Jorma Karman

STONE AGE SETTLEMENTS ON THE TORNE RIVER; ENVIRONMENTAL ASPECTS

Abstract

In the region of the Torne River there has been almost a total lack of local knowledge about cultural development and chronology. Up to now a generalized discussion, mainly based on archaeological evidence from other areas near and far, has constituted the frame of inference for prehistoric remains.

The archaeological survey, test excavations and sampling have been carried out by the author on the lower and middle Torne River. Some results related to this work will be presented. They include radiocarbon dated coastal sites, mainly from 3500–4100 BP, pollen samples from mineral soils in dated archaeological contexts and faunal remains. Sorva, one of the few Late Mesolithic sites studied in northern Sweden so far, is introduced. The significance of the new information is explained.

Jorma Karman, Riksantikvariämbetet, P.O. Box 847, S-97126 Luleå, Sweden.

Introduction

The Stone Age sites discussed have to a great deal been recorded under the Second Ancient Monument Survey of Sweden. In this part of the country, i.e. the easternmost river valley of the province of Norrbotten, it actually was the first survey. During the years 1985–1986, 1990 and 1992 a 220 km long section of the Torne River catchment basin was completed. The northern and northwestern boundary of the survey area roughly coincide with the highest shore line limit, the northern boundary lying on the Muonio River basin.

In this area test excavations, selective survey of coastal sites with house depressions and sampling for radiocarbon dating and environmental analysis have been carried out by this author. The Stone Age dwelling sites have never previously been systematically studied and only some occasional, very limited salvage excavations have been done. Two of the main objectives are to establish a regional chronology and to obtain settlement patterns.

The palaeobotanical samples have been analyzed by J.-E. Wallin, Dept. of Ecological Botany, University of Umeå (Wallin 1990–1992). The osteological analysis was performed by M. Vretemark (Vretemark 1988–1992).

The sites

Two of the sites are described in some greater detail, Alanen Koijuvaara and Sorva. The data on the site locations are given in Table 1 (see also Fig. 1). The elevations are according to the Second Precise Levelling of Sweden (RH 70). The lower value of the column for elevation range is used for calculating the slope gradient. The lower values — with the exception of Sorva south — are very likely equivalent, or nearly so, to the shorelines at the time of the settlements (cf. below in *Coastal association*).

One of the sites, Saivaara upper, is not mentioned in the text, only in the tables. Its geographic location is 66°03'N, 23°34'E. The site has been briefly described by Klang (1989, 137–138). A map with the site area has been published by Baudou (1992, 22). The altitudinal data in Table 1

Table 1. The expositional, altitudinal and topographical data on the sample locations at the lower Torne River sites. In the column "Elevation range" the higher value is the embankment surface at the sample point with the exception of Annivaara, where the samples were collected from a cultural layer at the fossil soil surface (68.76 m) the higher value still representing the embankment of house 1. Sorva north expresses a river bank profile 9. Oct. 1990 at low water (85.32 m) a beach scarp at 86.02 m most likely reflecting a summer stage.

	Site	Measured distance (m)	Elevation range m.a.s.l.	Slope gradient (m)
1.	Ylinen Perävaara east; house 3 (0177-264)	110 (W-E)	47.90-42.90	0.9:20
2.	Ylinen Perävaara east; house 4 (0177-264)	110 (W-E)	47.90-42.90	0.9:20
3.	Al. Koijuvaara lower; house 1 (0177-166)	55 (W-E)	49.00-46.57	0.9:20
4.	Al. Koijuvaara upper; house 3 (0177-166)	135 (W-E)	51.68-47.66	0.6:20
5.	Keräsvaara north lower; house 1 (0177-241)	- (S-N)	Ca 55 Disturbed area	
6.	Keräsvaara north upper; house 1 (0177-241)	- (E-W)	Ca 60-50	3.0:20
7.	Saivaara upper; house 2 (0177-249)	150 (W-E)	61-57	0.5:20
8.	Annivaara; cultural layer (0169-110)	24 (NNW-SSE)	71.45-68.76	2.2:20
9.	Sorva south; house 1 (0199-268)	31 (ENE-WSW)	96.02-91.71	2.8:20
10	Sorva north; pit 1 (0199-268)	48 (WSW-ENE)	96.33-85.32	4.6:20

are according to Sturk (1992).

Alanen Koijuvaara

The site is situated on the southeasternmost part of the low relict mountain of Alanen Koijuvaara. The location is 5 km to the west of the Torne River and 18 km to the NNW of the municipality of Haparanda (65°59'N, 23°56'E). In the area there are wave-washed sandy and gravelly tills which are partly rich in boulders (Karman 1991). In the immediate vicinity there is a mire and boggy surroundings are altogether common as is often the case in the north Bothnian low relative relief area (Ericson & Wallentinus 1979; Rudberg 1971, 19).

The site consists of 20 house depressions which are arranged in three rows and a single depression. Two unchecked shallow depressions lie in the northern proximity. There is 25 m between the upper and the middle row and 45 m between the middle and the lower row. In the rows the houses are arranged with their long axis roughly parallel with the long axis of the nearest neighbour and the orientation of the beach berm or ridge.

On account of the vertical and even the horizontal arrangement of the houses there is every prospect of chronological zoning (cf. Baudou 1977, 29–31; Gräslund 1974, 38). In this respect the site is one of the most suitable ones so far discovered on the lower reaches of the Torne River, inclusive of the Sangis, Keräs and Kaakama rivulets. The site is, however, quite inaccessible, which has restricted the efforts.

The seven house depressions at Al. Koijuvaara upper lie quite strictly along Litorina beach berms at 52.60 m a.s.l. Only two of the houses in the middle of the row lie slightly lower at 52.20 m. Forty metres north of the row there is a single house depression. The row itself has a shape of a bow.

At Al. Koijuvaara the middle three house depressions have been identified at 50.50 m a.s.l. Close by along the same beach ridge there are three shallow depressions containing fire-cracked rocks and thus possibly implying temporary dwellings or insubstantial shelters.

At Al. Koijuvaara lower nine house depressions lie along the east-eastsoutheast facing beach berms. Seemingly there are three clusters of houses, each one composed of three houses arranged in a linear fashion. The northwesternmost house of

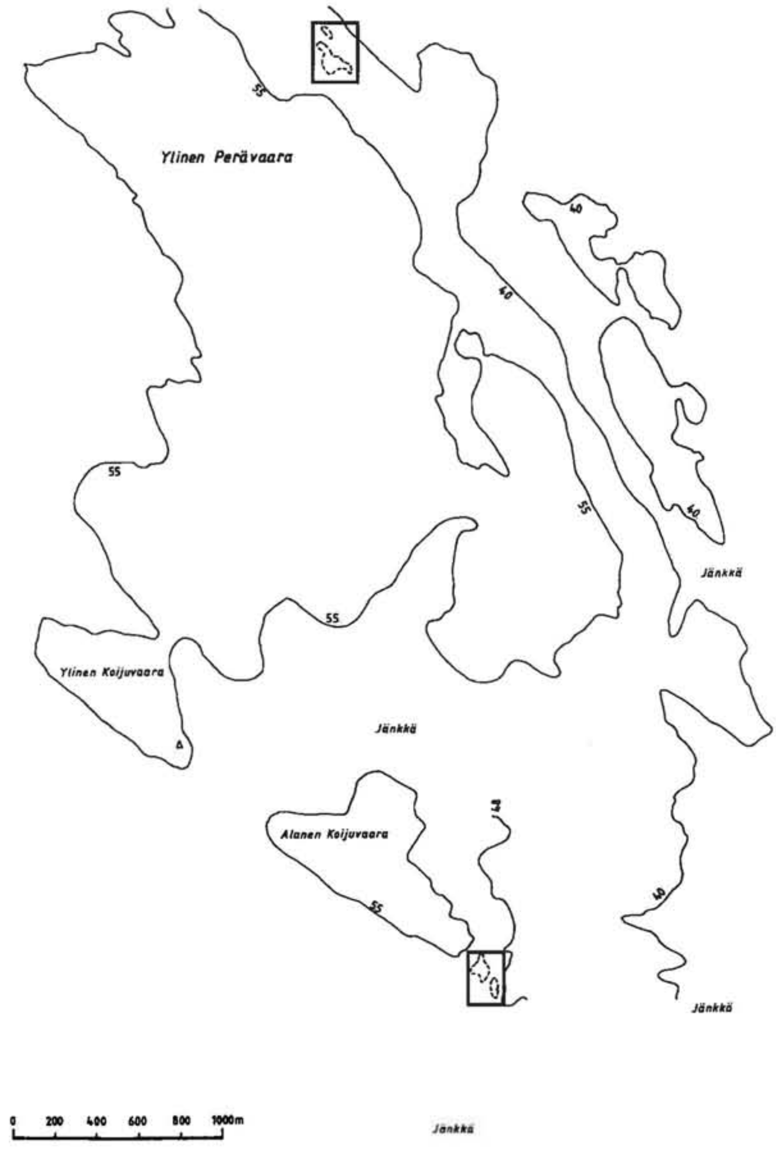

Fig. 1. General topography of the landscape in the vicinity of the Ylinen Perävaara east and Alanen Koijuvaara sites on the lower Torne River. Jänkkä = peat bog.

the middle group is overlapping the southernmost house of the northern group. The southernmost house of the southern group, house 1 (Fig. 2), lies at 48.80 m a.s.l. and the northernmost house of the northern group at 49.00 m.

The depressions are surrounded by embankments made up of large amounts of fire-cracked rocks (cf. Karman 1993a & 1993b, 387), burnt bones and other debris. Conclusively, these embankments are trash heaps. The space between the embankments of the different houses is none to a few metres, mostly none. On the Torne River basin and in northern Norrland a tent made of skins and on occasions of birch bark probably was the traditional type of dwelling throughout the Stone Age and the Bronze Age. Taking into account the

Table 2. The vertical distribution of burnt bones and the sample levels for pollen and radiocarbon dated charcoal in an 1 x 1 m excavation square (x61 y68) in the SSE embankment of house 1 at Sorva south (0199–268). The markedly decreasing pollen content from sample 1 to 3. (A list of abbreviations at the end of the article).

Level		Species	Weight (g)	%	M.a.s.l	Depth
Excavation levels with complete square extension						
	Soil surfice (A)				95.98-96.05	0
I	A°: 2-4 cm	Elk	10	1.9	95.94-A	8
	A²: 2-4.4 cm	Unidentified	48	9.0		
II	B: Brown-redbrown soil with dark brown shades	Elk	6	1.1	95.89-95.93	13
		Unidentified	95	17.8		
III		Elk	17	3.2	95.84-95.88	18
		Unidentified	200	37.5		
IV		Elk	15	2.8	95.79-95.83	23
		Unidentified	83	15.6		
V		Elk	6	1.1	95.74-95.78	28
		Unidentified	38	7.1		
VI	The date of this level: 5640±60 BP	Unidentified	15	2.8	95.70-95.73	32
			533	100		
Limited excavation in the SE for sampling						
	Sample 3				95.65-95.70	37
		Tiny piece of bone (1-2 mm)			95.64	38
	Sample 2				95.63-95.64	39
		Tiny charcoal particle (2 mm)			95.625	39.5
		Light ca. 2 mm thick horizontal stripes: Fossil soil surfice and C horizon			95.60-95.62	42
	Sample 1				95.57-95.60	45

Al	1.	12	10.2 %	2.	5	6.2 %	3.	2	4.5 %	Al
Be		22	18.6 %		9	11.2 %		4	9.1 %	Be
Pn		78	66.0 %		60	74.2 %		33	75.1 %	Pn
Poa		3	2.5 %		1	1.2 %		-	-	Poa
As		1	0.9 %		-	-		-	-	As
Cyp		1	0.9 %		-	-		-	-	Cyp
Art		1	0.9 %		-	-		-	-	Art
Er		-	-		1	1.2 %		-	-	Er
Cal		-	-		1	1.2 %		-	-	Cal
Fil		-	-		2	2.4 %		3	6.8 %	Fil
Ep		-	-		2	2.4 %		2	4.5 %	Ep
		118	100.0 %		81	100.0 %		44	100.0 %	
Lyc		42	26.0 %		49	37.7 %		146	76.8 %	Lyc
Pol		242	67.2 %		242	74.9 %		300	87.2 %	Pol

scope of the consideration, it should be stated that it is supported by the character of the cultural remains at the recorded sites which are several thousands. This kind of dwelling structure would also make it easier to understand the distribution of debris in the houses at the Torne River sites.

So far the site of Alanen Koijuvaara lower has revealed the largest amounts of burnt animal

Fig. 2. House 1 at Alanen Koijuvaara lower. 0 cm = 48.91 m above sea level. Hatched area is the enbankment surrounding the living floor of the dwelling.

bones on the lower Torne River. A total of 760 g (1876 fragments) were recovered from house 1. They originated from seal. One fragment of an unspecified bird was present. Only one seal species has been identified, the ringed seal, *Phoca hispida*. That is the situation at the other sites, too (sites 1, 2, 4, 5 and 7 in Table 1). At Ylinen Perävaara east (Fig. 3), in house 3, two fragments

Table 3. The pollen analyses of soil samples from the dwelling sites on the lower Torne River (a list of abbreviations at the end of the article). At Sorva north (locality 10) were also found eight pollen of Myrica (0.9%).

	1. Yl. Perävaara; House 3		2. Yl. Perävaara; House 4		3. Al. Koijuvaara lower; House 1		4. Al. Koijuvaara upper; House 3		
Al	20	5.3	12	3.5	26	3.6	65	9.3	Al
Be	14	3.7	13	3.8	151	21.1	134	19.2	Be
Pn	319	83.5	296	87.1	291	40.7	410	58.7	Pn
Pi	23	6.0	3	0.9	-	-	-	-	Pi
Ti	-	-	-	-	1	0.1	1	0.1	Ti
Poa	2	0.5	3	0.9	172	24.1	41	5.8	Poa
El	-	-	2	0.6	-	-	-	-	El
Cyp	-	-	2	0.6	29	4.1	9	1.3	Cyp
Art	-	-	-	-	2	0.3	-	-	Art
As	-	-	-	-	2	0.3	-	-	As
Fil	-	-	-	-	3	0.4	-	-	Fil
Sa	-	-	-	-	1	0.1	-	-	Sa
Ci	2	0.5	-	-	-	-	-	-	Ci
Ep	2	0.5	9	2.6	37	5.2	39	5.6	Ep
	382	100.0	341	100.0	715	100.0	699	100.0	
Lyc	27	6.6	16	4.7	8	1.1	3	0.2	Lyc
Pol	731	65.7	191	35.9	88	10.9	32	4.4	Pol
Sph	22	5.5	20	5.5	7	1.0	-	-	Sph

	6. Keräsvaara upper; House 1		7. Saivaara; House 2		8. Annivaara; Cult. layer		10. Sorva north; Pit 1		
Al	1	1.7	1	1.0	106	19.8	189	20.8	Al
Be	7	12.2	7	13.0	259	48.1	601	66.2	Be
Pn	39	67.2	77	77.0	142	26.5	100	11.0	Pn
Pi	3	5.2	-	-	-	-	-	-	Pi
Ti	-	-	-	-	2	0.4	-	-	Ti
Ul	-	-	-	-	-	-	1	0.1	Ul
Ju	-	-	1	1.0	-	-	-	-	Ju
Poa	6	10.3	3	3.0	4	0.8	3	0.3	Poa
Cal	-	-	-	-	1	0.2	-	-	Cal
Cyp	-	-	1	1.0	3	0.6	-	-	Cyp
Er	2	3.4	2	2.0	1	0.2	-	-	Er
Ru	-	-	-	-	-	-	2	0.2	Ru
Ran	-	-	-	-	-	-	1	0.1	Ran
Fil	-	-	-	-	-	-	3	0.3	Fil
Sa	-	-	-	-	2	0.4	-	-	Sa
Ep	-	-	2	2.0	16	3.0	1	0.1	Ep
	58	100.0	100	100.0	536	100.0	909	100.0	
Lyc	-	-	5	5.0	29	5.1	-	-	Lyc
Pol	-	-	18	15.0	157	22.6		[present]	Pol
Pte	1	1.7	-	-	1	0.2	-	-	Pte
Sph	-	-	2	2.0	71	11.7	-	-	Sph

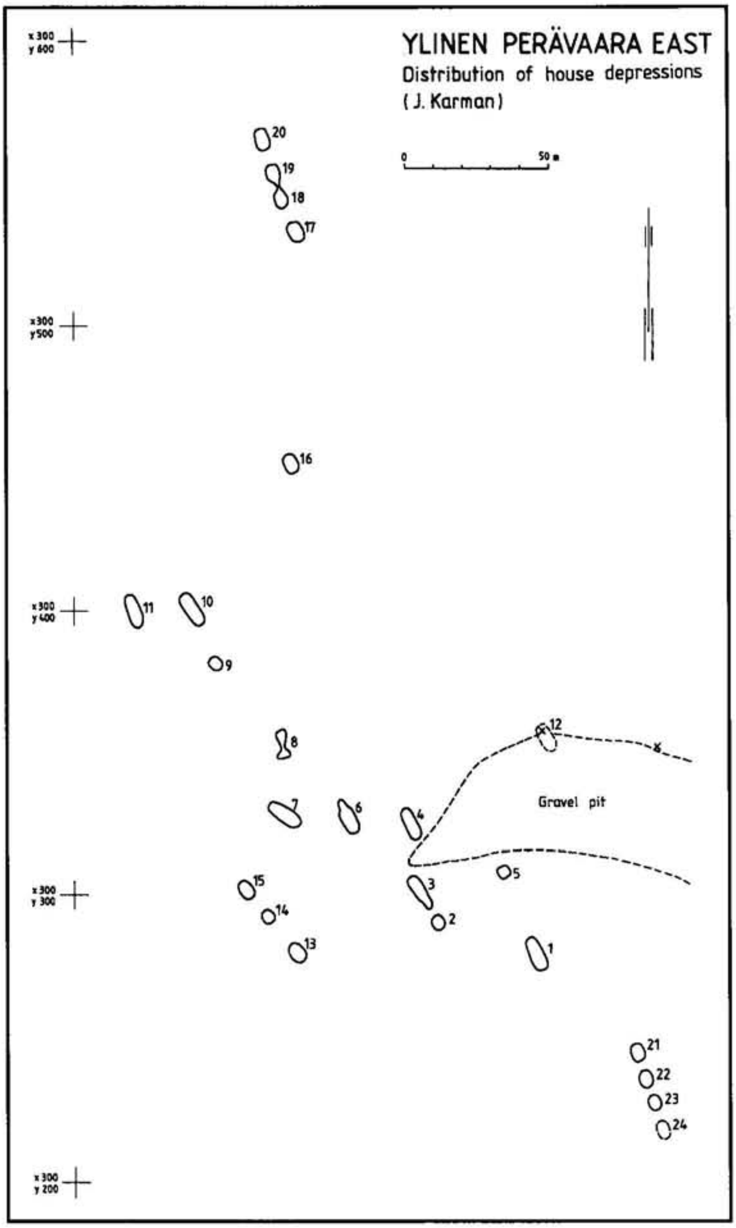

Fig. 3. Site map of Ylinen Perävaara east. The site is situated 2 km west of the Torne River. Map drawn by Annica Boklund.

from a 0–1 month old pup of ringed seal was recovered. Also two phalanxes of beaver were found in house 3. Likewise was found one fragment of beaver in house 4 at the same site (Vretemark 1988–1992).

Annivaara

The site is located on the northwest side of the relatively large mountain of Annivaara on the southward part of a low-level sand ridge (66°11'N,

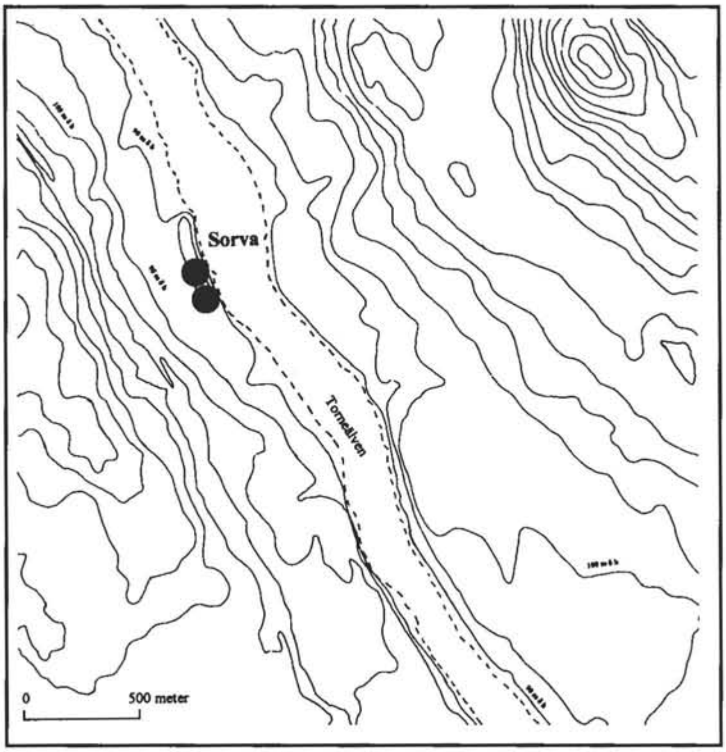

Fig. 4. Location of the Sorva sites in the Torne River Valley 140 km from the river mouth. Map drawn by Jeanette Joelsson.

23°43'E). In the prehistoric times about 5700–5600 calendar years ago the sandy deposits made up a WSW protruding promontory with a propitious position near the Torne River estuary.

At the site samples were taken from a fossil mineral soil surface under a 0.78 m thick peat layer at a forested mire fringe. The finds at the spot, i.e. in a narrow trial pit, were one fire-cracked rock and directly associated small pieces of charcoal in the sand. From this level, 68.76 m a.s.l, comes also the soil sample for the pollen analysis. The test pit is situated 24 m from house 1 and it is quite obvious that the debris is related to it or the very adjacent dwelling. Scattered quartz flakes and fire-cracked rocks are otherwise found in the site area.

Sorva

The site is located 140 km from the mouth of the river (66°53'N, 23°56'E; the distance according to Hjorth 1971). It is situated on a steep-sided, narrow ridge constituted of sandy river sediments. In the west between the ridge and a hillside there is a fossil river channel, peatland at present. In the east the ridge makes up the western bank of the river, the also steep eastern bank being composed of morainic deposits (Fig. 4).

According to visible structures the site dimensions are on the order of 240 by 50 metres. The structures, a total of approximately thirty, can be discerned as shallow depressions in the ridge surface which follows the 96 meter-level. They are mostly round or rounded and three-four metres across. The depressions are grouped in the northern and southern part, the divide being an area without visible structures. In the northern part two or three depressions can be connected with each other, in kind of double and triple structures.

The double phosphate analysis in the area without visible structures (citric acid and spot test: RAGU-report 910731) on samples from 0.57–0.61 m below the soil surface showed clearly enhanced values thus giving a proof of occupational activities even in this, seemingly empty area. No artefactual materials could be encountered in the scattered test squares but further testing is needed to get a definite answer. In the northern part a depression — pit 1 — is under excavation and in the southern part a house depression — house 1 — is partly excavated.

Table 4. ^{14}C dates. The site numbers refer to Table 1. The calibrated age probability distribution according to Stuiver & Reimer 1993, method B. The calibrated age ranges 1σ (S.D.) and 2σ (S.D.) are given. The determinations from the Stockholm laboratory have not been ^{13}C corrected through neither normalization -25‰ nor the program option (cf. Stuiver & Polach 1977, Table 1). The other dates have been normalized -25‰ by the laboratory.

Site	Lab.No	Age BP	Cal BP	Range 1 S.D.	Range 2 S.D.
1.	St-13391	3890±70	4350, 4330, 4290	4420-4180	4510-4090
2.	St-13191	3590±110	3870, 3850, 3840	4060-3690	4160-3570
3.	St-12848	3540±70	3830, 3790, 3780	3880-3690	3980-3640
3.	Ua-2169	3620±90	3960, 3950, 3890	4080-3730	4150-3640
4.	Ua-883	3910±105	4380, 4370, 4350, 4330, 4300	4500-4150	4590-3980
4.	Ua-882	4140±110	4780, 4760, 4630, 4600, 4590	4830-4450	4960-4300
5.	St-12850	4035±110	4510, 4470, 4440	4790-4300	4830-4180
7.	Ua-2885	4660±75	5450, 5420, 5330	5570-5300	5590-5070
8.	Ua-2058	4940±80	5660	5840-5590	5890-5490
9.	Ua-2884	5640±60	6410	6490-6320	6630-6300
9.	St-13212	4900±75	5650, 5640, 5620	5740-5580	5890-5460
10.	St-12847	6910±150	7670	7880-7570	7960-7470

There is a time connection with the Sorva north occupation and the Litorina limit. The beginning of the Litorina phase in the central part of the Gulf of Bothnia has been placed at 7000 BP (Miller & Robertsson 1979). The Litorina limit has not been determined within the actual area but it should lie between 90–95 m (Eronen 1974, 136–138; Fromm 1965, 202–204; Saarnisto 1981, 29). A close correspondence exists between the Sorva north date and the 6980±220 BP date for Clypeus limit at Vähä-Vuotunki in Ylikiiminki (Eronen 1974), which is the nearest dated point in the northern Baltic basin.

At Sorva a date on plant detritus — small shrubstems, tiny sprigs — from the bottom layer of the peat in the hillside channel has given an age of 4900±75 BP (St-13212) for the last discharge. It was probably an unusually high spring flood as the 1.5 cm thick sample horizon was separated from the continuous peat layer by a slight inflow of mud. The sample was taken at 89.51 m a.s.l. but in the northern part the channel bottom should lie somewhat higher between 90–91 m.

A partly peat-covered beach scarp can be discerned at the foot of the western slope of the ridge at 92 m a.s.l. At this stage the erosive development of the present river channel gradually began to prevail. The assumption is supported by the local topography. The date for the hillside channel indicates a slow erosion of the main channel. The erosion in both the channels had now, i.e. approximately 6900 BP, reached the morainic deposits which underlie the river sediments.

The channels had got solid bottoms that — possibly for the first time — created favourable conditions for weiring. It is supposed here that some of the depressions could be associated with this and perhaps also other kinds of fishing. The test excavation of pit 1 gave no debris. The only visible character was the pit itself with a soot and charcoal layer at the bottom. According to the analysis the layer also contains great amounts of fossil pollen (Wallin 1990–1992) indicating that the pit for some time remained open. As a comparison can be mentioned that practically no pollen, only spores, were found in the cultural layer inside house 1.

The above mentioned hypothesis is contradicted by the faunal evidence from house 1, where the absolutely dominating species was elk (*Alces alces*). A fragment of hare (*Lepus timidus*) was also present together with some unidentified fragments of small mammal bones, which are likely to be underrepresented. The osteological examination of the whole material including the unidentified fragments shows that there are no bones of seal, bird or fish. Furthermore, only 360 m from Sorva north on an old river terrace at the same elevation lies a smaller site with burnt bones of elk and fire-cracked rocks (Vretemark 1988–1992).

House 1 is the only identified dwelling structure. The partial excavation recovered only three tools, one inside and two outside the house. Two of them were quartz scrapers; one inside. The use of the third implement is unclear; as such it was only a small-sized, flat and rounded pebble. Two quartz flakes were found in the embankment surrounding the floor area. The majority of materials recovered consisted of fire-cracked rocks and burnt bones. These were concentrated in the embankment and a dump outside the dwelling. The greatest amount of fire-cracked rocks recovered from a one-by-one metre square was three litres. The same volume was measured in two of the squares in the dump area (cf. also Karman 1993a & 1993b, 384).

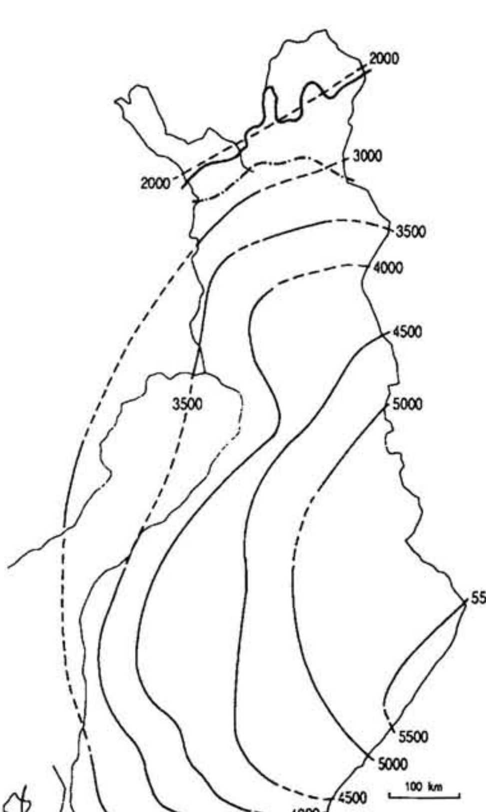

Fig. 5. The isochrones for the spread of Norway spruce *Picea abies* in Finland. The map is based on ^{14}C dated pollen diagrams. Years BP. The southern part of the study area on the Swedish side (sites 1–8 in Table 1) is crossed by the 3500-years isochrone. From Korhola 1990.

At present we have to accept that the settlement pattern of the Sorva population is largely unknown. The low artefact and waste density inside and outside house 1 strongly suggest that the stone tools were produced somewhere else. Thus the site can hardly have been a main residential site where one could expect a much greater variety of archaeological residues (Binford 1988; Bjerck 1989).

What was then the function of the site? The cultural materials from the dwelling indicate that it was only used for a limited period of time, perhaps a few years up to a couple of decades depending on the regularity/irregularity of the seasonal round. One gets the impression of an even accumulation of debris that after some time came to an end (Table 2). The dwelling might have belonged to a hunting group occupying a periodical camp and re-using the location for a special purpose which mainly seems to have been the exploitation of elk. At the time of Sorva north and some time onwards a major river crossing was apparently situated along the site; a favourable circumstance for both the animal and the hunters as regards their use of landscape.

This kind of subsistence strategy would better than the implied fishing activities explain the whole structure of the site. The many depressions could be interpreted as storage facilities for meat instead of fish. Of course, the two alternatives do not need to be mutually exclusive, but the seasonality problem can not get a final solution on the basis of the so far recovered archaeological material. At present only Sorva south with its dwelling structure can be regarded as a late autumn-winter occupation. For that speaks the house depression itself and the amount of fire-cracked rocks. In the winter also elk aggregate in river valleys, whereas in summer they live dispersed over a wider area. In northern Sweden summer areas about twenty times larger than winter areas have been recorded (Broadbent 1979; Forsberg 1985; Sandegren & Bergström 1982 have in detail discussed this subject).

A major problem is the large difference between the two dates from the site; house 1 5640±60 BP and pit 1 6910±150 BP (Table 4). Is there any possibility of error? Both dates come from well sealed contexts and as far as the older date is concerned there should be no such possibility.

House 1 has been affected by soil movements. The soil is composed of coarse silt-fine sand and of the so-called destroyed ferric podsol type (Troedsson 1973, 210–211). The bones and fire-cracked rocks were highly fragmentary and the charcoal, when found, was in tiny pieces. It is possible that some downward movement of both microscopic and macroscopic organic matter has occurred (cf. Hodgson 1978, 48–50; Protz 1982, 507; Rolfsen 1980). A section of the embankment (Table 2) indicates that the burnt bones are disintegrated in the A and the upper part of the B horizon due to more acid conditions and leaching as is shown by other studies (Broadbent 1979, 37; Matiskainen 1989, 42; Okkonen 1991). The question is: Can the loosening-up of the upper soil by roots, rhizomes and soil fauna have affected the cultural deposit and caused a deep, downward translocation? There are no certain signs of that actually. There are very few earthworms in the raw humus and they stay in the topmost layer. For example, pollen grains do not generally sink below the loose förna layer at the top (Fægri et al 1989, 148).

To what an extent the soil processes have affected the distribution of charcoal in the cultural layer is not easy to assess, but it is obvious that at least one or two new determinations are needed to assure an adequate basis for dating house 1. Despite of that there is a good chance for the date to be highly reliable. The pollen analyses reveal different environmental contexts at Sorva north and south thus supporting the ^{14}C dates and verifying a time lag between the occupations (Tables 2 and 3; see further *Coastal association* below).

As have been seen, the lithic waste indicating tool production is missing at Sorva south. The quartz flakes may represent the reparation of damaged scrapers or other tools not recovered. Large amounts of elk bones have been found. In conclusion, Sorva south seems to have been a hunting camp utilized during the late autumn - early winter migration of elk or later in the winter when the hunting of aggregated elk and the snaring of small game were preferable.

Aspects on the environment of the coastal sites

Sampling the pollen

The principal inspiration to the sampling comes from Anderson & Bank (1952) who studied soil profiles in the Aleutians. As stated by Anderson & Bank, "the investigations should provide data of correlative value for geology, biology and anthropology... By correlation of samples from the archaeological sites and by radiocarbon dating, a picture should be obtainable of climatic and living conditions prevailing by the time of the ancient... settlements". One of the sources on north Swedish soils is the great dissertation of Olof Tamm (1920).

As a part of the ongoing research, the aim of the pollen sampling is to study the effects of palaeoenvironmental changes on the subsistence strategy. The analyses have a chronological significance as regards specific arboreal pollen identified in the samples. The distance of the settlements from the littoral can be estimated through the presence and/or the frequency of species indicating different vegetational gradients (e.g. Ericson & Wallentinus 1979). Through more thorough sampling procedures, i.e. several samples in each house, results with high confidence for establishing the ancient shoreline and other environmental parameters of the sites can be obtained.

In the present study the analysed soil samples taken at different sites come in most cases from the same stratigraphic context as is here presented for Sorva south (Table 2, sample 1). So do also the dates on charcoal and with those directly connected, osteologically determined faunal remains. The fossil soils underlaid the cultural materials in the embankments of the houses. According to the appearance of the old soil surface the sampling level coincided with the upper part of the fossil A_2 horizon, in most cases faint and poorly developed, and with that integrated pollen from the decayed humus. Apparently this kind of study of terrestric, dry-land deposits has fairly good prospects as the pollen from the trees of the canopy hardly travels more than 50 m inside a forest, and that of herbs and grass, especially entomophilous species, even less (cf. Fægri et al 1989, 148).

Climatic change

The outlines for climatic change in the area of the Gulf of Bothnia from 1 cal BC to approximately 10 000 cal BC have been briefly described (Karman 1993a; 1993b).

The volcanic aerosols are a major cause for the short-term climatic variations so far identified. The cooling effect of an aerosol veil can last up to ten years. For example, the year without summer — AD 1816 — is believed to be a result of the eruption of Tambora in 1815, an Indonesian volcano. Actual in this context and more debated is the famous eruption of Thera (Table 5; Baillie & Munro 1988; Hammer et al 1987; LaMarche &

Table 5. A comparison (in conventional radiocarbon years) with the Mediterranean eruptions of Thera and Avellino and so far obtained, possibly connected dates from the houses at the Torne River sites. These are contrasted with tree-ring and ice-core dates on the eruption of Thera and another, slightly earlier, violent eruption of an unknown volcano (the different dates outside Sweden according to Baillie & Munro 1988; Hammer et al 1987; Johnsen et al 1992; LaMarche & Hirschboek 1984; Manning 1992).

Lower Torne River.		**Thera.**	
Determinations on long-lived samples; charcoal, in some cases several hundred years old. Ages BP.		The destruction level at Akrotiri. Determinations on short lived samples. Weighted means from each laboratory. Ages BP.	
1. Yl. Perävaara east;		Copenhagen:	3356±32
house 3	3890±70	Heidelberg:	3321±40
2. Yl. Perävaara east;		Oxford:	3338±17
house 4	3590±110	Simon Fraser:	3380±17
3. Al. Koijuvaara lower;	3540±70	Zürich:	3445±37
house 1	3620±90	Pennsylvania:	3317±20
		Avellino.	
		Dates on samples relevant to the eruption. Ages BP.	
		3430±50	3270±160
		3340±160	3130±210
		3300±80	3040±210
4. Al. Koijuvaara upper;			
house 3	4140±110		
house 2	3910±105		
5. Keräsvaara north 1:er;			
house 1	4035±110		

Corresponding dates for eruptions/frost events in calendar years BP (BC):

Irish oak-tree-rings	North American tree-rings	Summit ice core acidity peaks
Thera 3578 (1628)	Thera 3578 (1628)	Thera 3595±7 (1645)
-	Unknown volcano 3985 (2035) (St. Helens?)	Unknown volcano 4000±10 (2050) (St. Helens?)

Hirschboeck 1984; Nesje & Johannesen 1992). Also the variations in solar radiation caused by the changes in Earth's orbital parameters had a great effect on the global climate between ca. 4500 and 4000 BP. During the Early Holocene the effect of enhanced summer insulation to the Northern Hemisphere reduced the climatic impact of volcanic eruptions (Nesje & Johannesen 1992; Woodward 1987, 53–56). A widespread change in climate about 4000 years ago is also evidenced by the rapid retreat of Scots pine in northern Scotland (Gear & Huntley 1991) and the disappearance of pine at high altitudes in the upper Muonio River basin. In the latter case the youngest dates on subfossil pines beyond the present tree limit at 505 m altitude are 3740±100 and 3760±110 BP (Eronen & Huttunen 1987).

Perhaps the most remarkable result of the pollen analyses is the identification of Tilia at both Alanen Koijuvaara upper and lower and the absence of Picea. Reversely, Picea is present at Ylinen Perävaara east (66°02'N, 23°56'E) while Tilia is missing (Table 3). It is true that the identified pollen grains of Tilia are extremely few, but there is a clear possibility that the regenerative plants were not very far away (cf. Erdtman 1943, 50–52; Fægri et al 1989, 126). The dwelling sites are situated at a distance of 4.2 kilometres from each other. The height above sea level of houses 3 and 4 at Ylinen Perävaara east is lower than the elevations of the houses at the Alanen Koijuvaara sites (Table 1). The altitudinal differences together with the pollen-analytic data strongly indicate diachronic occupations, which however is not so clear on the basis of the ^{14}C dates alone (Table 4). The occurrence of Picea pollen at Keräsvaara north upper (Tables 1 and 3; site 6: geographic location 66°02'N, 23°40'E) might indicate a scattered, pioneer stand which in that case would be about 4000 calendar years old, but probably not much older than that.

Earlier studies have shown that the spruce arrived to the actual area around 3500 BP (Hjelmroos 1979, 12, 41; Reynaud & Hjelmroos 1981, 54, 64; Saarnisto 1981, 24; Tikkanen 1978, 66–67), see Fig. 5. During the hypsithermal Picea was held back in the easternmost Fennoscandia by a biotope that did not favour the tree (Korhola 1990, 271–273, cf. also Fægri et al. 1989, 131). It has been inferred that "its range expansion relates to episodes of cool (summers), humid and snowy climate with little seasonal ground frost rather than migrational lag". The expansion was hardly a straightforward response to the general Late Holocene climatic cooling (Kullman 1990, 106; Kullman & Engelmark 1990, 330). Also, as stated by Fægri et al. (1989, 128): "The general rule is that a taxon or a plant community is more indicative the nearer one is to the limit of its area of occurrence."

Recent research indicates that vegetation changes in response to climatic variations sometimes may be so rapid that they are out of reach of the palaeoecological methods (Kullman 1990, 113). The reaction of vegetation to a negative ecological change may be almost instantaneous, especially in regard to flowering (Fægri et al. 1989, 166–168). In the case of Tilia, pollen tube extension fails to occur when the temperature falls to or below 15°C and its regeneration can also be prohibited due to incomplete embryo and endosperm development caused by the rapid fall in the late summer temperature (Woodward 1987, 139–141).

Coastal association

With regard to the regional catchment system the coastal distribution of the settlements is — with one exception — evidenced by the pollen record. In the following some aspects of the coastal vegetation at the time of the settlements are considered. The purpose of the reasoning is to exemplify the application of the method in environmental analysis.

The exception mentioned is Sorva south (Table 2). The presence of shore-vegetation indicators Alnus and Betula is in that case easily understood through the river channel connection of the camp. The nearest Alnus and Betula might have been growing in the deciduous fringe along the channel only some 30 m away (cf. measurements in Table 1), which is supported by the occurrence of Filipendula.

Salix pollen has been identified in only two soil samples of eleven, the one from Alanen Koijuvaara lower and the other one from Annivaara with one and two grains respectively. Salix species produce great quantities of pollen, the dispersal of which, however, is not as good as that of anemogamous pollen. The resistance of exines is good (Fægri et al. 1989, 118; J.-E. Wallin, personal communication). According to Wallin (1990–1992) indicate Poaceae, Epilobium, Asteraceae and Artemisia at Al. Koijuvaara lower an open landscape.

In both cases it is possible to argue that the camps were situated near shallow shores or, as regards Annivaara, in a sheltered shallow bay. Further, it is likely that the sample points, at Al. Koijuvaara lower house 1, lied above the highest shore drift, 1–2 m above the annual mean water-level. In the present times along the shores of the Bothnian Bay *Alnus incana* forms extensive stands in the upper geolittoral and lower epilittoral, i. e. in the upper area situated above the annual mean water-level and the area above the extreme high water-level. The *Alnus incana* border is with increasing shelter gradually replaced by *Salix phylicifolia* thickets. In the middle part of the archipelagos, on the low-level, wave-washed morainic shores exposed to storms, only scattered bushes of *S. phylicifolia* together with sparse *A. incana* may occur. Landwards in the epilittoral above Alnus a Betula border succeeds. Betula spp. colonize the uppermost geolittoral below the highest shore drift but reach their climax higher up (Erdtman 1943, 39; Ericson 1972, 229–236; Ericson & Wallentinus 1979, 30, 45, 49–50, 54, 98–99, 127, fig. 18, also 137, fig. 38: damages).

The really low Sphagnum and Lycopodium content and the absence of Ericales together with the other palynological evidence at Alanen Koijuvaara lower show that the terrestrial conditions for boreal forest were not yet established. For example, the Alnus pollen frequencies between 9–21 % at other sites — Al. Koijuvaara upper, Annivaara and Sorva north — should also reflect the vicinity of Alnus fringe in the littoral. In the case of Sorva north an estuarine situation is the explanation for the high frequencies of both Alnus and Betula, which is supported by the occurrence of Myrica (for further details about all sites cf. tables).

Marine hunting

In this paper it is suggested that the past climatic variation has influenced the resource base of the Bothnian hunters causing shifts in the settlement pattern and accentuating marine hunting during several periods, of which an especially noticeable one occurred in the Torne River area during c. 3500–4100 calendar years BP (Table 1, 4 and 5). The postulate is put forward on the score of more than 140 house depressions recorded on the lower Swedish Torne River at fair elevations (J. Karman, unpublished survey results).

The great majority of the sites are seemingly seasonal, re-occupated camps with distinct linear clusters of dwellings. The seasonality of these cold-weather, obviously winter/early spring base camps have been estimated from burnt bones. Ringed seal *Phoca hispida* is the absolutely dominating species. It is possible that the extractive activities have been influenced by climatic conditions. In a wider context along both the Swedish and Finnish shores of the northern Baltic, in the interior of northern Sweden (e.g. Baudou 1977, 96–97; Ekman & Iregren 1984, 58, 77–78; Lundberg 1986) and northern Norway (e.g. Helskog 1984, 42–47) a large number of prehistoric settlements may be related to climatic changes.

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Abbreviations:

Al	Alnus	Lyc	Lycopodium
Art	Artemisia	Pi	Picea
As	Asteraceae	Pn	Pinus
Be	Betula	Poa	Poaceae
Ca	Calluna	Pol	Polypodiaceae
Ci	Cichoriaceae	Pte	Pteridium
Cyp	Cyperaceae	Ran	Ranunculaceae
El	Elymus	Ru	Rumex
Ep	Epilobium	Sa	Salix
Er	Ericaceae	Sph	Sphagnum
Fil	Filipendula	Ti	Tilia
Ju	Juniperus	Ul	Ulmus

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