the profile section of Trench 4 and general stratigraphy of Järvensuo 1 with descriptions of different layers.

particularly of durable materials, e.g. quartz, burnt bone and pottery, as well as organic finds, including unburnt bones, nutshells, and the bases of two vertical posts.

Trench 4 revealed a similar sequence of peat and lakebed deposits (see Figure 2), slightly altered by the proximity to a rocky lakeshore below the slope, as well as modern drainage disturbances. A homogeneous peaty plough zone (Layer 1) overlaid brown *Carex* peat, which contained abundant natural wood pieces and tree trunks (Layer 2), in turn gave way to darker, moist deposits rich in wood and *Sphagnum* mosses.

The first artefact discovered c. 56 cm below the surface was – astonishingly – a wooden entirely worked figurine depicting a natural-sized snake (see Koivisto and Lahelma 2021). Next to it was another carved artefact, both embedded in the upper peat horizon (Sublayer 3A), which was rich in undecomposed plant remains and natural pieces of wood. Six vertical and horizontal posts and concentrations of fragmentary laths were also encountered. The deeper peat levels (Sublayers 3B–3C) contained several bark artefacts, a wooden shaft, a fragment of a polished stone axe, and wooden posts.

The fine detritus gyttja horizon (Layer 4) contained fewer finds, mainly hazelnuts and a few bark artefacts. At the base, the coarse detritus gyttja/lakebed sand horizon (Layer 5) yielded a few quartz and bark fragments, and nutshells, as well as several pieces of unburnt bone, including an almost intact half of a mandible from a large mammal. During the post-excavation phase, the soil samples from this layer revealed cordage fragments and knots from fishnets (Koivisto, Suomela, and Lempiäinen-Avci 2024).

A total of 29 AMS 14C dates are currently available from Järvensuo 1 (Table 1 and Figure 3). There are large measurement errors (>±100 radiocarbon years) in the results

Table 1. Compilation of 14C dates from Järvensuo 1.

Lab ID	14C age	14C STD	cal BCE (95.4%)	Type	Material	Species	Collection n:o	Other ID	Year	Sample location	Horizon	Reference
Hel-2360	3410	100	2008-1459	soil sample	peat	–	–	–	1985	Coring site 3	3	Vuorela 2002; Koivisto 2021
Hel-1695	3610	120	2337-1627	soil sample	gyttja	–	–	–	1982	Coring site 1	4/5*	Siiriäinen 1983; Koivisto 2021
Ua-74748	3636	31	2133-1900	nutshell	organic	*Corylus avellana*	KM42675:102	–	2020	Trench 4	3A	This study
Hel-1942	3690	130	2462-1750	soil sample	peat	–	–	–	1982	Coring site 2A	3	Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021
Ua-74744	3693	32	2199-1974	post	wood	*Populus tremula*	KM42675:140	P1067	2021	Trench 4	3C/4	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-74746	3765	31	2290-2042	wood sample	wood	–	KM42675:70	–	2021	Trench 3	5*	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-74743	3796	31	2344-2136	paddle	wood	*Betula* sp.	KM42675:41	P1062	2021	Trench 3	4	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-78231	3866	33	2462-2207	post	wood	indet.	–	P1072	2021	Trench 3	4	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-74741	3868	31	2461-2209	float	bark	*Pinus sylvestris*	–	P1051	2021	Trench 3	3C	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-67655	3908	32	2471-2291	figurine	wood	*Juniperus communis*	KM42675:98	P1002	2020	Trench 4	3A	Koivisto and Lahelma 2021
Hel-2361	3930	100	2852-2137	soil sample	gyttja	–	–	–	1985	Coring site 3	4	Vuorela 2002; Koivisto 2021
Hel-1943	4000	100	2873-2210	soil sample	gyttja	–	–	–	1982	Coring site 2A	4	Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021
Hel-1004	4210	140	3331-2462	paddle	wood	*Pinus sylvestris*	–	K10496	1958	Drainage ditch	4*	Siiriäinen 1983, Edgren 1984; Koivisto 2021
Hel-1694	4430	120	3510-2777	wood sample	wood	–	–	–	1982	Coring site 1	4/5*	Siiriäinen 1983; Koivisto 2021
Ua-81468	4492	31	3351-3037	pottery	organic crust	–	KM42675:48	–	2021	Trench 3	4	This study
Ua-74749	4513	33	3358-3099	nutshell	organic	*Trapa natans*	KM42675:147	–	2021	Trench 4	4	This study
Ua-79367	4527	31	3363-3101	bone	bone (unburnt)	*Alces alces*	KM42675:96	–	2020	Trench 3	5	This study
Ua-81471	4762	32	3637-3382	pottery	organic crust	–	KM21493:6	–	1982	Drainage ditch	-	This study
Ua-81470	4771	31	3639-3386	pottery	organic crust	–	KM30676	–	1997	Drainage ditch	–	This study
Hel-2362	4790	140	3950-3109	soil sample	gyttja	–	–	–	1985	Coring site 3	4	Vuorela 2002; Koivisto 2021
Hel-1696	4880	120	3951-3376	charcoal sample	charcoal	–	–	–	1982	Coring site 1	4/5*	Siiriäinen 1983; Koivisto 2021
Ua-74745	5358	32	4327-4054	stake	wood	*Populus tremula*	KM42675:159	P1070	2021	Trench 4	5	Koivisto, Suomela, and Lempiäinen-Avci 2024

Ua-81469	5486	33	4443-4253	pottery	organic crust	–	KM42675:93	–	2021	Trench 3	5	This study
Ua-79368	5526	32	4446-4333	bone	bone (unburnt)	*Alces alces*	KM42675:39	P1043	2021	Trench 3	4	This study
Ua-79420	5643	41	4580-4358	tooth	molar (unburnt)	*Alces alces*	KM42675:162	–	2021	Trench 4	5	This study
Ua-78230	5953	34	4935-4726	cordage	bast	indet.	–	MN49	2021	Trench 4	5	Koivisto, Suomela, and Lempiäinen-Avci 2024
Ua-74742	6163	33	5212-5011	long artefact	wood	*Pinus sylvestris*	KM42675:33	P1039	2020	Trench 3	4/5	Koivisto, Suomela, and Lempiäinen-Avci 2024
Hel-1944	6470	110	5623-5217	soil sample	gyttja	–	–	–	1982	Coring site 2A	5	Aalto, Siiriäinen, and Vuorela 1985; Koivisto 2021
Ua-74747	7033	41	6011-5804	bone	bone (burnt)	*Esox lucius*	KM42675:88	–	2021	Trench 3	5	This study

*Ditching disturbance.

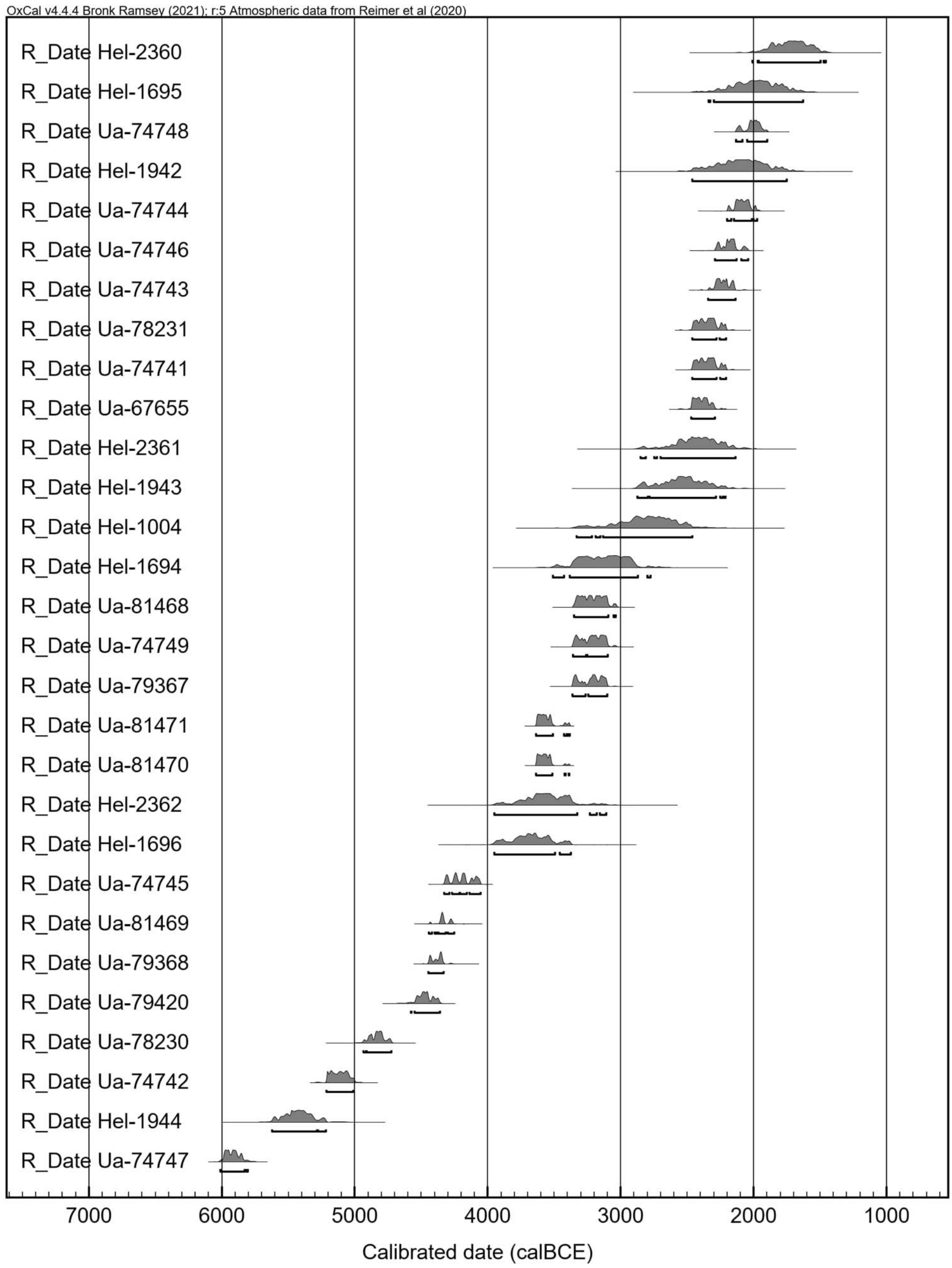


Figure 3. Calibration plot of AMS 14C dates from Järvensuo 1.

obtained from the 1980s materials, with only one direct 14C date from an archaeological artefact (Hel-1004). Furthermore, most of the previously dated materials – wood, charcoal, and bulk organic sediment – were extracted from the same rather thin (c. 13 cm) cultural horizon observed in the drainage ditch section, resulting in, nevertheless, a wide chronological interval of over 2000 years. This suggests distortion of the stratigraphy and redeposition of materials near the ditch. Our new 14C dates, extracted mainly from artefacts from all excavated horizons (totalling over 200 cm in thickness), range between c. 6010 and 1900 cal BCE, thus covering an extensive period of over four millennia. Most samples represent terrestrial sources and derive from materials found further away from the disturbed ditch. They can therefore be considered reliable and related to anthropogenic activities.

As in other parts of the Baltic Sea, certain sources of dating error must be considered, including the old-wood effect (e.g. Carpelan 2004), as well as marine (MRE) and freshwater (FRE) reservoir effects (Fischer and Heinemeier 2003; Lougheed, Filipsson, and Snowball 2013; Philippsen 2013). The old-wood effect can, in some circumstances, have a biasing effect on 14C dates, making them earlier than the actual time of artefact deposition. While there is no reliable way to estimate the scale of this effect on wood-derived samples, the overall own-age effect has been estimated +/- 50 radiocarbon years (Oinonen, Pesonen, and Tallavaara 2010), which can be considered a fairly low figure in this timescale. Dates obtained from burnt bone may reflect pyrewood rather than the bone itself (Hüls et al. 2010; Olsen et al. 2013; Van Strydonck, Boudin, and de Mulder 2010), while unburnt bone may be unreliable due to low collagen content (e.g. Scirè Calabrisotto et al. 2013). At Järvensuo 1, only one sample (Ua-74747) derives from burnt fish bone, which minimises these concerns. Three samples (Ua-79367, Ua-79368 and Ua-79420) are from unburnt bone, though they contained sufficient collagen and can be considered as reliable. Concerning the FRE, Lucquin et al. (2023) detected the presence of aquatic- and plant- derived lipids in the analysed pottery sherds from Järvensuo 1. However, due to the nature of the non-calcareous eutrophic Lake Rautajärvi, there is currently no basis to assume that the FRE would affect pottery crust dates (Ua-81468, Ua-81469, Ua-81470 and Ua-81471; see Pesonen 2021). However, further research is ongoing on this topic.

To sum up the results of the stratigraphy and dating, the accumulation of peat (Layer 3) in the excavation trenches can be dated to c. 2470–1460 cal BCE. The 14C dates in fine detritus gyttja (Layer 4) fall to c. 4450–2140 cal BCE. However, the dated vertical artefacts – the wooden paddle and post – have obviously been struck through gyttja from the overlying peat horizon and can be attributed to a later phase. The remaining dates (from pottery, hazelnut and unburnt bone) are more reliable, and date this horizon to c. 4450–3040 cal BCE. The directly dated artefacts from the bottommost lakebed sediments (Layer 5) suggest their deposition c. 6010–3100 cal BCE. However, erosion and runoff from dryland sediments involving the redeposition of finds are likely.

Finds

A total of 524 finds were recorded in 2020–2021. Figure 4(A) illustrates the quantity of all find types and Figure 4(B) their proportions for each trench. The various material groups are described below.

Wooden Artefacts

Wood was the most abundant find material (28%), with the majority found in peat in Trench 4. Altogether 11 posts were recovered in the two trenches, five still standing vertically or obliquely *in situ* at the ancient lakebed. Two posts (Ua-74744 and Ua-78231; Figure 5(A)) and one stake (Ua-74745) have direct 14C dates; c. 2200–1970, 2460–2210

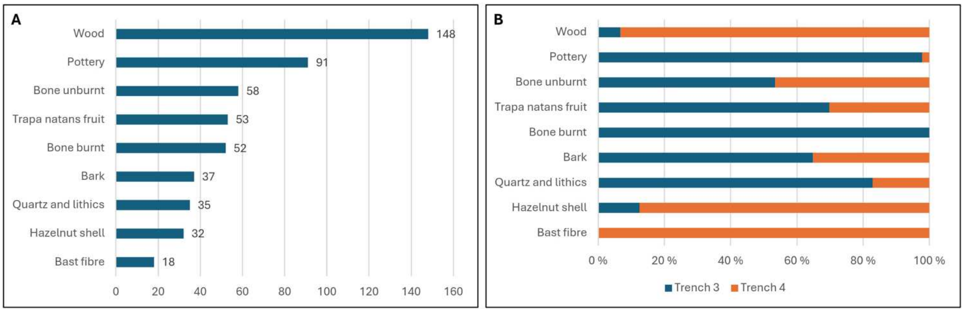


Figure 4. A. Total number of finds (n = 524) from 2020 to 2021; B. Relative proportions of find types per trench.

and 4330–4050 cal BCE (Koivisto, Suomela, and Lempiäinen-Avci 2024), respectively, placing them to the Early and Final Neolithic.

Among the wooden artefacts, two long, entirely worked rods, three paddles (or their fragments) (Figure 5(B)), a small plug, a shaft (Figure 5(C)), and a few plank-shaped

Figure 5. Wooden artefacts from Järvensuo 1: A. Vertical post (P1072) *in situ*; B. Broken paddle (KM42675:41) standing vertically *in situ*; C. Shaft (KM42675:108) *in situ*; D. Ladle-shaped figurine (KM42675:99) lifted; E. Head of the snake figurine (KM42675:98) lifted, and F. lying horizontally *in situ*.

artefacts were recovered. Two delicately carved figurines were also found: a snake figurine (Koivisto and Lahelma 2021; Figure 5(E and F)), and, next to it, a ladle-shaped figurine (Figure 5(D)), perhaps depicting a profile of a waterfowl, elk, or human.

The earlier drainage ditch find from the 1980s – the wooden scoop with a bear's head handle (KM21493:1) – is probably one of the most iconic pieces of wooden portable zoomorphic art from Neolithic Finland (e.g. Aalto, Siiriäinen, and Vuorela 1985; Immonen 2002; Koivisto 2021; Siiriäinen 1983; Taavitsainen 2001). The snake figurine makes a new addition to the list of zoomorphic artefacts in boreal Fennoscandia. In the Mesolithic, Neolithic and Early Bronze Age northeast Europe, bears, water fowl, elk, and snakes, and sometimes humans, have been portrayed in tools and figurines, made from e.g. amber, antler, bone, lithics, wood, and clay (e.g. Carpelan 1974; Chairkina 2014; Kashina 2015; 2025). However, the naturalistic wooden snake from Järvensuo 1 is unique to date, and its initial function – as a ritual staff, toy, piece of art, or something else – can only be hypothesised (see Koivisto and Lahelma 2021 with references).

In conjunction with the findings from the 1980s investigations (see Koivisto 2021), at least five wooden paddles have been found in a relatively confined area of Järvensuo 1. The 2020–2021 excavations yielded two identifiable paddles, as well as fragments of a third – and possibly a fourth. The most well-preserved specimen (see Figure 5(B)), though in several matching pieces, was found in Trench 3 in a vertical position. It was directly 14C dated to c. 2340–2140 cal BCE (Koivisto, Suomela, and Lempiäinen-Avci 2024), thus placing it in the Final Neolithic. The remaining fragmentary and broken paddle elements are too poorly preserved to allow any interpretation of their shape or reconstruction. They likely represent two or even three additional paddles found in the upper peat, which can be stratigraphically dated to the Final Neolithic.

The first of the Järvensuo 1 paddles (K10496), discovered during ditch digging in the 1950s, has been 14C dated to the Middle/Late Neolithic (c. 3330–2460 cal BCE; Koivisto 2021). The second paddle (KM23822:31) was discovered during the 1985 excavations (see Koivisto 2021). Although the artefact has not been securely dated, it was found lying horizontally in peat, suggesting a contextual dating to the Middle/Late Neolithic (Koivisto 2021). All the paddles from Järvensuo 1 may thus be placed in the time range of c. 3330–2140 cal BCE. Dozens of partly similar wooden paddles, as seen at Järvensuo 1, have been found in wetland contexts in northeast Europe and Eurasia (e.g. Bērziņš 2008; Mylnikov, Chairkina, and Reinhold 2024; Rauschenbach 1956; Vankina 1970). They date mainly to c. 4000–2000 cal BCE (Kashina and Chairkina 2017), in line with the Järvensuo 1 specimens.

Two slender, entirely worked rods were found by the vertical paddle (in Trench 3). During the fieldwork, this was suggested as a potential association between the findings. However, the almost two-meter-long, angular-profiled vertical rod provided a significantly older 14C date (Ua-74742), c. 5210–5010 cal BCE (Koivisto, Suomela, and Lempiäinen-Avci 2024), placing it in the Late Mesolithic/Early Neolithic, whilst the paddle was nearly 3000 years younger.

Bark Artefacts and Fibre Technologies

The pine bark artefacts (n = 24) consist mainly of fishnet floats (n = 20), the most typical variant being a shuttle-shaped artefact made of pine bark, approximately 20 cm long, with a longitudinal groove and notches at both ends (Figure 6(A)). One such specimen was 14C dated to the Final Neolithic, c. 2460–2210 cal BCE (Koivisto, Suomela, and Lempiäinen-Avci 2024). A few perforated, ovate and angular variants (Figure 6(B–D)) are also included in the assemblage. The birch bark artefacts (n = 13) include simple fishnet roll floats (n = 10) and a few folded or rolled sheets of birch bark (Figure 6(E)). The latter probably represents bark raw material stored in shallow water. Two fishnet pebble sinkers also feature birch bark sheeting and bast cordage (Figure 6(F and G)).

In addition to the previously discovered seven bark floats from Järvensuo 1 (see Koivisto 2021), about 200 specimens of broadly similar types have been found in Finland (Pesonen et al. 2024), among them the pine bark floats from the famous Antrea net find from c. 8400 cal BCE (Miettinen et al. 2008) and floats presumably originating from several Late Neolithic nets from Lähdepuro in Pori (Kauhanen 1974). Similar types are known from wetland sites in northeast Europe, such as Sārnate, Latvia (Bērziņš 2008; Vankina 1970), Šventoji, Lithuania (Rimantienė 2005), and Gorbunovo, northwest Russia (Rauschenbach 1956), dated mainly to the 4th and 3rd millenniums BCE.

The excavations also yielded rare fishnet remains, i.e. tiny fragments of twisted bast cordage and knots (n = 18), most likely from *Tilia*, *Salix, Populus,* or similar species (Koivisto, Suomela, and Lempiäinen-Avci 2024; Suomela, Suhonen, and Koivisto 2025). The largest knots (c. 5 mm in diameter) are visible to the naked eye; the remainder are tiny (c. 1–3 mm) microscopic fibres with identifiable symmetrical structures. One knot has a direct 14C date of c. 4940–4730 cal BCE, placing it in the earliest Neolithic (Koivisto, Suomela, and Lempiäinen-Avci 2024). Similar finds are known from a few waterlogged and submerged contexts in boreal Fennoscandia (e.g. Kauhanen 1974; Miettinen et al. 2008), the eastern Baltic (e.g. Rimantienė 2005; Vankina 1970), and Scandinavia (e.g.

Figure 6. Bark artefacts. A. Shuttle float (KM42675:29); B. Perforated angular float (KM42675:27); C. Ovate float (KM42675:128); D. Rounded angular float (KM42675:139); E. Birch bark roll (KM42675:26); F. Sinker stone wrapped with birch bark strips (KM42675:42); G. Sinker stone with birch bark wrapping and ties of bast cordage (KM42675:37).

Hallgren 2023; Jørgensen 2013; Myking, Hertzberg, and Skroppa 2005; Stjernquist, Nilsson, and Nybelin 1953), which date from c. 8400 cal BCE onwards.

Pottery and Lithics

The pottery assemblage from 2020 to 2021 comprises a small collection (n = 91) of fragmentary sherds representing mainly Typical and Late Comb Ware styles of the Finnish Neolithic (cf. Pesonen 2021). Almost all were found in the vicinity of the ditch, where the horizons were mixed and loose, suggesting runoff from dryland and redeposition. The majority are small, fragile, and fragmented pieces of brownish-grey paste, poorly fired and tempered with sand, crushed stone, shell, and some organic, decomposed material (Figure 7(A–E)). A few sherds with intact surfaces contain comb, pit, and stamp imprints as well as striation. In line with the stylistic characteristics, the organic crust dates (see Table 1) place these materials mainly in the 4th millennium cal BCE, whilst one date (Ua-81469) from a sherd with oval stamps (Figure 7(B)) also suggest Early Comb Ware influences, e.g. the southwest Finnish Sperrings 1 and 2 Wares (c. 5155–4225 cal BCE) or Jäkärlä Ware (c. 4030–3830 cal BCE), or similar (chronologies according to Pesonen and Oinonen 2019).

Among earlier finds, approximately 100 sherds (KM21493, KM23822 and KM30646) with stamp, pit, 'fingernail', and line decoration, as well as striations and heavy surface scraping, are included (Koivisto 2021). Their clay matrix is also grey and porous, rather poorly fired, with mineral and dissolved organic temper. It is apparent that a proportion of the fragmentary pottery sherds found in various decades nearby the disturbed ditch area originate from the same pots.

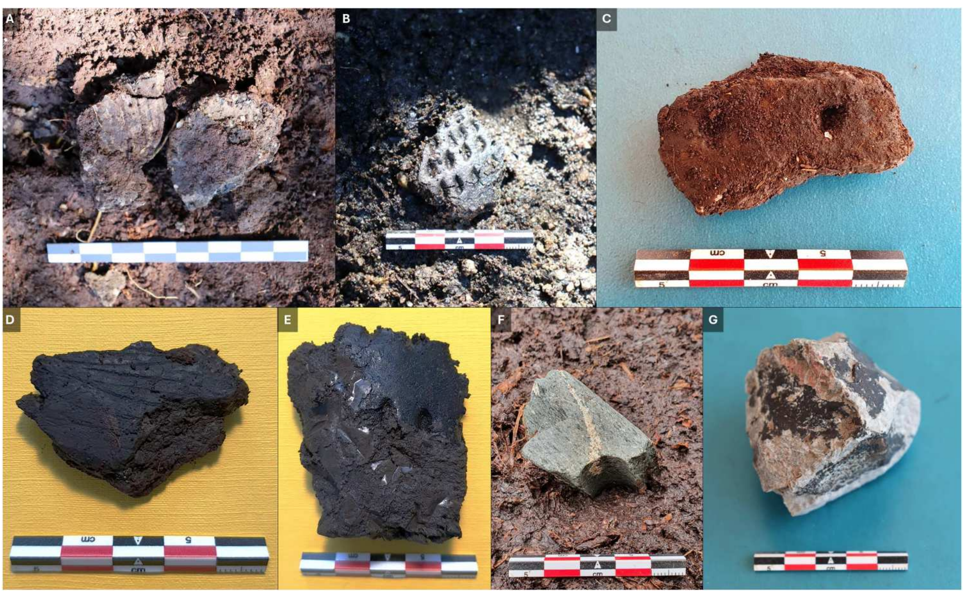


Figure 7. Fragile pottery sherds with: A. striation and light comb-stamp imprints (KM42675:1), B. densely arranged oval stamp imprints (KM42675:93), C. circular imprints (KM42675:129), D. scraping (KM42675:3) and E. oval pits (KM42675:136). F. Polished stone axe fragment made from grey diabase (KM42675:127) and G. cracked stone smeared with birch bark tar (KM42675:44).

The quartz material (n = 27) is generally of poor quality and mixed with other rock types such as feldspar. Very few (n = 3) artefacts and cores were found, and their raw material is presumably local, as veins of quartz in bedrock with somewhat similar knapping waste are known in close vicinity to the site (Pohjakallio 2005). In addition, eight lithic tools were found, including the two pebbles covered with birch bark (see Figure 6(F and G)) and a cracked stone smeared with birch bark tar (Figure 7(G)), all presumably utilised as net sinkers. A piece of a perforated stone axe was also found (Figure 7(F)), thick and thoroughly polished, with a symmetrical and carefully drilled shaft hole. Earlier finds (KM21493 and KM23822) include a fragment of a polished adze made of diabase, two polished stone tool fragments, a porphyry scraper, and a few quartz artefacts and knapping waste (Koivisto 2021).

Faunal Remains

A total of 110 bone remains were recovered (Table 2), of which about half (n = 52) are burnt. The majority are unidentified mammalian bones, and three fish bones were identified: two lower jaw fragments of northern pike (*Esox lucius*) and a vertebra fragment of European perch (*Perca fluviatilis*). Interestingly, a collection of unburnt animal bones (n = 58) was also recovered (Figure 8(A–D)) – a most rare occurrence in the boreal Fennoscandian Stone Age context, where such finds are practically exclusively preserved in a burnt state. The majority of the identified specimens are Eurasian elk (*Alces alces*) containing elements from various body parts: scapula, vertebrae, upper and lower limbs, and pelvis. Furthermore, an almost complete right mandible of an approximately 1.5–2.5-year-old elk individual with most of its teeth intact (Figure 8(B)) was recovered from the lakebed horizon (Trench 4, Layer 5). All unburnt bones found are from skeletal elements that have typically been used for making tools and weapons, i.e. straight long bones and flat scapula. The majority contain fresh breakages, and a few bear cutmarks (Figure 8(C and D)). The minimum number of individuals (MNI) for all elk taxa is only one. However, the direct 14C dates of three unburnt elk remains (Ua-79367, Ua-79368 and Ua-79420) suggest longer-term, Early and Middle Neolithic elk carcass processing and discarding practices, between c. 4580 and 3100 cal BCE (see Table 1). The burnt pike bone (Ua-74747) reflects earlier, Late Mesolithic fishing and food preparation activity c. 6010–5800 cal BCE.

The earlier find assemblage includes about a dozen unburnt bone fragments and a large ruminant tooth, along with a few burnt bones (see Koivisto 2021). Unfortunately, the unburnt materials are degraded today (fragmented and pulverised), so their reanalysis is not possible. However, the bones may originate from the same elk individual(s).

Plant Remains

Nearly 2200 botanical macro remains were identified and classified into 62 taxa (Table 3). The majority are uncharred, with only one charred specimen. In general, the majority of plant remains represent various *Carex* species, reflecting the natural vegetation of the lakeshore area, while open water is indicated by yellow cowlily (*Nuphar lutea*), water hemlock (*Cicuta virosa*), purple loosestrife (*Lythrum salicaria*), and marsh cinquefoil (*Potentilla palustre*). Well-preserved edible plants were also identified, including hazelnuts and

Table 2. Results of the zooarchaeological analysis.

Unburnt bone									
KM42675:	Trench	Layer	Other ID	n	Bone	Species	Breakages	Cutmarks	Observations
39	3	4	1067	1	tibia sin supraprox fr.	*Alces alces*	X	X	142x52x20 mm, possibly waste from marrow extraction
64	3	5	10318	1	tibia fr.	*Alces alces*	X		137.2x35.3x33.6 mm, potentially broken off
65	3	5	10320	10	pelvis ilium, acetabulum dex. fr.	*Alces alces*	X	X	110.3x64.5x52.00 mm (largest piece), fragmentary, cutmarks on two surfaces
66	4	5	10322	1	vertebra?	Megamammalia			Fragile piece
70	3	5	10337	1	indet.	Megamammalia?			56x20x9 mm, large mammal (e.g. deer, moose, bear, or wild boar)
76	3	5	10343	1	metatarsus dist. fr.	*Alces alces*	X	X	96.6x75.2x110 mm, one surface potentially cut off'
81	3	5	10359	10	malleolare (whole 1 fr.), tibia dex. dist. (3 fr.)	*Alces alces*			65.6x49.6x32.4 mm (largest piece), articulated pieces, several tibia fragments
82	3	5	10360	1	humerus sin. diaph. fr.	*Alces alces*	X	X	128.0x38.0x40.0 mm, split point shaped artefact
83	3	5	10361	1	tibia dex. diaph. fr.	*Alces alces?*		X	123.7x31.7x6.9 mm
84	3	5	10362	1	ulna dex. prox., inc. semilunaris fr., in two parts	*Alces alces*			21.3x15.6x51.7 mm
94	3	5	10375	1	calcaneum sin. fr.	*Alces alces*			129.0x52.0x42.0 mm
95	3	5	10376	1	indet. fr., vertebra fr.	Mammalia, megamammalia			In several pieces, elk?
96	3	5	10377	1	scapula sin. fr.	*Alces alces*		X?	160.5x20.8x8.0 mm (largest piece), possible point shaped artefact, tip broken
162	4	5	10351	1	mandibula, PM1-3, M1-3	*Alces alces*			Young individual, c. 2.5 years, fragile and badly degraded
Burnt bone									
KM42675:	Trench	Layer	Other ID	n	Bone	Species	g		
56	3	5	10306	5	indet.	indet.	0.27		
57	3	5	10309	1	indet.	Mammalia	0.29		
77	3	5	10355	2	indet.	Mammalia	1.28		
78	3	5	10356	2	indet.	indet.	0.1		
79	3	5	10357	6	indet.	Mammalia	1.81		
79	3	5	10357	1	vertebra	*Perca fluviatilis*	0.05		
80	3	5	10358	2	indet.	indet.	0.01		
88	3	5	10369	1	dentale fr.	*Esox lucius*	0.22		
88	3	5	10369	1	dentale fr.	*Esox lucius*	0.18		

(*Continued*)

Table 2. Continued.

Unburnt bone									
KM42675:	Trench	Layer	Other ID	n	Bone	Species	Breakages	Cutmarks	Observations
88	3	5	10369	6	indet.	indet.	1.27		
88	3	5	10369	21	indet.	Mammalia	4.14		
88	3	5	10369	1	costa fr.	Mammalia	0.13		
89	3	5	10370	2	indet.	indet.	0.14		
89	3	5	10370	1	indet.	Mammalia	0.08		

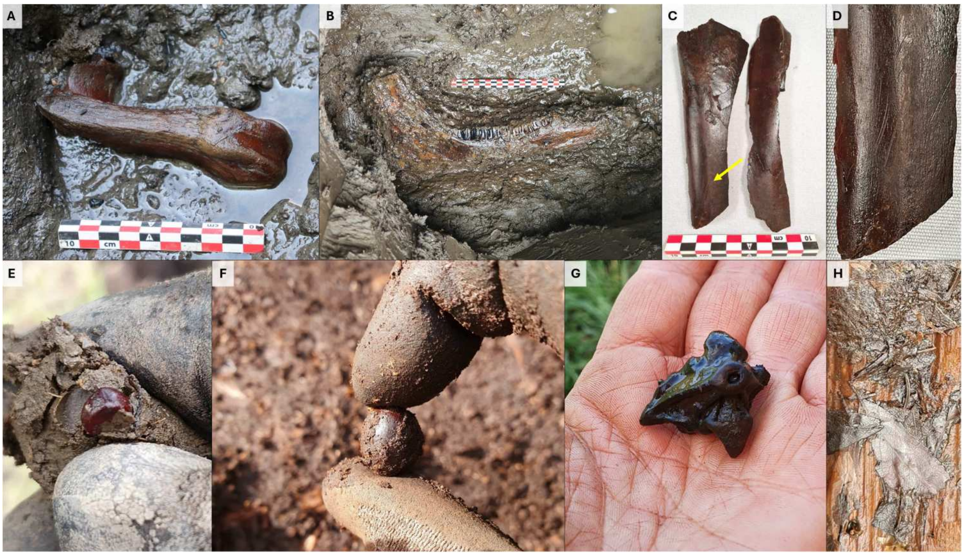


Figure 8. Unburnt elk bones and plant remains: A. calcaneum (KM42675:94), B. mandible (KM42675:162), C–D. tibia with cutmarks (KM42675:39), E. cranberry, F. hazelnut, G. water chestnut, H. leaves on top of a wooden artefact.

water chestnuts (Figure 8(E–G)), most shells broken, presumably by humans (cf. Vanhanen and Pesonen 2016). Interestingly, whole specimens of water chestnuts, containing their rarely found sepals and barbed spikes, were also found, suggesting that the shallow water area has provided an optimal growing location for this species. Already during the excavations, it became apparent that the plants were excellently preserved, and at several horizons different plant species could be visually identified and collected collected (Figure 8(H)).

Discussion

Stratigraphy and Long-term Use of the Lakeshore

The stratigraphy and available 14C dates (see Figures 2–3 and Table 1) indicate that the archaeological layers at Järvensuo 1 accumulated over an extended period in the shoreline and shallow-water environments. Because the excavated trenches were of the same size and located in the same shore zone, albeit in slightly different parts of it, it is possible to compare the quantity of finds in different horizons (Figure 9(A)). The number of finds in both trenches was almost the same (Trench 3, n = 276; Trench 4, n = 248); however, there were some differences in their distribution across layers. The majority (62%) of finds in Trench 3 came from the bottommost lakebed deposits (Layer 5), while in Trench 4, most finds (65%) came from peat (Layer 3). If durable materials – typical non-organic finds (e.g. pottery, quartz, burnt bones) preserved in Stone Age dryland contexts, and perishable organic materials (e.g. wood, bark, unburnt bone and nutshells) are compared, 61% of all finds in Trench 3 are durables, whereas almost all (97%) in Trench 4 are organic (Figures 9(B and C) and 10). In both trenches, the saturated *Sphagnum* and *Carex* peat layers were favourable for the preservation of wood and bark, and in the

Table 3. Results of the plant macrofossil analysis.

	Sample no.		9	18	24	42	48	50	29	30	31	32	33	49	
	Trench/Layer		3/3A	3/3B	3/3C	3/4	3/5	3/5	4/3B	4/3C	4/3C	4/4	4/4	4/5	
	Other ID		523	846	1015	10188	10348	10367	1105	1106	1107	1108	1109	10354	
	Unit		layer	layer	layer	layer	layer	layer	profile	profile	profile	profile	profile	layer	
Economic plants															
Corylus avellana	Common hazel	sf		2			10								12
Empetrum nigrum	Crowberry	s					2					3	2		7
Rubus chamaemorus	Cloudberry	s											1		1
Rubus idaeus	Raspberry	s	3				12	3	2		2	3	38	14	77
Rubus saxatilis	Stone bramble	s					2							3	5
Trapa natans	Water chestnut	sf					50	3				1	15	24	93
		f												1	1
		h											2		2
Vaccinium oxycoccos	Cranberry	s					4			1		2			7
		l								1				2	3
Ruderal plants															
Arctium sp.	Burdock	s								3	1		1		5
Atriplex/Chenopodium	Orache/Goosefoot	s									1				1
Cirsium sp.	Thistle	s								1					1
Galeopsis bifida	Bifid hemp-nettle	s					1					1			2
Persicaria lapathifolia	Pale persicaria	s					1				2			1	4
Urtica dioica	Common nettle	s					2								2
Aquatic plants															
Hippuris vulgaris	Mare´s-tail	s												2	2
Nuphar lutea	Yellow water-lily	s		12			18					7	3	14	54
Nymphaea alba coll.	White water-lily	s		2			1					1	7	4	15
Potamogeton natans	Broad-leaved pondweed	s					11			1	1	8	2	6	29
Potamogeton sp.	Pondweed	s				2		1				1	2		6
Schoenoplectus lacustris	Common club-rush	s		1		1	19	3				3	50	50	127
Fen and wetland plants															
Alisma plantago-aquatica	Water plantain	s		2	2		10	3		1	5	1	6	4	34
Bidens tripartita	Trifid bur-marigold	s		13											13
Calla palustris	Bog arum	s		3						1			1		5
Carex nigra-type	Common sedge type	s		15						8		2	10		35
Carex pseudocyperus	Cyperus sedge	s								2					2
Carex rostrata	Bottle sedge	s	50	50	50		50		44	24	20	10	50	10	358
Carex vesicaria	Bladder sedge	s							5	1	2				8
Carex sp.	Sedge	s		7						11	6				24
Cicuta virosa	Cowbane	s		10	22		3			2	2		2	5	46

Filipendula ulmaria	Meadowsweet	s				5			1	1		3	2	12
Galium palustre	Marsh bedstraw	s				1			2					3
Iris pseudacorus	Yellow flag	s								4			1	5
Juncus cf. *alpinoarticulatus*	Alpine rush	s										2		2
Lycopus europaeus	Gypsywort	s	2	8		6			1	2				19
Lysimachia thyrsiflora	Tufted loosestrife	s	16	23		3								42
		cf		4										4
Lythrum salicaria	Purple loosestrife	s	100											100
Menyanthes trifoliata	Bogbean	s	1				1		3	5	1	1	3	15
Potentilla palustris	Marsh cinquefoil	s	50	4	1	16			4	1		5	1	82
Potentilla sp.	Cinquefoil					1			30	25	1	5	2	64
Ranunculus repens	Creeping buttercup	s								1		1		2
Scheuchzeria palustris	Rannoch rush	s										2		2
Scrophularia nodosa	Common figwort	s										1		1
Scutellaria galericulata	Marsh skullcap	s	7											7
Solanum dulcamara	Bittersweet nightshade	s							1			1	1	3
Veronica scutellata	Marsh speedwell	s								5				5
Viburnum opulus	Guelder rose	s										1		1
Viola palustris	Marsh violet	s										1		1
Trees														
Alnus glutinosa	Black alder	s	1	2		23	6		8	16	3	50	50	159
Alnus incana	Grey alder	s				3				2				5
Alnus sp.	Alder	s							2					2
Betula nana	Dwarf birch	s					1		1					2
Betula pendula	Silver birch	s		50		50	5			1		50	50	206
		sc		1		50						50	50	151
Betula pubescens	Downy birch	s							13	11	38	50	10	122
		sc								3	2	50	10	65
Betula sp.	Birch	s	4	2	1				2		4			13
Juniperus communis	Common juniper	s							1	22				23
		n							1	2		3	1	7
Picea abies	Norway spruce	n						***1***	3	6				10
Pinus sylvestris	Scots pine	s		2		2				1			2	7
Populus tremula	Aspen	sc	3		1	8	2			5		10	9	38
		l				1							1	2
Prunus padus	Bird cherry	s				1				3		3	6	13
Rhamnus frangula	Alder buckthorn	s											3	3
Salix sp.	Willow	t	50											50
Sorbus aucuparia	Rowan	s								2				2
Tilia cordata	Small-leaved lime	s									2			2

(*Continued*)

Table 3. Continued.

	Sample no.		9	18	24	42	48	50	29	30	31	32	33	49	
	Trench/Layer		3/3A	3/3B	3/3C	3/4	3/5	3/5	4/3B	4/3C	4/3C	4/4	4/4	4/5	
	Other ID		523	846	1015	10188	10348	10367	1105	1106	1107	1108	1109	10354	
	Unit		layer	layer	layer	layer	layer	layer	profile	profile	profile	profile	profile	layer	
	TOTAL		**53**	**351**	**170**	**6**	**366**	**28**	**52**	**130**	**160**	**94**	**481**	**342**	**2220**
Other plant remains															
Charred wood	w				*	*		*			*	*	*		
	Wood	w							*						
Indeterminate plant remains	Undetermined														
Seed		s			2	1	2		2	4	8		2	4	
Leaf		l		1						2			4	5	
Bud		b		3		1	2				1		2	10	
Rhizome		r		*	***						9	1		1	
Mosses															
Sphagnum	Peat moss	sl		*		*	***	*			*	**	***	**	
Ferns															
Monilophyta		st									3				
		sp											**		
Fungi															
Cenococcum geophilum	Mycorrhizal fungus	s	*						*			*	*		

Abbreviations: sf = shell fragment; s = seed; f = fruit; h = horn of persistent sepal; l = leaf; c = capsule fragment; sc = scale; n = needle; t = twig; b = bud; r = rhizome; sl = shoots and leaves; st = stalks; sp = spore.

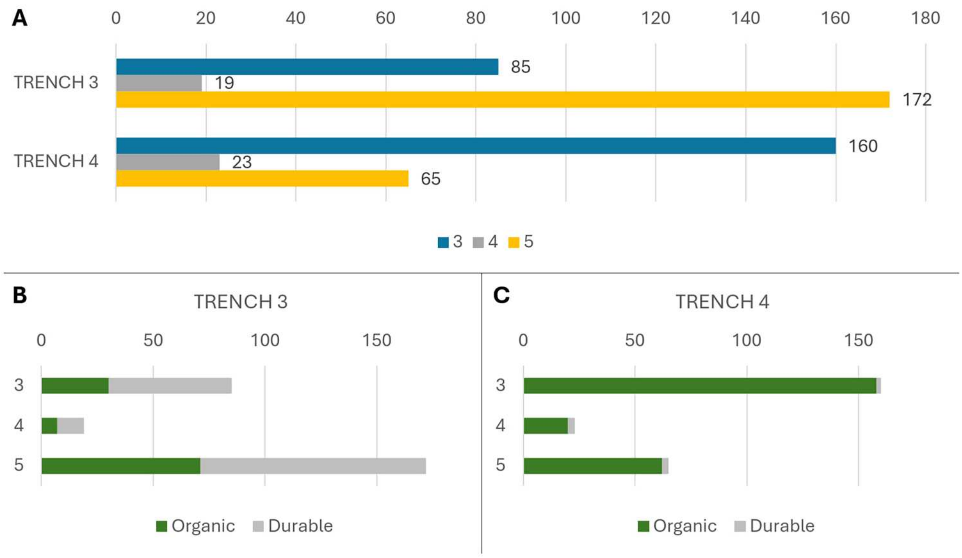


Figure 9. (A) Total number of finds in both trenches from different layers (3 = peat; 4 = fine detritus gyttja; 5 = coarse detritus gyttja/lakebed sand). Comparison of the proportions of organic and durable finds in different layers in Trench 3 (B) and Trench 4 (C).

lower, constantly waterlogged gyttja and lakebed sand horizons, the preservation conditions were also favourable for unburnt bones, which were not found at all in the upper peat layers. As no distinct differences were observed in the general preservation conditions between the two trenches, the discrepancies in find distribution may suggest varying uses of the lakeshore at different times.

From the Late Mesolithic through the Early Neolithic (c. 6000–4000 cal BCE), the area constituted a semi-dry sandy shore zone with signs of occasional human activity. As

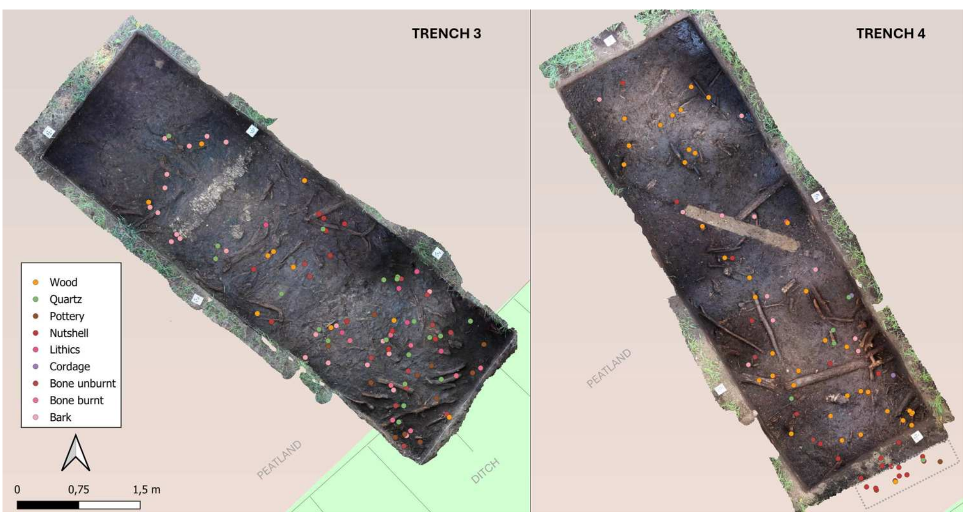


Figure 10. Horizontal distribution of all finds from all layers in the two trenches.

Rautajärvi transgressed, the earlier cultural horizons were inundated, with archaeological materials eroding and redepositing as unstratified finds within lakebed sediments (Layer 5). In the southeast part of Trench 3, the majority (59%) of finds in this horizon are durables (e.g. quartz, pottery and burnt bones) (Figure 9(B)), found on a c. 150 cm wide sandy terrace beneath peat (see Figure 10), probably representing a former sandy plateau by the lake during a lower water level. Preserved organic materials (e.g. unburnt bone and wood) deeper in the lakebed were likely deposited in shallow water; the partly degraded specimens underwent episodic exposure and redeposition.

Continued lake transgression through the Middle to the Late Neolithic (c. 4000–2500 cal BCE) produced deeper-water conditions, resulting in the accumulation of a thick, grey, homogeneous, fine detritus gyttja matrix (Layer 4) overlaying the earlier, coarser deposits. This horizon generally contained fewer finds in both trenches (see Figure 9(A)). Following the abrupt lake regression of c. 2500 cal BCE, the lake margin shifted to a waterlogged shoal zone and underwent gradual paludification.

The shifts between inundation and exposure of the shore zone obviously impacted the local resource base and environment. Shifting shoreline and vegetational zones created varied opportunities for human subsistence and resource availability. Final Neolithic groups, c. 2500–2000 cal BCE, appear to have adapted to these changes and continued to exploit local resources after the lake receded. After this phase, the anthropogenic signal ends abruptly at Järvensuo 1. The long-term use of the site until this point was likely driven by the abundance and easy access to various aquatic and terrestrial resources, as well as favourable connections to main coastal and inland routes and networks. The subsistence base of these Final Neolithic groups may have altered, or the suitability of the overgrown lakeshore for human activities altered to a stage that other types of habitats around and nearby Lake Rautajärvi were utilised and occupied more actively. As a result, the 'lake life' at Järvensuo 1 lost its significance.

Subsistence and Seasonal Activities

From the Late Mesolithic to the Late Neolithic (c. 6000–2500 cal BCE), the find materials indicate episodic exploitation and seasonally structured activities by hunter-gatherers, centred around freshwater fish, terrestrial mammals, and wild plants during their main procurement seasons. Contemporaneous dryland occupations along the adjacent lake edge (see Figure 1(B)), and at the nearby Kuoppanummi site further uphill, were utilised periodically. Wooden stakes and posts, paddles, fishing net components, quartz, lithics, and animal bones indicate water-edge occupation and fishing-related activities during higher-water phases. Broken shells of hazel and water chestnut indicate autumn harvesting seasons (cf. Vanhanen, Kriiska, and Nordqvist 2025), while fishing with nets and wooden traps may have occurred year-round (Koivisto 2023). Ethnographic and historical data from comparable lakes suggest that similar equipment was particularly effective during spring and early summer spawning seasons of pike and cyprinids (Koivisto and Nurminen 2015 with references). Although fish bone assemblages from Järvensuo 1 and nearby dryland sites are sparse, identified taxa – mainly pike and perch (Pohjakallio 2005) – correspond well with these analogies.

In addition to elk remains from Järvensuo 1, zooarchaeological data from nearby dryland sites further indicate the exploitation of, for example, Eurasian beaver (*Castor* *fiber*), wild reindeer (*Rangifer tarandus*), and grouse (Pohjakallio 2005). Optimal hunting seasons for elk and reindeer potentially occurred in late summer and early autumn, when the shallow shoal zone likely attracted these species, allowing hunting with a bow or spear. Winter hunting was enabled in the surrounding mixed coniferous forests. Beaver may have been hunted for meat, fat, and fur in late autumn and winter, as well as for other purposes, such as the production of tools and utensils (cf. Maigrot 2014), and for medical and ritual purposes (Hussain and Brusgaard 2024; Jääskeläinen 2023; Mannermaa et al. 2019). Other species, such as grouse, waterfowl, and elk, could also have benefited from the presence of beavers and their constructions in the area (Jääskeläinen 2023), thus also increasing the diversity and abundance of resources for human exploitation at the lake.

Following lake regression (c. 2500 cal BCE), the southern shoreline developed into a wetland with periodic flooding, thick with aquatic vegetation, and coinciding with the increase in human activity during the Late/Final Neolithic. The flat shoal zone was used for a wide range of activities, including fishing and equipment maintenance, woodworking, plant processing, boating, tool use and discard, and waste disposal. However, the concentration of specific wooden artefacts, i.e. the two figurines, and the previously discovered bear scoop, all found in a limited area below the cliff slope, may suggest some symbolic (ritual) behaviour, involving the deposition or discarding of wooden zoomorphic artefacts in wetland (see Koivisto and Lahelma 2021). The vertically placed paddle (in Trench 3) may also bear some similar connotations, a suggestion supported by parallels from Mesolithic and Neolithic Scandinavia (e.g. Larsson 2007; Sørensen 2020; 2023). Direct 14C dates place the Järvensuo 1 snake figurine and paddle between c. 2470 and 2140 cal BCE, and the two other artefacts can be (contextually) attributed to the same phase.

The elk mandible may also be associated with certain northern European Mesolithic and Neolithic occurrences of animal mandible deposition in wet contexts (Lahelma 2012; Sørensen 2020) and funerary settings (Grünberg 2013). Interestingly, there is an absence of all incisors and the incisor-formed canine with the Järvensuo 1 specimen – elements widely used as raw material for ornaments and rattles (Larsson 2006; Mannermaa et al. 2021; Rainio et al. 2021). However, the mandible turned out to be over 2000 years older (c. 4580–4360 cal BCE) than the wooden zoomorphic artefacts in the same trench, making this interpretation complex.

Cultural Connections and Significance

In addition to the material culture record, there are certain similarities in the setting and long-term use of prehistoric sites located on the shores of shallow lakes and peatland basins in northeast Europe (e.g. Bērziņš 2008; Charniauski and Kryvaltsevich 2011; Mazurkevich et al. 2009; Piličiauskas et al. 2025; Rimkus et al. 2025; Šturms 1940; Rimantienė 2005; Vankina 1970). Multi-phase habitation surfaces, pile dwellings, fishing gear, and other wooden structures have been documented in close association with shallow lake and wetland margins at sites spanning from the Early/Middle Neolithic to the Early Metal and Bronze Age (e.g. Bērziņš 2008; Piezonka et al. 2020; Mazurkevich et al. 2020; Pranckėnaitė et al. 2021). Archaeological and palaeo-environmental evidence suggests that wooden dwellings and platforms were typically erected during periods of lower water levels, subsequently becoming inundated (e.g. Dolukhanov and Miklyayev

1986; Kittel et al. 2018; Mazurkevich 2020). A few other wetland sites in Finland with reported wooden post constructions, such as Kärräniemi in northern Finland (Siiriäinen 1986) and Silmäkeneva in southern Finland (Matiskainen and Ruohonen 2004), may be related to the same phenomenon. In addition, certain similarities in the Swedish Middle Neolithic 'Alvastra pile dwelling' and surrounding wetland evidence (Browall 1986; Historiska museet 2026) have not previously been considered in this cultural context. Thus, the possible geographical extension north and westward of the phenomenon definitely deserves further investigation.

Against this comparative background, Järvensuo 1 can be considered part of the same tradition characterised by the long-term repeated use of shallow, dynamic lake shoreline areas. Here, anthropogenic activity also appears to have increased after lake regression. However, direct evidence of pile dwellings or wooden platforms is still lacking, and comparisons must be evaluated primarily through stratigraphic, artefactual, palaeo-environmental, and archaeobotanical proxies. The wooden posts, some still standing vertically *in situ* by the waterfront, require further investigation, as the excavation area has so far been so limited. Despite their suggested association with fishing structures (cf. Koivisto 2023), it is not out of the question that other types of wooden constructions also existed at Lake Rautajärvi.

Organic artefact parallels also link Järvensuo 1 with wider northeast European lake site tradition, suggesting a shared subsistence technology, strong woodworking tradition, and possible mutual symbolic practices. The artefacts from Järvensuo 1 specifically indicate a well-developed woodworking tradition associated with everyday fishing, boating, and construction, as well as artistic and possibly symbolic activity. Bark and fibre technologies reflect deep material expertise and crafting skills (see Suomela, Suhonen, and Koivisto 2025), as well as a significant investment of effort in fishing and the crafting and maintenance of associated gear. Although quartz, pottery and lithic artefacts are scarce among the overall materials, their presence suggests technological diversity within an otherwise predominantly organic assemblage. The nearby dryland sites, especially the long-occupied Järvensuo 2, c. 500 m east, have yielded relatively abundant quartz and lithic materials (Pohjakallio 2005), where such tools may have been predominantly produced and maintained. The scarcity of lithics at Järvensuo 1 could thus indicate that the wetland zone functioned as a more specialised resource procurement site where lithic tools were brought only when needed.

Artefactual evidence also points to wider regional networks and long-distance contacts. Around a dozen archaeological sites and stray find locations are known along the former lakeshores (see Figure 1(B); Koivisto 2021; Pesonen 2008). Their finds also include artefacts from non-local materials (e.g. flint and metatuff), indicating longer-distance networks or trade. In addition, multiple Neolithic (and later) pottery traditions are represented in this microregion: Typical Comb Ware (c. 3800–3545 cal BCE), Late Comb Ware (3540–3195 cal BCE), Corded Ware (2900–2200 cal BCE), Kiukainen Ware (2300–1500 cal BCE), and Textile Ware (1900–500 cal BCE) (chronologies according to Mökkönen and Nordqvist 2019; Nordqvist 2018; Pesonen and Oinonen 2019; see also Koivisto 2021). The density and diversity of known sites and materials indicate sustained use of the lake and its surroundings from the Mesolithic throughout the Neolithic and into the Early Iron Age (c. 6000–500 cal BCE), partly consistent with the chronological range documented at Järvensuo 1. Together, these data demonstrate that Lake Rautajärvi formed a long-lived and intensively used cultural landscape for several generations of people, with Järvensuo 1 representing one of the key nodes of activity within the broader network.

Conclusions

Järvensuo 1 is a rare hunter-gatherer wetland site in the boreal biogeographic region of Fennoscandia. It was investigated preliminarily in the 1980s, and renewed excavations in 2020–2021 demonstrated that the site still has significant wetland archaeological potential. The waterlogged deposits have preserved organic materials and stratified activity areas, demonstrating over four millennia of human activity within a dynamic lakeshore environment.

The findings suggest that the site was used repeatedly in multiple phases between c. 6000 and 2000 cal BCE. The resulting stratigraphy reflects the complex interplay between human activity and environmental processes, lake transgression and regression, shoreline paludification and modern drainage disturbances. The deposits demonstrate successive phases of lakeshore development and utilisation, ranging from Late Mesolithic dryland and waterfront activities to Final Neolithic activity zones centred on the shallow shoal zone at the water's edge.

The artefactual evidence suggests that a wide variety of human activities were carried out. From the Late Mesolithic to the Late Neolithic (c. 6000–2500 cal BCE), these included fishing-related activities, food preparation, harvesting of hazels and water chestnuts, elk carcass processing, and waste disposal. During the Late/Final Neolithic (c. 2500–2000 cal BCE), activities comprised fishing, equipment maintenance, woodworking, plant processing, boating, tool use and discard, waste disposal, and possible artefact deposition. All this reflects an economy focused on the intensive and seasonal exploitation of local lake and woodland resources, which presumably influenced the location of hunter-gatherer occupation, mobility patterns, and the timing of various activities.

The wetland component of Järvensuo 1 can be best characterised as a 'multifunctional home shore', closely integrated with the nearby dryland activity and occupation areas. Subsistence strategies focused on freshwater fish, nutrient-rich plants, and terrestrial mammals. The waterlogged plant assemblage reflects natural lakeshore vegetation with evidence of human procurement. Together, these findings emphasise the significance of Lake Rautajärvi and its surroundings as a consistent and productive resource base for Mesolithic and Neolithic hunter-gatherers of the Häme region for multiple millennia.

More broadly, our study significantly expands the empirical and interpretative scope of wetland archaeology in the north – a field that has remained under-researched in boreal Fennoscandia. The Järvensuo 1 site demonstrates that lakeshore and wetland areas were central to hunter-gatherer life, constituting key locations for various domestic, economic, and symbolic activities, revealing their significant potential for archaeological and multidisciplinary research. Integrating wetlands with evidence from adjacent dryland contexts enables us to refine prevailing models of Mesolithic and Neolithic lifeways, emphasising the significance of systematically investigating shoreline and wetland areas to gain a fuller understanding of the past.

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