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PREHISTORIC CULTIVATION AND PLANT GATHERING IN FINLAND

AN ARCHAEOBOTANICAL STUDY

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ACADEMIC DISSERTATION

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ABSTRACT

Better knowledge of cultivation and plant gathering enables a deeper understanding of prehistoric societies. People-plant interactions have resulted in the creation of human ecological niches and, over time, people began to increasingly gain their subsistence from productive economies. However, in Finland prehistoric cultivation and plant gathering remain poorly understood. What plants were gathered during the prehistoric period, and how would they have been used? When do the first signs of cultivation occur, and where did it originate from? How did cultivation develop after its introduction?

This study reviews and expands on archaeobotanical data on cultivation and plant gathering in Finland. The aim is to provide a long-term perspective of plant-people interactions in the area. Such knowledge is valuable for scholars studying prehistoric societies, plant use and agricultural history.

The primary method employed in this study is the archaeobotanical analysis of plant macrofossils. This method enables species-level identifications of plant remains found at archaeological sites. In this study, such plant remains were retrieved from flotation samples gathered at archaeological sites in Finland and Sweden. Altogether, approximately 800 samples were studied. In addition, several remains of plants were directly accelerator mass spectrometry (AMS) radiocarbon dated, thus enabling an absolute chronology for these particular remains. Secondary methods employed in the study include the anthracological analysis of wood charcoal, ethnography and geochemistry.

A review of charred and waterlogged plant remains from the Stone Age in Finland show that numerous wild plants were collected. During the Holocene thermal maximum, hazel and water chestnut grew further north than today. Wild plants were used throughout Finland during the Stone Age, although the number of taxa diminished northwards. Use of starch-rich plants, such as water-lilies, appears to have decreased after the onset of agriculture.

The earliest macrofossil remains of cultivated plants in Finland, naked barley and naked wheat, were found at Pitted Ware Culture sites on the Åland Islands. Radiocarbon dates show that these remains date from the years 3300–2500 cal BC.

Cultivated plants occur for the first time in mainland Finland during the second millennium BC. Radiocarbon-dated plant remains indicate continuous cultivation of barley on mainland Finland since approximately 1500 cal BC. The early development of plant cultivation is, however, poorly understood.

Larger assemblages of plant remains have been discovered during the first millennium AD. At Isokylä, in southern Finland, such assemblages show that barley was the main crop cultivated during the Iron Age, cal AD 200–550. Both hulled and naked barley were cultivated together with other crops. Here,

the earliest find of hemp in Finland was discovered and directly dated to cal AD 258–425.

The Late Iron Age can be considered as a period of agricultural expansion. The site of Orijärvi shows that permanent field cultivation, with hulled barley as the main crop, was conducted from approximately cal AD 600 onwards.

The results of this study have implications especially for studies of prehistoric societies, which can be better understood with a deeper knowledge of their plant use. Plants not only provided nutrients, medicine, fuel and construction materials, but people could even construct their niches by removing or preserving certain plants in their surroundings. The active role of humans should be considered when studying past environmental changes, for example via pollen analytical studies.

Cereal grains found at Pitted Ware Culture sites on Åland forces us to consider whether these hunter-gatherers could have conducted small-scale cultivation, possibly even reaching mainland Finland. Cultivation most probably originated from east-central Sweden, where it was first introduced by the Funnel Beaker Culture approximately 4000 cal BC.

Later, continuous cultivation throughout the Bronze Age must have had social consequences, and the appearance of numerous cairns might well be associated with an increasing reliance on agriculture. The Iron Age find of hemp at Isokylä might indicate contacts with areas farther south.

Remains of ancient fields and the archaeobotanical material at Orijärvi and other similar sites show that field cultivation was conducted in Finland at the latest since the Late Iron Age. These finds call into question whether we can consider slash-and-burn cultivation as the earliest cultivation method in Finland.

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LIST OF ORIGINAL PUBLICATIONS

This thesis includes the following publications:

I Vanhanen, S., & Pesonen, P. 2016. Wild plant gathering in Stone Age Finland. *Quaternary International* 404: p.43–55.

Authors' contributions: Santeri Vanhanen collected and studied archaeobotanical material for the study and surveyed ethnographical literature. Petro Pesonen collected dates from archaeological sites and collected archaeobotanical materials. Both designed the study and wrote the paper.

II Vanhanen, S. et al. 2019. Maritime Hunter-Gatherers Adopt Cultivation at the Farming Extreme of Northern Europe 5000 Years Ago. *Scientific Reports* 9(1): p.4756.

Authors' contributions: Santeri Vanhanen, Stefan Gustafsson and Håkan Ranheden studied archaeobotanical materials. Niklas Björck provided material from Tråsättra and wrote parts of the paper. Marianna Kemell provided SEM images of plant casts. Santeri Vanhanen and Volker Heyd wrote the paper.

III Vanhanen, S., & Koivisto, S. 2015. Pre-Roman Iron Age settlement continuity and cereal cultivation in coastal Finland as shown by multiproxy evidence at Bäljars 2 site in SW Finland. *Journal of Archaeological Science: Reports* 1: p.38–52.

Authors' contributions: Santeri Vanhanen analysed soil samples for the study. Satu Koivisto excavated the site and surveyed archaeological material from earlier excavations. Both designed the study and wrote the paper.

IV Vanhanen, S. Accepted. Roman Iron Age and Migration Period plant cultivation in Salo Isokylä, SW Finland. In S. Vanhanen & P. Lagerås (eds) *Archaeobotanical Studies of Past Plant Cultivation in Northern Europe*, Barkhuis.

V Vanhanen, S. 2012. Archaeobotanical study of a Late Iron Age agricultural complex at Orijärvi, Eastern Finland. *Fennoscandia archaeologica* XXIX: p.55–72.

The publications are referred to in the text by their roman numerals.

ABBREVIATIONS

cf.	Confer (compare): uncertain identification
cal.	Calibrated
AD	Anno Domini, after birth of Christ
BC	Before Christ
sp.	Species
ssp.	Subspecies
s.l.	Sensu lato (in the broad sense)
var.	Variety

1 INTRODUCTION

This thesis aims to study the development of cultivation and plant gathering in prehistoric Finland. Both of these subjects are poorly understood.

Our knowledge of plant gathering is limited, and the available data are scattered in various published and unpublished sources. Therefore, the current archaeobotanical data regarding wild plants need to be reviewed and combined with new analyses. *The first aim is thus to better understand wild plant gathering during the prehistoric period in Finland.*

Interpretation of palynological results has led to disagreement on the date when plant cultivation began in Finland, whereas interpretation of macrofossil plant remains can be considered more straightforward, but this dataset has been limited and scattered throughout different sources. It remains poorly known what crops were cultivated during different time periods and what arable weeds were associated with these crops. Therefore, previous and new archaeobotanical analyses of prehistoric crops need to be reviewed. *The second aim is thus to better understand the onset and development of plant cultivation in prehistoric Finland.*

The aims of studying prehistoric plant gathering and cultivation will be achieved by investigating archaeobotanical plant remains collected from archaeological sites in Finland and the Åland Islands. These studies are combined with material gathered from east-central Sweden. Plant remains are dated using the accelerator mass spectrometry (AMS) radiocarbon method. Plant cultivation and gathering will be further analysed by studying ethnographical records, geochemistry and anthracology.

Archaeobotanical data have not been fully exploited in discussions regarding economic, subsistence and societal development in prehistoric Finland. The study of plant use is important because cultivation and other forms of plant use profoundly affect societies. Studying wild plant use enables us to better understand how people adapted to their environment. People were able to create their niches by removing or preserving different plant species. With the onset of crop cultivation, plant-people interaction became even more profound when the success of both plants and people became interdependent. Reliance on domestic crop cultivation could create surpluses, enabling the growth of stratified societies. *Ultimately the thesis seeks to understand long-term changes in plant-people interactions.*

This compilation concentrates on the long-term development of plant gathering and cultivation. Detailed studies on plant use and societal influences of cultivation practices are provided in the papers presented in this thesis.

2 LITERATURE REVIEW

2.1 ARCHAEOBOTANICAL STUDIES OF WILD PLANT GATHERING

The first people to settle in the area of Finland did so during the Stone Age, between 8900 and 8700 cal BC. They were hunter-gatherers. Finds of burned bones from archaeological excavations provide knowledge about what animals these Stone Age people hunted (Ukkonen 2001; Mannermaa 2008). However, not much is known about what plants they gathered.

A review of Stone Age subsistence in Finland shows that plant food only received minor attention in earlier works and was not considered in economic models (Nunez 1991, 24–26). Lately, a survey of the Stone Age in Finland proposed that scholars can only make rough assumptions about the status of plant gathering in prehistoric economies because actual evidence is rarely available (Halinen 2015, 30). Plant gathering has thus assumed a subsidiary role in the general narrative of the Stone Age in Finland. This is unjustified, as several studies have shown that remains of wild gathered plants can be found at archaeological sites and can contribute to studies of prehistoric societies (Colledge et al. 2014; Antolín et al. 2014).

Earlier, only hazelnut shells or other large plant remains were retrieved at archaeological excavations (Luoto 1991). Hazelnuts were indeed one of the most important plant foods in northern Europe during the Stone Age, but hazel was far from the only species used by hunter-gatherers. Fortunately, the development of the flotation method and use of sieves with small mesh sizes has made it possible to retrieve small plant remains (Nesbitt 2006). The flotation method has been used in Finland to study plant remains at several Stone Age sites (Jussila 1994; Lempiäinen 2010; Aalto et al. 1981; Jussila 1992; Vuorela et al. 1982; Aalto 1983; Aalto et al. 1985; Jussila 1996). These studies have revealed the use of various wild plants, with water chestnut being particularly emphasised (Jussila 1994; Vuorela et al. 1982). Several other wild plants have also been identified and their possible uses have been discussed by various scholars.

However, most Stone Age archaeobotanical studies have not been published. These studies have neither been compiled nor discussed in a larger framework. This makes it difficult to take these studies into account in economical or other models applied to the study of prehistoric people.

2.2 IDENTIFICATION OF WILD PLANT GATHERING

Remains of wild plants in archaeobotanical assemblages can be interpreted according to their ecological requirements or according to their potential use

as gathered plants. Ecological interpretation aims to reconstruct past environments using modern analogies. In this study, the focus lies on plant gathering. Plants can be gathered for food, medicine, fuel, building materials and other purposes. Finding evidence of wild plant gathering in archaeobotanical assemblages is complicated because we lack commonly accepted criteria for their interpretation (Berihuete-Azorín 2016) and because plants in archaeological deposits have complex taphonomical histories (van der Veen 2007; Jacomet 2013; Colledge et al. 2014). The interpretation of a plant's use is commonly based on ethnographic or historical analogies, experimental archaeology and archaeological observations.

Ethnographical sources are important for interpreting the economic use of wild plants (Berihuete-Azorín 2016). It is assumed that the use of a plant has either continued in a region or is similar throughout different regions. Ethnographical analogies can be considered stronger if both the archaeological and ethnographical sources are from the same area where plant use could have continued, and flora remained similar. Historical changes in the vegetation caused by climate change and for other reasons should, however, be considered. For example, ethnographic information regarding use of the water chestnut is not available in Finland because the plant became extinct before its use could be recorded.

Wild plants found in archaeobotanical assemblages can be interpreted in various ways. This is shown by a selection of taxa interpreted as gathered plants in Finnish Stone Age assemblages, presented in Table 1. These assemblages consist of both waterlogged and charred plant remains, and the table contains only taxa interpreted as gathered plants by the authors. In each case, water chestnut is interpreted as an edible or useful plant. However, when the publications are compared, many differences arise. Some plants occur in different categories, such as knotgrass (*Polygonum aviculare*), which is considered as an edible or useful plant (Aalto 1983) or as a plant introduced by humans (Vuorela et al. 1982). Macrofossil remains of trees are interpreted as useful plants (Lempiäinen 2010) or simply as trees (Aalto et al. 1981; Aalto et al. 1985; Vuorela et al. 1982). Both plant gathering for human use and ecological requirements are thus considered simultaneously. For example, the plant taxa at Järvensuo, in southwestern Finland, is categorised as follows : useful plants, aquatic plants, littoral plants and trees and shrubs (Aalto et al. 1985). The category 'useful plants' indicates that these plants were gathered, whereas the rest are categories based on ecological requirements.

Table 1. *Interpretation of wild gathered plants in Finnish Stone Age assemblages (data from Pennala* (Vuorela et al. 1982)*, Järvensuo* (Aalto 1983; Aalto et al. 1985)*, Pörrinmökki* (Jussila 1994; Jussila 1996)*, ten Stone Age sites in Päijät-Häme* (Lempiäinen 2010)*, and Naarajärvi and Tahinniemi* (Jussila 1992)*; f=probably fragmented by humans)*

Pennala	Järvensuo	Pörrinmökki	Päijät-Häme	Naarajärvi and Tahinniemi
Waterlogged	Waterlogged, Charred	Charred	Waterlogged	Charred
Gathered 1 of 25	Gathered 12 of 46	Gathered 15 of 21	Gathered 21 of 51	Gathered 3 of 18
Used by people	**Edible or useful plants**	**Food**	**Food**	**Food**
Trapa natans, f	Aegopodium podagraria	Equisetum sp.	Trapa natans	Fragaria vesca
	Corylus avellana, f	Nuphar lutea		Rubus idaeus
	Empetrum nigrum	Poaceae	**Useful plants**	Vicia sp.
	Fallopia convolvulus	Trapa natans	Acer platanoides	
	Fragaria vesca, f	Vaccinium myrtillus	Alnus incana/sp.	
	Juniperus communis	Vaccinium vitis-idaea	Betula pendula	
	Persicaria lapathifolia	Vicia sp	Picea abies	
	Polygonum aviculare	Rubus idaeus	Pinus sylvestris	
	Rubus idaeus, f			
	Trapa natans, f	**Medicine**	**Useful or medicinal plants**	
		Stellaria graminea	Alchemilla sp.	
	Fibre plants		Cicuta virosa	
	Tilia cordata	**Useful plants**	Comarum palustre	
	Urtica dioica	Arctostaphylos uva-ursi	Corylus avellana	
		Fragaria vesca	Empetrum nigrum	
		Galium odoratum	Fragaria vesca	
		Juniperus communis	Nuphar lutea	
		Prunus padus	Nymphaea alba	
		Schoenoplectus lacustris	Phragmites australis	
			Rubus idaeus	
			Schoenoplectus tabarnaemontani	
			Spergula arvensis	
			Trifolium repens	
			Urtica dioica	
			Vaccinium oxycoccus	

Several approaches have been proposed for identifying wild gathered plants in archaeobotanical assemblages. Colledge and Conolly (2014, 199) suggest using the edibility ratings 3–5 from the *Plants For A Future* database

(http://www.pfaf.org) to identify edible taxa in waterlogged samples. This method is valuable for identifying food plants, but it excludes gathered plants that were not used as food. Dietch (1996, 89) suggests four criteria for identifying taxa used by people: the presence of carbonised seeds, the presence of seeds in archaeological features, the quantity of seeds per taxon and the relative quantity compared to other species as well as the spatial distribution of the seeds. Regnell (2011, 10) proposes three criteria for identifying wild plants utilised by humans: taxa present in very large quantities, taxa present in exotic habitats and taxa showing obvious signs of human processing.

While the identification of plant gathering and ecological interpretation of the plant remains are both important, they must be carried out separately. Assemblages of waterlogged plant remains are numerous and rich in taxa, but in such assemblages it can be difficult to distinguish between gathered plants and local flora. Charred remains represent only a fraction of the taxa most likely used in the past, and the low quantity of remains hampers their interpretation. It is, however, possible that the majority or all charred plant remains found in archaeological contexts were gathered by people. Ethnographical materials, archaeological observations and archaeobotanical material itself contribute to the identification of wild plant gathering in archaeological contexts.

2.3 ARCHAEOBOTANICAL STUDIES OF PREHISTORIC CULTIVATION

It is commonly accepted that plant cultivation practices reached the area of Finland during the prehistoric period. However, different dates for its onset have been proposed. Alenius et al. (2013, 17) suggest a date of approximately 5300 cal BC and Lahtinen and Rowley-Conwy approximately 500 cal BC (2013, 678). The dates thus differ nearly by 5000 years! This arises from different criteria used to interpret the pollen records discussed in detail in these and other Finnish and international papers (Mökkönen 2010; Mökkönen 2012; Alenius, Mökkönen, et al. 2017; Mökkönen 2011; Luoto 2012; Simola 2011; Behre 2007).

The assessment of macrofossil plant remains provides an independent method for studying the onset of cultivation. Such a method will be presented in this thesis and can be compared with the results obtained from other methods. The study of macrofossil plant remains from archaeological sites, also known as archaeobotany or palaeoethnobotany, can be considered to have started in Finland in 1975, when Karl-Ernst Behre held a course on it in Oulu (Lempiäinen 2006, 32). In the same year, the flotation method was successfully tested at archaeobotanical excavations (Núñez et al. 1976). The archaeobotanical dataset has thus accumulated in Finland for around 40 years. Before this, only occasional remains of cultivated plants were collected at excavations (Kivikoski 1946, 61; Sarkamo 1970, 42). Regardless of the

important contribution of archaeobotanical studies, many basic questions still remain unanswered. The earliest plant cultivation practices are poorly known because only small amounts of cultivated plants have been found at Stone Age and Bronze Age sites. Even later developments are difficult to follow because data are scattered in various publications and reports.

The spread of agricultural practices into Europe from southwest Asia can be considered rather well known (Shennan 2018; Zohary et al. 2012; Colledge et al. 2005). Agriculture reached the central European loess plain in approximately 5500 cal BC with the Linearbandkeramik Culture (Bogaard 2004). Then, after more than a thousand years, Funnel Beaker groups took with them cultivation practices and animal husbandry into southern Scandinavia and up north into the Mälaren Valley in approximately 4000 cal BC (Sørensen et al. 2012, 111). The eastern Baltic region has not been studied to the same degree as Central Europe or Scandinavia, but a recent study proposed that plant cultivation reached the eastern Baltic region during the Bronze Age, as evidenced by a barley grain directly radiocarbon dated to 1392–1123 cal BC (Grikpėdis et al. 2017, 269). Pollen studies have also suggested an earlier introduction of cultivation to the Baltic region (Poska et al. 2006). However, a barley impression and charred barley grain dating back to the Corded Ware period have been found in Estonia (Kriiska 2009, 168; Jaanits 1992, 49). These finds indicate local cultivation or interaction with cultivating groups.

When did plant cultivation reach Finland? A candidate for the earliest crop is a barley grain found at the Pitted Ware Culture (3300–2300 cal BC) site of Kolsvidja on the Åland Islands (Lindqvist 1988). The grain has not been dated, and its age has therefore been questioned (Nunez 1989).

One of the most persistent questions has been: Did Corded Ware groups (c. 2800–2300 cal BC) cultivate plants in Finland? This question has been addressed by surprisingly few archaeobotanical analyses. Some soil samples and plant impressions in ceramics have been studied from Corded Ware sites (Zvelebil 1981; Edgren 1984, 10–11), but these remains have not resulted in finds of cultivated plants. These studies have not found macrofossil evidence for plant cultivation dating back to the Stone Age in Finland.

Barley, cereal grain fragments and other charred plant remains were found at the Kiukainen culture (2300–1500 cal BC) site of Niuskala in southwestern Finland (Pihlman et al. 1985). Later, pollen and additional archaeobotanical samples were analysed and a barley grain was directly AMS radiocarbon dated to 1890–1021 cal BC, thus becoming the oldest dated cereal grain in Finland (Vuorela et al. 1988, 86) (calibrated dates with two sigma intervals are used in this thesis, and plant dates from Finland are provided in Appendix I). After this find, a barley grain found at Kitulansuo in eastern Finland was dated to 1431–1016 cal BC (Lavento 1998, 50). These results show that the earliest directly dated macrofossils of cultivated plants in Finland date back to the second millennium BC, similarly as in the southern parts of the eastern Baltic.

The later development of plant cultivation is known to some extent, even though many gaps remain. A review of macrofossil finds from Finland have found that there was a hiatus (c. 1500–500 cal BC) in the finds of cultivated plants between the Niuskala find and the beginning of the Pre-Roman Iron Age (Häkkinen et al. 1996, 147). Similarly, the small amount of AMS-dated cereal grains has led to the question of whether there was Bronze Age cultivation at all in Finland (Lahtinen et al. 2013). After first being carried out during the Late Neolithic or Early Bronze Age, plant cultivation would thus have ceased during the rest of the Bronze Age. Cultivated plants have, however, been more recently dated to this period. These consist of two barley grains dated 1007–845 cal BC and 832–553 cal BC and an oat grain dated 757–413 cal BC found at Alatalo in southern Ostrobothnia (Holmblad 2010, 135).

The development of plant cultivation during the first millennium AD has been discussed in two previous compilations (Häkkinen et al. 1996; Aalto 1997). The authors identify the cultivated species of the prehistoric period known at the time. Later studies have been presented as unpublished reports or articles (Lempiäinen 2011; Lempiäinen 2010; Lehtonen et al. 2010; Lempiäinen 2009; Lempiäinen 2002; Engelmark et al. 2002; Onnela et al. 1996). It has been difficult to obtain an overview of the development of plant cultivation based on these reports and articles. This has been particularly difficult for researchers outside Finland, with many of the findings being written in Finnish or Swedish.

2.4 DYNAMICS OF AGRICULTURAL SPREAD

The spread of agriculture can be studied as a global phenomenon (Fuller et al. 2014), a Pan-European phenomenon (Robb 2013; Rowley-Conwy 2011; Shennan 2018) or a regional phenomenon (Zvelebil et al. 1984; Gron et al. 2018). On a global scale, the development of agriculture can be seen as a coevolutionary process improving the fitness, population size and densities of both crops and humans (Fuller et al. 2014, 6151). It is commonly accepted that agricultural practices in Europe originated in southwest Asia, where various plants and animals were domesticated (Zohary et al. 2012). How this agriculture spread into different parts of Europe is a much-debated issue in archaeology. In Europe, agriculture can be seen as a one-way street leading eventually from hunting and gathering to agriculture (Robb 2013, 669). When agriculture moved northwards, both the crop spectra became smaller and the cereal grain sizes diminished (Colledge et al. 2005; Fuller et al. 2015).

Two principal models have been important for studying the spread of agriculture on a regional level: immigration and indigenism (Rowley-Conwy 2011, S433–S434). Indigenism means that domesticated crops were taken into cultivation by people already settled in a certain location (Zvelebil 1994), whereas migrationism means that domesticated species were brought to new areas by migrating peoples (Rowley-Conwy 2011). It has been suggested that

the intensification of plant gathering provided a prerequisite for the adoption of cultivated crops by local people (Zvelebil 1994, 64), but indications of this sort of intensification are contested (Rowley-Conwy 2004, S97–S99). In recent years, the idea of indigenism has largely been refuted.

The remains of cultivated plants, bones of domestic animals and other materials have convincingly shown that agricultural practices were indeed brought to several areas by migrating peoples (Rowley-Conwy 2011; Sørensen et al. 2012). Such migration has also recently been demonstrated in several parts of Europe by analyses of ancient DNA from human remains. These analyses show that farmers originating from Anatolia migrated throughout Europe and mixed with local people (Olalde et al. 2018; Haak et al. 2015). In Scandinavia, it has been shown that people of the Funnel Beaker Culture had Central European genetic origins (Malmström et al. 2015; Mittnik et al. 2018). These migrating farmers, however, interacted with local hunter-gatherers, as shown by material culture exhibiting both continuity from the Mesolithic era and novelties from the migrating farmers (Gron et al. 2018).

Based on ethnographical studies, it has been demonstrated that learning agricultural practices is such an intense and slow process that it is difficult to argue that agriculture could have spread as an idea and that people had to form a so-called community of practice to learn these skills (Sørensen 2016, 211–213).

It has been suggested that small-scale cultivation without animal husbandry spread into Finland during the Comb Ware period (Mökkönen 2010, 25) or contemporaneously with the initial occurrence of pottery, Sperrings Ware, approximately 5300 cal BC (Alenius et al. 2013, 17), most probably originating from the Volga-Kama region (Piezonka 2015, 560). The introduction of Sperrings pottery has been considered the result of small-scale migration or exogamy, whereas the typical Comb Ware pottery is considered to have been brought by migrants into Finland, who however appear to have interacted with the indigenous people (Nordqvist 2018, 93, 100). This suggested agricultural spread is poorly known and currently only shows up in pollen records.

One of the most discussed cultures responsible for the spread of agriculture into Finland is the Corded Ware Culture, dated 2800–2300 cal BC. Marked changes in archaeological material culture has been taken as evidence that Indo-European-speaking Corded Ware groups migrated to Finland, where they settled in clayey areas that could serve as pastures (Äyräpää 1952, 292–293). Studies of ancient DNA have recently shown that the onset of the Corded Ware Culture in nearby areas in Estonia and Sweden was indeed caused by migration (Allentoft et al. 2015), and the culture also appears to have spread Indo-European languages (Haak et al. 2015). Recently, a study of ancient lipids has shown Corded Ware groups used dairy milk in Finland (Cramp et al. 2014), and even a fossilised goat hair has been found at a Corded Ware burial site in Finland (Ahola et al. 2018). Ceramic analyses have shown that there were interactions between Corded Ware groups in Estonia, Finland and

Sweden (Holmqvist et al. 2018, 90). The traditional Corded Ware narrative is thus backed up by recent studies. Archaeological source materials, however, indicate interaction between Corded Ware and local groups (Nordqvist 2018, 116).

It has proven difficult to find continuous traces of agriculture from the Corded Ware period onwards, though the first bones of domestic animals date back to the subsequent Kiukainen Ware culture, 2300–1500 cal BC (Bläuer et al. 2013, 1651; Storå 2000, 61), and the earliest cereal grains have been connected with this culture (Vuorela et al. 1988). Lipid analyses point towards an increasingly maritime subsistence for the Kiukainen Ware groups (Cramp et al. 2014, 7). Archaeobotanical and osteological records for the Bronze Age are equally patchy, and the continuation of cultivation practices during this period has been questioned (Lahtinen et al. 2013).

The intermittent archaeobotanical and osteological record has led people to suggest that the onset of agriculture was a slow and gradual process (Zvelebil et al. 1984, 123; Lahtinen et al. 2016, 435; Cramp et al. 2014, 7). The slow establishment of agricultural practices has been considered the result of Finland's agriculturally marginal geographical setting, where the preconditions for agriculture fluctuated together with a changing climate (Cramp et al. 2014, 7). It might, however, be difficult to separate a gradual process of agricultural establishment from a patchy archaeological record. The cultivation record might appear intermittent due to poor bone preservation, the small number of archaeological excavations and small number of archaeobotanical studies. Therefore, it is important to review and expand archaeobotanical data to be able to better evaluate the spread and development of agriculture in the study area.

Recent studies in several regions have shown that migrating peoples brought agricultural practices into different areas of Europe and thereafter interacted with local groups. This might also be the case in Finland, even though here such migration is not demonstrated through analyses of ancient DNA, but instead shows up as changes in the archaeological record. Scholars have suggested that different migrating cultures brought agricultural practices into Finland, but that the actual plant cultivation and animal husbandry of such groups does not always appear in archaeobotanical or other records. The establishment of plant cultivation was thus supposedly a gradual process, but this conclusion might be the result of patchy data; hence, the idea must be evaluated in more detail by taking more archaeobotanical data into account.

2.5 IDENTIFICATION OF CULTIVATION PRACTICES

Researchers have proposed two main views of early agriculture in Finland: that the slash-and-burn method was used for the earliest cultivation (Vuorela 1986, 54; Tolonen 1987; Huttunen 1980) or that manured fields were

cultivated since the Late Bronze Age (Engelmark et al. 2002, 14; Meinander 1984, 17).

Slash-and-burn cultivation can be defined as cutting and burning forest to cultivate crops for at least one year (Myrdal 1995, 9). In Finland, this type of cultivation practice is known from medieval and later historical sources (Orrman 2003, 89–103). Nutrients for the crops are released from the soil and vegetation when boreal forests are burned, whereas in temperate forests nutrients are already available in the soil (Engelmark 1995, 29–30). For this reason, it has been suggested that slash-and-burn cultivation in northern Europe was mainly conducted in boreal forests, although clearance burning and other types of burning could have been conducted even in temperate forests (ibid.).

Huhta or huuhta-type slash-and-burn cultivation was conducted mainly in spruce forests. Knowledge of the huhta method is based on eighteenth- and nineteenth-century sources, according to which the process was conducted as follows: the largest trees were ring barked, a selection of trees were felled, trees were left to dry for a year or two, the huhta was burned in mid-summer and rye was sown right after burning (Orrman 2003, 99). Sometimes, the same area was cultivated repeatedly, and sometimes barley or oat was sown on the plot (ibid.).

Pollen analyses have been used to identify slash-and-burn cultivation. The practice, however, has been defined in different ways by different authors (Segerström 1995, 41; Myrdal 1995). In addition, clearly defined criteria for the identification of slash-and-burn cultivation using pollen data are not available and vary between publications. Nevertheless, the main criteria for identifying slash-and-burn cultivation can be summarised as follows: a decline in the amount of spruce pollen or other changes in tree pollen (Vuorela 1986, 60), an increase in the amount of charcoal particles (Huttunen 1980), an increase in the amount of herb pollen, especially sheep's sorrel (*Rumex acetosella*) (Alenius et al. 2009, 149; Tolonen 1987, 365), and the appearance of rye pollen (Tolonen 1987, 362). Vuorela (1986, 60) has also shown that *Picea* pollen declines contemporaneously with the occurrence of Cerealia pollen.

It can, however, be difficult to identify slash-and-burn cultivation. Vuorela (1986, 53–54) has this to say about the issue: 'It has also proved impossible to draw a sharp boundary between indicators of small permanent fields associated with the settled areas and those indicating solely slash-and-burn cultivation.' She nevertheless cites Soininen (1974), stating: 'It is evident, however, that the traditional slash-and-burn method has been in use since the very first agricultural activities.' This reasoning thus appears to suggest that if slash-and-burn cultivation was practiced during the historical period, it must have also been practiced earlier in prehistory (Engelmark 1995, 28).

The use of pollen analysis to interpret slash-and-burn cultivation has been criticised by, among others, Engelmark (1991, 90) and Segerström (1995). They raise five main points criticising the use of pollen analysis to identify

slash-and-burn cultivation: 1) the temporal resolution of the pollen analysis can be too low for identifying such short events (Segerström 1995, 39); 2) spruce forests can be cleared regardless of the cultivation method (Engelmark et al. 1993, 70); 3) microscopic charcoal can originate from domestic fire keeping or forest fires (Engelmark 1991, 90); 4) *Rumex acetosella* and other types of fire-indicating herb pollen can originate from any type of clearance; and 5) rye can also be cultivated on permanent fields (Engelmark 1992, 373).

Meinander (1984, 17) maintained that crops were cultivated on manured fields by coastal groups in Finland during the Bronze Age. Engelmark (1991, 89) noted that arable weeds found at the Iron Age site of Kalaschabrännan grow on tilled soil, are annual plants spread by seeds and require lots of nutrients, especially nitrogen. Based on these observations, he proposed that permanent manured fields were cultivated at this site. A larger dataset studied in Scania caused him to suggest that the growing of hulled barley in manured soils became common during the Late Bronze Age (Engelmark 1992, 375), a model that has been influential in Sweden (Welinder 1998, 233). Similarly, based on archaeobotanical finds of hulled barley, arable weeds and meadow plants, Holmblad (2010, 136) proposed that hulled barley could have been cultivated on manured fields in Ostrobothnia since the Late Bronze Age (from c. 1100 cal BC onwards). Engelmark's model has been questioned because all cereals benefit from manuring, and the transition from naked barley to hulled barley is not simultaneous everywhere in southern Scandinavia (Lagerås et al. 1999, 267–268). It should be noted that the criteria for identifying different cultivation methods using macrofossil data has not explicitly described for the Nordic materials, though such criteria have been proposed in continental Europe (Bogaard 2004; Kreuz et al. 2011; Jacomet et al. 2016).

Rye is considered the most suitable cereal crop for slash-and-burn cultivation in boreal forests (Engelmark 1995, 30–31). The early occurrences of rye in northern Europe have been interpreted as a result of rye first occurring as a weed among other cereals (Behre 1992, 152). In Finland, rye became more common since the Viking Age (Lempiäinen-Avci et al. 2017, 442). Such an increase in Sweden, based on arable weed finds, has been interpreted to indicate the introduction of the three-field system (Engelmark 1992, 373). The increase in the amount of rye appeared much later than the earliest cultivation in Finland. If we thus consider that rye is a precondition for slash-and-burn cultivation, then this practice might not be the earliest type of cultivation because rye only becomes common much later than the occurrence of the first cultivated plants. However, this does not rule out the fact that other crops could have been cultivated with the slash-and-burn method.

As discussed above, both pollen and macrofossil analyses have been used for the interpretation of cultivation methods. This study concentrates on macrofossil plant remains, and therefore, this source material is used to interpret cultivation methods. This approach is based on the growth requirements of arable weeds, which can be used to gain knowledge about the

kinds of soils in which plants were cultivated and the kinds of cultivation methods that were practised (Engelmark 1985). The dataset for such studies in Finland is still limited, and further archaeobotanical studies should be conducted to expand it.

3 AIMS OF THE STUDY

As shown above, current knowledge about prehistoric plant gathering and cultivation in Finland is insufficient. Knowledge of plant use is, however, crucial when studying the development of past societies and their cultural landscapes. Prehistoric plant use in Finland is approached via the following research questions.

How can we identify gathered wild plants in archaeobotanical assemblages, and how did wild plant gathering develop over time?
-This question is mainly studied in Paper I and amended with data from Papers II–V.

When does plant cultivation begin in Finland, and where does such cultivation originate from?
-The question is studied in Paper II.

How does plant cultivation develop after its initial onset? What crops were cultivated and which cultivation methods were applied during different time periods?
-The question is studied in Papers II–V.

4 MATERIALS

4.1 GEOGRAPHICAL AND CHRONOLOGICAL SCOPE

The papers included in the thesis each have a distinct geographical and temporal scope. The main study area is modern Finland, situated mostly in the boreal zone between the 60th and 70th parallels north. The majority of the analysed material comes from southern Finland (Figure 1). In Paper I, material from northern Finland was studied and included in a compilation of Stone Age archaeobotanical studies. Paper II contains material from east-central Sweden.



Figure 1 Sites studied in Papers I–V, marked with numbers 1–5.

This thesis deals with a time span ranging from the Mesolithic era to the beginning of the medieval period (Figure 2). In Paper I, the emphasis lies on the Neolithic period, 5200–1800 cal BC, and in Paper II on the Pitted Ware Culture, 3500–2300 cal BC. The emphasis in Paper III is on the Pre-Roman Iron Age, 500–0 cal BC. The material in Paper IV dates back to the Roman Iron Age and Migration Period. In Paper V, the emphasis is on the Late Iron Age, 600–1200 cal AD.

More than 802 soil samples of varying volumes were studied for this thesis. All of them were investigated using archaeobotanical methods; additionally, 34 were analysed geochemically and six were analysed using wood anatomical methods. In this thesis, 41 plant remains were AMS radiocarbon dated in different laboratories.

Archaeobotanical studies from 76 Stone Age sites in Finland were compiled in Paper I. These contained charred and waterlogged archaeobotanical material and hand-picked plant material from archaeological excavations. The paper also contains archaeobotanical analyses of 174 new samples from nine Stone Age sites (Paper I: supplementary data).

For Paper II, 61 soil samples with a total volume of approximately 89 litres from six sites in Åland and southern Finland were studied using archaeobotanical methods. Additionally, plant impressions in Corded Ware ceramics were investigated. From these sites, nine plant remains were submitted for AMS radiocarbon dating by the author.

At Bäljars 2, presented in Paper III, 46 archaeobotanical soil samples with a total volume of approximately 82 litres were analysed. Geochemical methods were applied to 34 of these samples. Wood anatomical analysis was conducted for 179 fragments of charcoal from six soil samples. Five plant remains were AMS radiocarbon dated.

The material presented in Paper IV was originally studied by Marjatta Aalto (1982; 1997). In the current study, this material was organised and studied anew and the plant remains were AMS radiocarbon dated. The original material consisted of approximately 167 samples from three nearby sites. AMS radiocarbon dating was conducted for nine plant remains.

Material from Orijärvi, presented in Paper V, consists of archaeobotanical study of 354 soil samples with a total volume of approximately 490 litres. At Orijärvi, 18 samples were AMS radiocarbon dated, 13 of which were cereal grains.

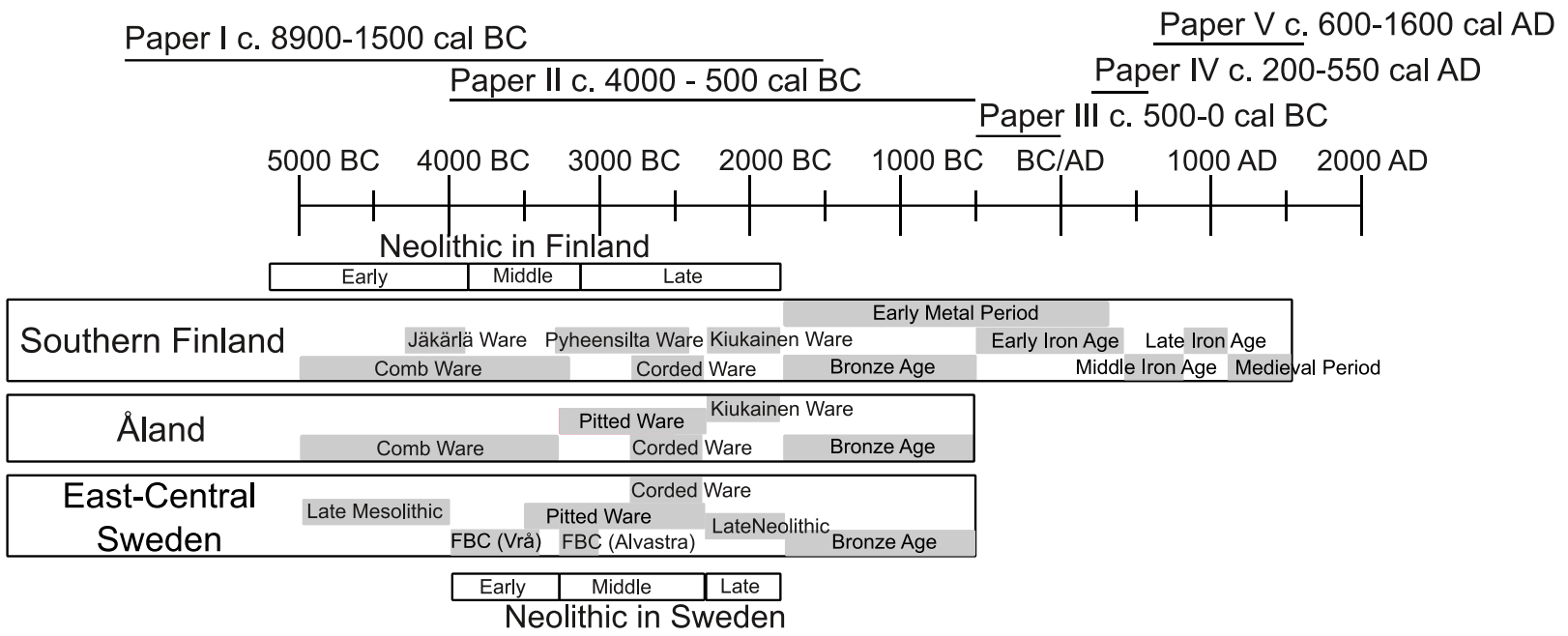

Paper I c. 8900-1500 cal BC
Paper II c. 4000 - 500 cal BC
Paper III c. 500-0 cal BC
Paper IV c. 200-550 cal AD
Paper V c. 600-1600 cal AD
5000 BC
4000 BC
3000 BC
2000 BC
1000 BC
BC/AD
1000 AD
2000 AD
Neolithic in Finland
Early
Middle
Late
Southern Finland
Early Metal Period
Jäkärlä Ware
Pyheensilta Ware
Kiukainen Ware
Early Iron Age
Late Iron Age
Comb Ware
Corded Ware
Bronze Age
Middle Iron Age
Medieval Period
Åland
Kiukainen Ware
Pitted Ware
Comb Ware
Corded Ware
Bronze Age
East-Central Sweden
Corded Ware
Late Mesolithic
Pitted Ware
LateNeolithic
FBC (Vrå)
FBC (Alvastra)
Bronze Age
Early
Middle
Late
Neolithic in Sweden

Figure 2 Chronological coverage of the papers discussed in this thesis and a simplified chronology for different time periods and cultural groups relevant for this study in southern Finland, Åland and east-central Sweden (modified after Haggrén et al. 2015; Edenmo et al. 1997, 138).

4.2 PRESERVATION OF ARCHAEOBOTANICAL REMAINS

Archaeobotanical plant remains have different modes of preservation (Zohary et al. 2012, 9–13). In Finland, archaeobotanical remains have been preserved mainly in charred or waterlogged conditions. Such remains can also survive close to metal artefacts or bones in graves, desiccated as isolation materials in buildings or as impressions on ceramics and in clay. These modes of preservation affect the composition and interpretation of the archaeobotanical material (Cappers et al. 2012, 173–198). Carbonized, i.e. charred, remains are emphasised here because they form the majority of the archaeobotanical material investigated in this study.

Charred plant remains have been preserved at almost all types of archaeological sites, but they occur in smaller quantities and contain fewer taxa than waterlogged remains (Jacomet 2013, 499–500; Colledge et al. 2014, 194). Charred archaeobotanical plant remains must be within the vicinity of a proper heat source for them to form. In this process, plant parts are reduced to carbon (Miksicek 1987, 219). Reducing burning conditions with a low oxygen supply can be beneficial for cereal charring (Märkle et al. 2008, S262). Such conditions in Iron Age furnaces in Denmark have led to the excellent preservation of cereals (Mikkelsen 2003). Similar conditions could also occur when plants are buried in the soil when they are heated (Sievers et al. 2008, 2916). Lighter plants parts can combust completely, whereas harder plant parts are more commonly preserved (Hillman 1981, 140).

It is difficult to interpret the quantity of different types of charred plant remains because not all plants are processed with fire or get charred as fuel (Colledge et al. 2014, 193). Plants that require heat for cooking or other preparation get charred more often (van der Veen 2007, 979). Charred remains are commonly left from plants used as fuel, accidentally burned plant foods, burned plant storage sites, plants burned by cleaning and intentionally burned diseased or infested crops (ibid.). Charred material can also be mixed with manure and used as fertilizer on arable fields or else manure can be burned as fuel (Cappers et al. 2012, 425–342). It has been noted that charred assemblages are coherent and represent routine practices conducted by people and that economic plants, such as cereal crops, are usually overrepresented in the charred material (van der Veen 2007, 987). Charred material thus hardly represents all types of vegetation at a site. In addition to routine practices, charred material can also form in catastrophic fires, which can preserve a snapshot of plant use at a site (Miksicek 1987, 219–220).

Waterlogged plant remains have been preserved in greater numbers and represent greater species diversity than do charred remains (Jacomet 2013, 500–501). More delicate plant parts survive in waterlogged conditions, and even charred remains can be better preserved in waterlogged conditions than at open air sites (ibid.). In Finland, waterlogged assemblages dating back to the Stone Age have been found buried under modern fields layers, where underlying lacustrine and peat deposits have been preserved (Aalto et al. 1985; Aalto et al. 1981; Vuorela et al. 1982). Waterlogged assemblages dating back to the metal period are rare, but several waterlogged assemblages have been found in medieval towns, such as Turku (Lempiäinen 2007). Waterlogged assemblages often contain plant material of mixed origin, which can derive from various types of domestic activities and local vegetation (Miksicek 1987).

It is possible that plants get deposited near the place where they were originally used and can therefore be used for the functional interpretation of settlement areas. In Scandinavia, this sort of approach has been used to, for example, demarcate areas for keeping animals, preparing food and processing cereal at Bronze Age and Iron Age settlements (Viklund 1998; Grabowski 2014). Plant material is, however, often redeposited. This can be caused by multiple factors, such as digging, ploughing and building activities (Paper V).

For the interpretation of archaeobotanical remains, it is important to understand the formation processes of this material. The mode of preservation, local environment and the archaeological context should be considered in each individual case when interpreting archaeobotanical remains. The material studied in this thesis have various origins, and the formation of these materials are discussed in the corresponding papers in more detail.

4.3 CEREAL NOMENCLATURE

Cultivated cereals are divided into different species, subspecies and varieties. In archaeobotanical studies, barley is divided into two subspecies and two varieties, rye into a single cultivated species, cultivated wheat into six species and into a further 16 subspecies, and finally, oat into one cultivated species (Cappers et al. 2012, 257–321). Wild cereals are commonly hulled, whereas domesticated cereals can be hulled or naked (ibid.). Hulled species have glumes tightly enclosing the grains and they spread as spikelets, whereas in naked or free-threshing crops the grains loosen when they are threshed (Zohary et al. 2012, 24; Cappers et al. 2012, 249). Thus, emmer and spelt are hulled crops because they disperse as spikelets, whereas barley (both hulled and naked forms) is a free-threshing crop because its dispersal unit is the grain kernel (ibid.).

The cereal nomenclature used in this study is presented in Table 2. In the archaeobotanical literature, poorly preserved cereal grains can be called

Cerealia, which signifies that the specimen can be a cereal from the genus *Hordeum*, *Secale*, *Triticum* or *Avena*.

Domesticated barley is divided into two subspecies: 2-row barley and 6-row barley, both of which appear in naked and hulled forms (Cappers et al. 2012). Due to poor preservation and the small quantity of the archaeobotanical material in this study, barley was not identified as 2- or 6-row forms, but instead in some cases as naked or hulled barley. However, according to historical sources and previous archaeobotanical analyses, the 6-rowed barley was the dominant or only cultivated subspecies during the early historic period (Lempiäinen-Avci et al. 2018, 13).

Free threshing wheat found in Finland is commonly considered to consist of bread wheat (*T. aestivum* ssp. *aestivum*) and club wheat (*T. aestivum* ssp. *compactum*). In this study, those remains that could not be separated from each other are called bread/club wheat (*T. aestivum* s.l.).

Hulled wheats found in Finland have been identified as emmer and possibly spelt. Often when only grains are found, these are addressed as emmer or spelt wheat (*Triticum dicoccum/spelta*).

Both cultivated and wild oats occur in Finland. Wild oat (*Avena fatua*) is a difficult arable weed. When only grain remains are found, it is difficult to distinguish between *A. sativa* and *A. fatua*, but grains can be considered *A. sativa* when found in pure assemblages. These species can be morphologically distinguished based on their floret bases and pedicels (Cappers et al. 2012).

Table 2. *Cereals nomenclature used in this study.*

English name	Botanical name
Hulled barley	*Hordeum vulgare* var. *vulgare*
Naked barley	*Hordeum vulgare* var. *nudum*
Barley	*Hordeum vulgare*
Bread/club wheat	*Triticum aestivum* s.l.
Oat	*Avena* sp.
Emmer	*Triticum dicoccum*
Spelt	*Triticum spelta*
Unidentified cereal	Cerealia

4.4 ETHNOBOTANICAL SOURCES

Ethnobotanical data was collected mainly from published sources. These ethnographical and historical accounts deal with traditional life in Finland during the 19th and 20th centuries and contain varying amounts of ethnobotanical data (Sirelius 1989; Vuorela 1975; Talve 1977). Limited information on plant use was available in ethnographic accounts of Fenno-Ugric peoples (Manninen 1934) and a regional account of Karelia (Manninen 1932). Rich information on the traditional use of berries and mushrooms was

retrieved from an unpublished master's thesis in ethnology (Hautala 1964). Information on plant use by the Sámi was included in a volume discussing food in the circumpolar region (Eidlitz 1969). Historical texts provided detailed information on the plants used in the former district of Satakunta in the 18th century (Gadd 1751) and the plants used for baking emergency bread in Finland during the 17th and 18th centuries (Wallenius 1782). The first mention of flora in Finland is from the 17th century and provides some information on, mainly medicinal, plant use (Til-Landz 1683). Also, more recent accounts of Swedish (Palmstruch et al. 1819) and Finnish (Lönnrot et al. 1866) floras provide somewhat similar information on plant use.

5 METHODS

5.1 PLANT MACROFOSSIL ANALYSIS

The main method employed in this thesis is the archaeobotanical analysis of plant remains. Soil samples of various volumes were first collected during archaeological excavations, sometimes by the author and sometimes by the excavation staff. Soil samples were flotated in order to separate organic and inorganic materials from each other (Figure 3). Flotation was conducted using, at maximum, a 0.5 mm sieve and sometimes a smaller 0.25 and 0.125 mm sieves.



Figure 3 On the left: a bucket with an overflow tube used for flotation. A sieve-mesh of 0.5 or 0.25 mm is attached to another bucket on the right, which cathes the floating plant material (image: Santeri Vanhanen).

When studying charred remains, the flotated material was dried and screened in different size fractions (e.g. >2 mm, 2–1 mm, and 1–0,5 mm), thereby speeding up the sorting procedure. Waterlogged materials were kept wet during the process. All organic flotated materials were studied with a stereomicroscope. During this stage, plant remains, such as grains and seeds, were picked out from the samples with light tweezers. After the samples had

been thoroughly examined with a stereomicrocope, the plant remains were identified with the help of the extant reference literature (Cappers et al. 2006; Jacomet 2006; Berggren 1969; Berggren 1981; Schoch et al. 1988; Anderberg 1994; Neef et al. 2012); plant reference collections in Helsinki, Umeå and Turku; and colleagues, especially Terttu Lempiäinen, Karin Viklund and Roger Engelmark. Numerous plant remains were photographed using a camera attached to a stereomicroscope.

Plant impressions on ceramics were studied for Paper II. This was carried out by first examining ceramic sherds for possible plant impressions. After finding promising cavities, silicone casts were made using dental silicone (Xantopren Comfort Light). The casts were photographed with a camera attached to the stereomicroscope. Some casts were also studied using a scanning electron microscope (SEM) by Marianna Kemell. Casts were identified using the same methods as with other plant remains.

5.2 COMPILATION OF ARCHAEOBOTANICAL DATA AND RADIOCARBON DATES

Previous archaeobotanical data and radiocarbon dates was compiled for each paper and for this thesis. Both published and unpublished sources were included in these compilations.

In Paper I, both literature and archaeological excavation reports were studied to detect archaeobotanical assemblages dating back to the Stone Age in Finland. A large proportion of the sites were found in published papers. Some sites were discovered by sending a query about Stone Age plant finds in Finland to an email list called *Arkeologilista* (=list of archaeologists), which is comprised mainly of Finnish archaeologists. Also, approximately 1,700 searchable scanned PDFs of excavation reports from the National Board of Antiquities in Finland were studied on a local computer. These reports were searched using various keywords, such as makrofossiili (=macrofossil), siemen (=seed), jyvä (=grain) and pähkinä (=nut). Archaeobotanical studies and information regarding the sites were retrieved from the unpublished database of Finnish Archaeological Artefacts (Sundell et al. 2010; Sundell et al. 2014; Pesonen et al. 2011). The database was accessed by Petro Pesonen, who gathered together chronological and typological information about the sites containing archaeobotanical material. Archaeobotanical data and site information were provided as supplementary excel tables. In the paper, commonly occurring plant species were discussed in more detail. These were selected if the charred remains of the species were found at five or more sites or if 50 or more plant remains of a species were found. Water chestnut was included in this discussion because it shows both signs of processing and was removed from its habitat in water. This selection consists of 16 taxa found as seeds or fruits and six taxa occurring as other types of remains. The distribution of 18 taxa were compared with their modern distribution. The

possible uses, mainly as food, of these taxa were discussed based on ethnobotanical sources and other archaeobotanical finds.

For Paper II, early finds of cultivated plants in Finland and east-central Sweden were surveyed. For Finland, the aim was to collect all radiocarbon-dated cereal grain finds dating from before the Common Era. For east-central Sweden and the Norrland coast, the aim was to collect cereal grain dates prior to approximately 2300 cal BC. The survey was mainly based on published material (Sørensen 2014; Sørensen et al. 2012; Edenmo et al. 2012; Hallgren 2008; Viklund 2011). Thereafter, the original reports were accessed whenever possible. Archaeobotanical assemblages with ten or more plant remains consistently dating back to the Swedish Early and Middle Neolithic periods (4000–2300 BC) in the study area were gathered for the paper.

For Paper III, cereal grains and archaeobotanical assemblages dating back to the first millennium BC in Finland were compiled.

In Paper IV, cereal grains and archaeobotanical assemblages dating back to the Roman Iron Age and Migration Period (0–550 AD) were compiled from published sources.

For Paper V, published and some unpublished archaeobotanical assemblages dating from the Merovingian Period to the Crusade Period/Middle Ages (circa AD 550–1300) were compiled.

The compilations made for the papers and the plant dates from the unpublished database of Finnish Archaeological Artefacts (Sundell et al. 2010; Sundell et al. 2014; Pesonen et al. 2011) formed the basis for the review presented in this compilation part of the thesis. Additionally, the existing literature and a selection of unpublished reports were examined to gather plant radiocarbon dates. The aim was to collect all radiocarbon-dated remains of cultivated and wild plants from Finland. In addition, site assemblages of cultivated plants dating from the prehistoric period until approximately AD 1200 were gathered. These included published sites with 20 or more cereal grains that could reliably be dated. Dates from cereal grains were preferred, and median dates rounded to the nearest 50 years were used.

5.3 CHARCOAL ANALYSIS

Wood anatomical study of charcoal fragments was conducted for Paper III. This approach, also known as anthracology, included splitting pieces of charcoal and examining their transversal, tangential and radial sections with a reflected light microscope with a 50–500 times magnification. Fragments were identified to the genus or species level using the existing literature (Schweingruber 1982; Fagerstedt et al. 2004). Also, a dendrological analysis was conducted in order to find out what type of firewood was used (Marguerie et al. 2007). The main aim was to identify whether fuel was obtained from branches or stems and if the wood was infected by insects or fungal hyphaea.

5.4 RADIOCARBON DATING

Several plant remains were submitted for AMS radiocarbon dating. The new and older radiocarbon dates collected from the literature were calibrated using an online version of OxCal 4.3 (Bronk Ramsey 2009) and the IntCal13 atmospheric curve (Reimer et al. 2013). Earlier versions of the programme were used in Papers III and V, and the calibrated dates may vary slightly between the papers and this compilation. Calibrated values of the radiocarbon dates (2 sigma) are used throughout the text (cal BC/cal AD).

5.5 GEOCHEMISTRY

Geochemical analyses applied in Paper III were conducted at the Environmental Archaeology Lab at the University of Umeå (MAL). The analyses consisted of measuring organic and inorganic phosphates, magnetic susceptibility and loss on ignition (LOI). The methods are described in detail in Paper III.

The aim of these analyses was to better understand archaeological structures excavated at Bäljars 2. Phosphate analysis can be used to define the extent of archaeological sites based on the condition that settlement activities have contributed to the rise of phosphate levels (Reitz et al. 2012, 152). High inorganic phosphate levels have been found at settlement sites (Engelmark et al. 1996). In contrast, manuring raises levels of organic phosphates and levels of soil organic matter (measured with LOI), and therefore, elevated values of organic phosphates and LOI can be considered to derive from ancient arable soils where manure has been added (Engelmark et al. 1996). In this study, the amount of organic phosphate was not directly measured; instead, it was estimated using a value called Pquota, which is a measurement of the relation between inorganic and organic phosphates. A higher Pquota value signifies a higher amount of organic phosphate in the soil. The Pquota value is lower at settlement sites and higher at locations with added manure (ibid.). The amount of soil organic matter can be measured via LOI, in which dry samples are weighed before and after burning at 550°C. Magnetic susceptibility values can be elevated in soils exposed to fire (Grabowski et al. 2013, 333).

5.6 ETHNOBOTANY

In Finland, ethnographical sources regarding plant use have not been systematically compiled, and thus the information is spread throughout various studies and archives. Ethnographical and historical source material, mainly from Finland, was used to interpret the archaeobotanical data in Paper I and briefly in Paper V. Source material used in Paper I is listed in section 4.4, and references are given in Paper V. The sources consist mainly of published

studies and a single unpublished thesis. No archival sources were studied or ethnographical fieldwork conducted.

The aim of using ethnobotanical sources in Paper I was twofold: to study the formation of the archaeobotanical record and to study how wild plants could have been used. The formation of the archaeobotanical record can be inferred by using ethnographical accounts to study the kinds of remains resulting from different actions, such as plant processing, waste management, food preparation and fire keeping. Such study can contribute to an understanding of how plant remains were charred, why particular plants have been deposited in certain places or why particular plants have certain breakage patterns. Ethnographical sources also provide information on how plants have been used: which plants have been eaten, which used for medicine, which used as construction materials and even which plant parts have been used for certain purposes.

Ethnographical material is equally important for the study of cultivated plants. Several aspects of processing and the formation of the archaeobotanical record have been understood via ethnographical studies (Hillman 1984). Well-preserved materials consisting of cereals, weeds and chaff are required to apply ethnographical analogies to archaeobotanical materials. Such material was, however, not available for this thesis, and therefore ethnographical material was used only in Paper V to interpret the use of cultivated plants for food.

6 RESULTS

6.1 GATHERED WILD PLANTS

Paper I reviewed the gathered plants found at Stone Age sites in mainland Finland. The intention was to compare plant finds from different periods of the Stone Age, but this proved to be impossible because several sites contained material from different time periods or else the dates were considered unreliable. Therefore, the dataset in Paper I most likely originates from the Stone Age in general. However, we collected typological and radiocarbon dates to make it possible to compare different time periods in the future.

We based our analysis on charred remains found at five or more (out of 43 sites) Stone Age sites in Finland and/or with a total of 50 or more remains. These taxa are presented in Table 3. We also used water chestnut because it was clearly gathered, especially when found in a charred state at an archaeological site. Then, we discussed the possible food use of these taxa based on ethnographic accounts. Several taxa found in charred assemblages were not discussed, but there is no particular reason why these taxa would not have been gathered by people.

We compared the distribution of plant finds of selected species with their modern distribution (Paper I: Figs. 2–6). The majority of the Stone Age plant remains were found within their current distribution range. Two species were found north of their current range: hazel, dated to 3510–2877 cal BC at Rävåsen (dates in Appendix I) (Hertell et al. 2006, 185; Miettinen 2005), and water chestnut at several sites in southern Finland. The distribution of the plant remains made it possible to discern three zones from south to north with diminishing plant spectra: a southern hazel and water chestnut zone, an intermediate wild strawberry and raspberry zone, and finally, a northern zone with mainly crowberry and bearberry. It should be noted that the southern and middle zones also contain species present in zones north of them.

Remains of wild plants were also discovered in the archaeobotanical assemblages presented in Papers II–V. Table 4 presents such remains, interpreted as gathered plants. The findings from these sites provide a long-time perspective on wild plant gathering. A relative amount of wild plants diminished gradually. The majority of the assemblages are, however, quite small. The use of several species, such as hazel and juniper, continued from the Stone Age until the Iron Age.

Table 3. *Ubiquity and total numbers of plant species commonly occurring at Stone Age sites in Finland (Paper I).*

Seeds and fruits	**Number of sites with charred plant remains (n=43)**	**Number of charred plant remains**	**Number of sites with waterlogged plant remains (n=7)**	**Number of waterlogged plant remains**
grass (Poaceae)	21	151	4	8 (many species)
bearberry (*Arctostaphylos uva-ursi*)	18	279	-	-
raspberry (*Rubus idaeus*)	18	105	2	13
juniper (*Juniperus communis*)	10	37	2	2
crowberry (*Empetrum nigrum*)	10	147	1	7
hazel (*Corylus avellana*)	9+34 hand-picked	371	1	2
Carex sp.	9	34	7	882 (many species)
fat hen (*Chenopodium album*)	7	83	-	-
wild strawberry (*Fragaria vesca*/cf. *F. vesca*)	7	12	2	24
Rumex sp.	6	25	1	1 (R. acetosa)
Viola sp./cf. *Viola* sp.	6	7	1	9
cereals (Cerealia/cf. Cerealia)	5	71	-	-
bird cherry (*Prunus padus*)	5	18	1	1
sheep's sorrel (*Rumex acetosella*)	5	5	-	-
yellow water-lily (*Nuphar lutea*)	3	133	5	>49
water chestnut (*Trapa natans*/cf. *Trapa natans*)	2	4	5	>1582
Other plant remains				
Scots pine needle (*Pinus sylvestris*)	21	593	2	3
Scots pine cone (*Pinus sylvestris*)	18	74	-	-
cowberry pedicel (*Vaccinium vitis-idaea*)	10	41	-	-
Norway spruce needle (*Picea abies*)	8	324	1	114
cowberry leaf (*Vaccinium vitis-idaea*)	7	36	-	-
bilberry pedicel (*Vaccinium myrtillus*/cf. *V. myrtillus*)	5	15	-	-
dropwort tuber (*Filipendula vulgaris*)	3	62	-	-

Table 4. *Presence of remains interpreted as gathered plants from Papers II–V. Material from Tengo Nyåker and Kauhala Oxhaga are plant impressions on ceramics, whereas material from other sites consist of charred plant remains. The presented material derives from Kloddberget (Paper II), Glamilders (Paper II), Tengo Nyåker (Paper II), Kauhala Oxhaga (Paper II), Bäljars 2 (Paper III), Isokylä (Paper IV) and Orijärvi (Paper V). Knotgrass and horsetail were interpreted as wild gathered plants only at the Comb Ceramic site of Kloddberget.*

Site	Kloddberget	Glamilders	Tengo Nyåker	Kauhala Oxhaga	Bäljars 2	Bäljars 2	Isokylä	Orijärvi
Archaeological period	Comb Ceramic	Pitted Ware	Corded Ware	Corded Ware	Bronze Age (R5)	Pre-Roman Iron Age (R2, R8)	Roman Iron Age and Migration Period	Late Iron Age and medieval period
Dating	5200–4300 cal BC.	2800–2600 cal BC	c. 2500 BC	c. 2500 BC	1400–1200 cal BC	400-200 cal BC	cal AD 100–500	cal AD. 600–1600
Amount of identified plant remains	75	257	3	1	22	5	2140	884
Sum of cultivated plants	0	21	0	0	15	1	1450	376
Sum of gathered wild plants	75	204	3	1	7	3	78	63
Cultivated+gathered wild plants	75	225	3	1	22	4	1528	439
Wild plants % from the above sum	100	91	100	100	32	75	5	14
bearberry (*Arctostaphylos uva-ursi*)							2	3
tuber oat grass (*Arrhenatherum elatius* var. *bulbosum*)		1						32
hazelnut (*Corylus avellana*)	2	177			3	1	36	
horsetail branch (*Equisetum* sp.)	2							
wild strawberry (*Fragaria vesca*)				1		1		5
juniper (*Juniperus communis*)	9		1		1	1	27	3
crab apple (*Malus sylvestris*)		2						
moutain melick (*Melica nutans*)			1					
bog myrtle (*Myrica gale*)							6	
knotgrass (*Polygonum aviculare*)	62							
bird cherry (*Prunus padus*)							1	
cf. bird cherry (cf. *Prunus padus*)			1					
lesser celandine (*Ranunculus ficaria*)		2			3			
rose (*Rosa* sp.)		22						
raspberry (*Rubus idaeus*)							5	20
stone bramble (*Rubus saxatilis*)							1	

6.2 CULTIVATED PLANTS

6.2.1 PITTED WARE CULTURE IN EAST-CENTRAL SWEDEN AND ÅLAND

Paper II presented the archaeobotanical data from six sites in Finland, east-central Sweden and the Åland islands (Figure 1, Figure 15, Figure 16). Three of these sites date consistently back to the Middle Neolithic period and contain somewhat larger charred plant assemblages: Glamilders, Tråsättra and Åby. The sites of Jettböle I and Jettböle II contained small plant assemblages collected by archaeologists excavating these sites. Svinvallen was dated to the Middle Neolithic period and the Bronze Age. These plant assemblages contained both cultivated cereals and wild plants. AMS radiocarbon dates conducted for 20 cereal grains from these sites confirm that the majority of the cereals date back to the Swedish Middle Neolithic period (c. 3300–2300 cal BC).

On Åland, the earliest naked barley derives from Jettböle I, AMS dated to 3324–2923 cal BC (Figure 4). A larger assemblage of naked barley and other plants was found at Glamilders. Here, four barley grains were dated to 2881–2503 cal BC. Two impressions of naked barley were discovered in ceramic sherds found at Glamilders. A naked wheat grain found at Svinvallen, situated near Glamilders, was dated to 2859–2495 cal BC.

In east-central Sweden, cereal grains at Åby were dated to 3089–2309 cal BC, with naked barley being the main crop, followed by hulled barley and naked wheat. Here, impressions of emmer/spelt and bread/club wheat were also discovered in the ceramic sherds. Cereal grains found at Tråsättra, dated to 2875–2286 cal BC, consisted of naked barley and naked wheat.



Figure 4 Cereal grains dated to the Stone Age. 1) Charred naked barley grain from Jettböle I, AMS dated to 3324–2923 cal BC; 2) charred barley grain from Glamilders, AMS dated to 2881–2634 cal BC; 3) charred bread/club wheat grain from Svinvallen, AMS dated to 2859–2495 cal BC (images: Santeri Vanhanen; black scale bars 1mm).

6.2.2 BRONZE AGE IN SOUTHERN FINLAND AND ÅLAND

We obtained Bronze Age AMS radiocarbon dates for cereal grains from Bäljars 2 and Ristimäki in southern Finland, and from Härdalen and Svinvallen in Åland (Figure 1, Figure 18). All of the AMS-radiocarbon-dated plant remains were barley (Figure 5). The remains from Åland were naked barley, and the

ceramic sherd from Ristimäki contained an impression of hulled barley. An oat grain was found in the context (R5) containing a Bronze Age barley grain at Bäljars 2, but it might be wild oat. These assemblages contained only a small number of cereal grains and other seeds.



Figure 5 Cereal grains dated to the Bronze Age. 1) Charred barley grain from Bäljars 2, AMS dated to 1431–1264 cal BC; 2) naked barley grain from Svinvallen, AMS dated to 997–551 cal BC; 3) an SEM image of a silicon cast of a hulled barley grain impression in a ceramic sherd from Ravattula, where the organic crust on the sherd was AMS dated to 1192–939 cal BC (details in Appendix I; images 1 and 2: Santeri Vanhanen; image 3: Marianna Kemell; black scale bars 1mm).

6.2.3 PRE-ROMAN IRON AGE AT BÄLJARS 2

The Bäljars 2 site (Figure 19) was presented in Paper III and complemented with radiocarbon dates in Paper II as well as in a paper discussing land use in southern Finland (Alenius, Haggrén, et al. 2017). Here, AMS dates indicate a long span of activities ranging from the Bronze Age to the medieval period. The dates of two remains from two different pit hearths fell into the Pre-Roman Iron Age: an unidentified cereal grain (R2) and a hazelnut shell (R8). These and other finds from Bäljars 2 indicate that plant cultivation and gathering were carried out at the site during the Pre-Roman Iron Age.

Ard marks were discovered at Bäljars 2. Geochemical analysis of sooty soil representing an ancient plough-zone layer yielding the ard marks (L5) indicate that the soil was a cambisol, also known as brown earth horizon. Find material, stratigraphical observations and AMS dates from Bäljars 2 indicate that the ard marks could originate from the Bronze Age or the Pre-Roman Iron Age, but the dating of these ard marks is not secure.

A varied charcoal assemblage dominated by *Salix* and *Betula,* with inclusions of *Picea, Alnus, Quercus* and *Pinus,* was found from this plough-zone layer. The ring curvature of the charcoal found in this context suggests that branches and trunks were burned and that more than half of the wood contained fungal hyphae. Even charred fragments of spruce needles and cones were present in this context.

Geochemical results show high organic phosphate content and high soil organic matter in a pit hearth (R8). These results suggest the deposition of manure in this particular context.

The results from Bäljars 2 indicate plant cultivation during the Pre-Roman Iron Age. The dates of the ard marks should, however, be confirmed with similar studies in the future, where AMS dates and stratigraphical observations would ascertain the age of the observed structures. The overall results from Bäljars 2 suggest that forests growing on cambisols were cleared with fire into arable fields, ploughed with an ard and cultivated using manure.

6.2.4 ROMAN AND MIGRATION PERIOD AT ISOKYLÄ

A rich and diverse charred archaeobotanical material was studied at three settlement sites situated in Salo Isokylä: Ketohaka 1, Ketohaka 2 and Vanutehtaamäki 1. Each was presented in Paper IV (Figure 20). Based on eight AMS radiocarbon dates, the charred plant remains date back to the Roman Iron Age and Migration Period.

Grapevine (*Vitis vinifera*) pips from Vanutehtaanmäki 1, reported as charred by Aalto (1997), turned out to be uncharred upon closer examination. An AMS radiocarbon date of a pip resulting from cal AD 1682–1935 confirmed that grapevine pips were recent intrusions at the Iron Age site.

Barley was the main crop at Isokylä (Figure 6). Both hulled and naked barley were found in roughly equal numbers. Oat and emmer/spelt wheat were minor crops. Rye and bread/club wheat occurred during the Late Roman Iron Age or Migration Period and flax during the Roman Iron Age. Hemp was dated to the Late Roman Iron Age and found in a Migration Period context (Figure 7). Finds of arable weeds at Isokylä point towards spring-sown and manured fields, where cereals could have been cut low on their stems.

The sites at Isokylä were situated near an estuary during the Late Roman Iron Age and Migration Period. Remains of wetland plants show that fodder from the estuary was collected as fodder for farmyard animals.

The archaeobotanical material from Isokylä is currently the largest published plant assemblage dating back to the Roman Iron Age and Migration Period. It is also the earliest large assemblage from mainland Finland, providing a diverse picture of Iron Age plant cultivation.



Figure 6 1) Hulled barley grain from Salo Ketohaka 2; 2) naked barley grain from Salo Vanutehtaanmäki 1; 3) rye grain from Vanutehtaanmäki 1, dated to cal AD 413–551; 4) bread/club wheat grain from Ketohaka 1; 5) emmer/spelt wheat grain from Salo Ketohaka 1, dated to cal AD 90–326; 6) oat grain from Salo Ketohaka 2 (images: Santeri Vanhanen; black scale bars 1mm).



Figure 7 1) Flax seed from Salo Ketohaka 1, from a pit dated to the Roman Iron Age; 2) hemp fruit from Vanutehtaanmäki 1; 3) hemp fruit shown at three different angles from Salo Ketohaka 2, AMS dated to cal AD 258–425 (images: Santeri Vanhanen; black scale bars 1mm).

6.2.5 LATE IRON AGE AT ORIJÄRVI

At the site of Mikkeli Orijärvi, archaeobotanical material was studied from a field complex dated mainly to the Late Iron Age (Paper V; Figure 21). The fields consisted of accumulated humus-rich soil layers, where a criss-cross pattern of ard marks was clearly discernible and covered an area exceeding 1,600 m^2 (Mikkola et al. 2015, 148–149).

The archaeobotanical material from Orijärvi was interpreted to originate from houses ploughed into fields or manure spread onto the fields. The mixed nature of this archaeobotanical assemblage made its interpretation difficult. Fortunately, AMS radiocarbon dates were conducted for plant remains, which showed that these date back to cal AD 600–1600.

Dated archaeobotanical material, stratigraphical observations and a palynological study from Lake Orijärvi (Alenius et al. 2007) showed that here, barley, rye and bread/club wheat cultivation commenced during the

Merovingian Period. Oat cultivation probably also started during this period. As evidenced by pollen finds and a contextually dated seed, hemp cultivation started during the Viking Age. A single seed of flax comes from a context dated to the late medieval or modern period. Based on charred cereal grains, barley was the main crop at Orijärvi and hulled barley was far more common than naked barley (Figure 8). Oat and rye were relatively common, whereas only small amounts of bread/club wheat were discovered.

Charred sclerotia of ergot were found in relatively large numbers. Ergot is a toxic parasitic fungus, which can infest cereals and other grasses, especially in wet climates (Cantell et al. 1936).

Arable weed flora was interpreted to indicate manured fields, grown mostly with spring-sown, and possibly even autumn-sown, crops. Weed flora also contained species growing in poor acidic soils and in a wet climate. Meadow and wetland plants were numerous and were interpreted to be remains of animal fodder, probably collected from the shores of the nearby lake.



Figure 8 Dorsal and ventral views of grains of bread/club wheat, rye, oat, naked barley and hulled barley from Orijärvi (images: Santeri Vanhanen; black scale bars 1mm).

6.2.6 COMPILATION OF PLANT RADIOCARBON DATES

Compilations of plant radiocarbon dates can reveal both dating and species composition of both cultivated and wild plants. The compilation of radiocarbon-dated plant remains presented in Appendix I consists of 254 dates. Out of these dates, 21 were obtained from uncharred plant remains and the remaining 233 from charred plant remains. The dates derived from 107 sites. Altogether, 157 cultivated and 97 wild plant remains have been directly radiocarbon dated (Figure 9).

Dated plant remains originate from two distinct areas: southern Finland and Lapland. All cultivated plants come from southern Finland, where even gathered plants and other types of plants have been dated. The dates from Lapland were obtained from bearberry and crowberry remains and derived from a research project studying hunting pits (Halinen 2005). Here, the dated plant remains most probably do not represent wild plant gathering, but instead the burning of local vegetation.

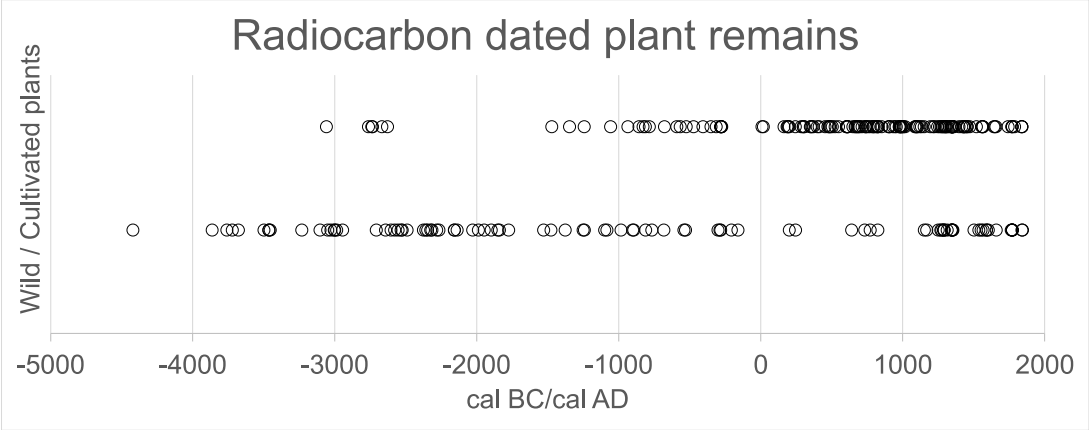


Figure 9 Median calibrated radiocarbon dates of wild (below) and cultivated (above) plant remains (data from Appendix I).

The calibrated median values of AMS-radiocarbon-dated remains of cultivated plants are presented in Figure 10 and Figure 11. These provide information on what species were cultivated during different time periods, but they cannot be used to infer the exact quantities of different cultivated species during these time periods.

The AMS-dated plant remains show that barley was present during all periods when cultivated plants occur, and the most common dated cereal until approximately cal AD 1200. Rye occurs since the Early Roman Iron Age, but it is not present during each period. Four rye dates cluster around cal AD 500–550. The number of rye dates increase during the Early Middle Ages, though it should be noted that 11 of the 16 Early Middle Age dates derive from the Mankby site (Lempiäinen-Avci et al. 2017). Two emmer/spelt dates cluster around cal AD 200. Bread/club wheat first occurs around 2600 cal BC on Åland. Later, bread/club wheat occurs since the Pre-Roman Period, though it is not present during each period. Oat occurs once during the Bronze Age and thereafter in small numbers since the Middle Ages. Other cultivated plants, such as legumes and fibre plants, are poorly represented and the only such dated remain is a hemp seed from the Late Roman Period.

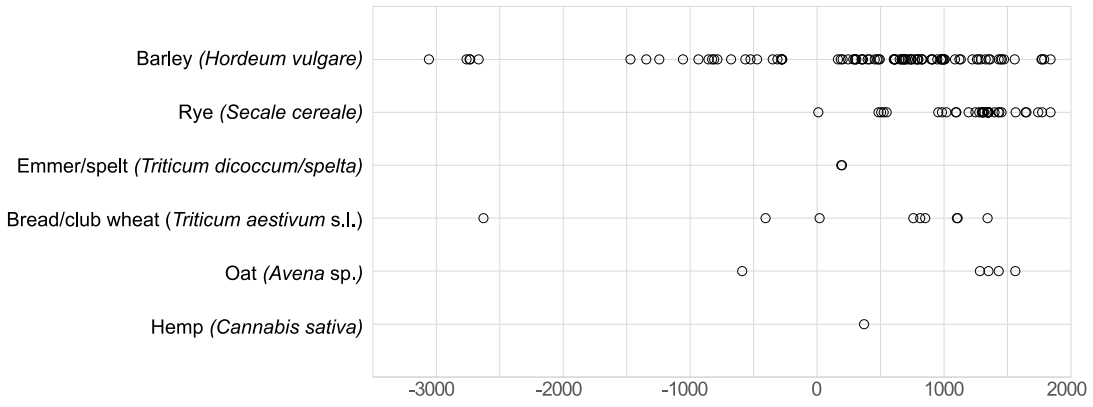


Figure 10 Calibrated median values of AMS radiocarbon dated cereal grains and seeds (data from Appendix I).

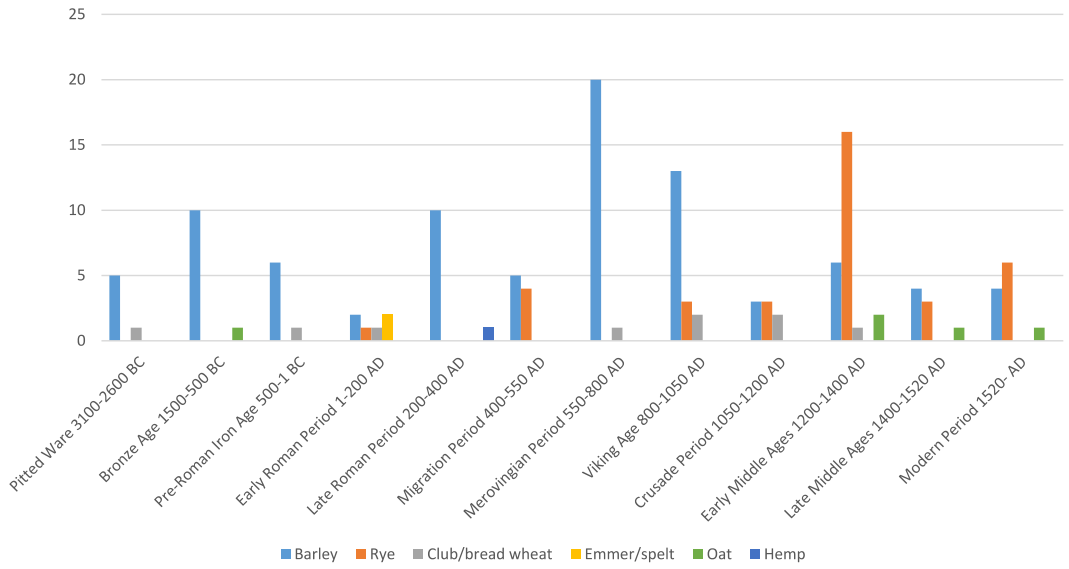


Figure 11 The number of dates of different taxa per archaeological period is based on the median value of each calibrated, radiocarbon-dated cereal grain or seed. Note that there is a hiatus in the dates falling between the Pitted Ware Culture and the Bronze Age (c. 2600–1500 cal BC) (data from Appendix I).

6.2.7 SITE ASSEMBLAGES OF CULTIVATED PLANTS

The 17 site assemblages presented in Figure 12 contain between 20 and 5,792 identified cereal grains. Only the Alatalo site dates back to the time before Christ, while the rest of the sites date roughly evenly throughout the first millennium AD and to the first centuries of the second millennium AD.

The compilation shows that barley dominates in all but two assemblages. Rye is dominant only in the two youngest assemblages, dated to cal AD 1000 and 1200. Rye is, however, present in nearly all the assemblages since the Roman Iron Age, but it does not increase gradually. Bread/club wheat is present in small quantities in some of the site assemblages during the first millennium AD. Emmer/spelt occurs in small quantities from the Roman Iron Age until the Merovingian Period (c. 200–800 AD). Oat is present at nearly all sites, but the identifications are based on grains only and it can thus represent even wild oat as well (*Avena fatua*).

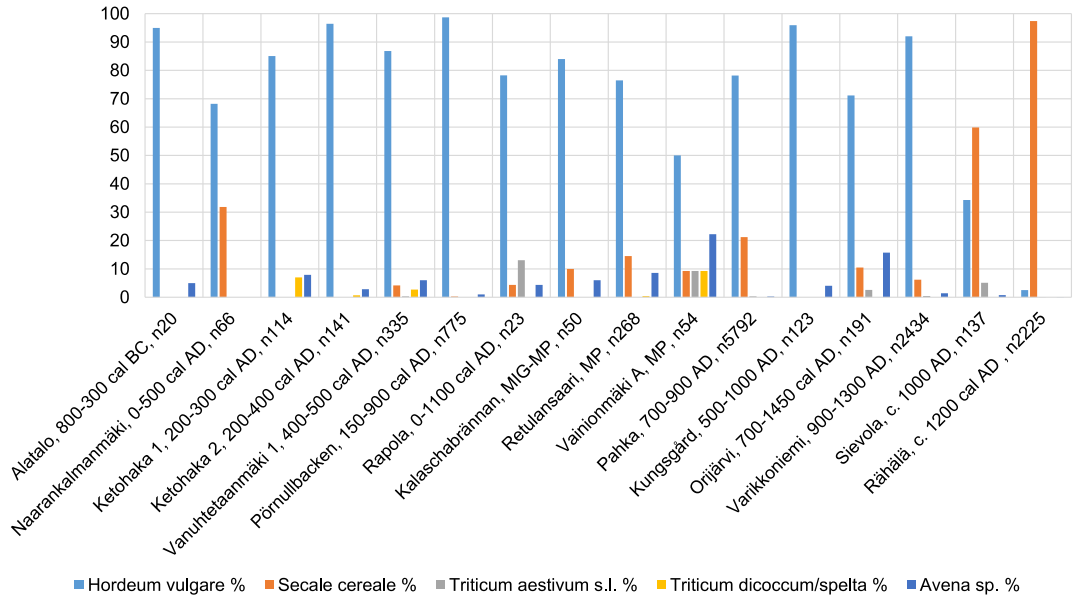


Figure 12 Percentages of identified cereal grains in archaeobotanical site assemblages with 20 or more cereal grains dated prior to c. 1200 AD. Cal: date based on radiocarbon dating from cereal grains (except Rähälä, where radiocarbon dates were obtained from charcoal); MIG: Migration Period; and MP: Merovingian Period. Only secure identifications of cereals are included (no cf. or Cerealia). *Triticum* cf. *aestivum* is included in *Triticum aestivum* s.l. Grain fragments are not included. Some sites included threshing remains of cereals, such as spikelet forks or rachis internodes, but these are not included in the counts (data based on Appendix II).

7 DISCUSSION

In this chapter, the findings presented in this thesis are compared with earlier archaeobotanical and archaeological data to better understand the long-term development of plant gathering and cultivation in Finland. The chapter starts with a discussion of wild plants. It aims to ascertain how we can identify plant gathering, what wild plants were gathered and how this practice developed in prehistoric Finland. This is followed by a discussion of plant cultivation, with the aim of establishing when plant cultivation began in Finland and where it originated. The discussion also aims to find out how plant cultivation developed after its onset and what crops were cultivated during different time periods.

7.1 PLANT GATHERING

7.1.1 INTERPRETATION OF WILD PLANT USE

Archaeobotanical remains of wild plants can be recovered using the flotation method, and these findings can be incorporated into prehistoric economy models. The identification of wild plant gathering is not, however, a straightforward process, but it can be studied with various models and approaches. Though it might be impossible to create a universal way to evaluate wild plant utilisation, each archaeobotanical assemblage should instead be considered within its temporal and spatial context.

Comprehensive and reliable archaeobotanical data advances our knowledge of plant gathering in the past. The density of plant remains at open air sites dating back to the Stone Age can be quite low, and thus, numerous samples of large volume are needed to gain a comprehensive view on the charred taxa present at a particular site. Direct AMS radiocarbon dates from plant remains should be used to obtain a reliable chronology.

Identification of gathered wild plants in archaeobotanical assemblages requires ethnographical, historical and other source material that provide information on how the plants could have been used (Berihuete-Azorín 2016). The possible food use of plants found in Finnish Stone Age archaeobotanical assemblages is discussed in detail in Paper I, with references to ethnographical and historical sources. In the paper, we propose that plants are found in charred assemblages mainly for reasons of 'food processing (roasting, smoking, frying, cooking), waste management, and fuel use' (cf. van der Veen 2007).

For the interpretation of wild plants in archaeobotanical assemblages, it is important to separate wild plant gathering from ecological interpretation, though both are important for gaining knowledge about a plant's use. This is

an issue especially for waterlogged remains, which often contain the remains of plants grown on a site or near a site (Behre et al. 1991, 83). It might be difficult to identify gathered plants in such assemblages (Colledge et al. 2014). Charred remains usually show a smaller diversity of species and are less suited to ecological interpretations (Behre et al. 1991, 83). A plant's modern ecological requirements can be used to study whether a plant might have been growing at a site or whether it might have been brought to the site from a different environment. Ecological interpretations should also consider changes in climate, vegetation and land area due to post-glacial land uplift.

It might well be that all plant species found in the charred assemblages should be taken into consideration when interpreting the use of wild plants because it is possible that even single charred remains represent utilised plants (Antolín et al. 2014; Jacomet 2013, 500). That the plant remains have been charred can be considered a sign of processing by people (Dietch 1996, 89). However, several such remains might represent plants used as fuel.

The subsistence mode of a society should be considered when interpreting wild plant use. Was it a hunter-gatherer or an agricultural society? If people cultivated crops, they might not have needed other starch-rich foods. The workforce might not have been available to collected various wild foods co-occurring with hay collection, harvesting or other agricultural tasks (Nunez 1991, 36). Did such people keep domestic animals? If so, they could have used animal manure for fuel, thus resulting in charred archaeobotanical remains of plants eaten by animals (van der Veen 2007, 979). These remains might be difficult to separate from plants gathered by people, and such remains could even originate from the dung of wild animals (Miller 1996).

Hunting and gathering remained the most important means of subsistence in Finland since the earliest Mesolithic period (c. 9000 cal BC) until at least 2000 cal BC. Archaeological remains from this period provide an extraordinary opportunity to study the long-term development of plant gathering. Studies of wild plants should not, however, be restricted to hunter-gatherers, but should instead encompass all types of societies. Such studies can reveal various aspects about long-term people-plant interactions.

7.1.2 DEVELOPMENT OF WILD PLANT USE

It would be fruitful to discuss the development of wild plant use in its entirety, but currently the imprecise chronological control for several archaeobotanical assemblages prevents this sort of discussion. Therefore, this section emphasises the use of hazel, water-lily and water chestnut, combined with a discussion on the long-time perspective of wild plant use based on materials studied in this thesis.

Altogether, 34 hazel remains have been AMS radiocarbon dated, and they can be used for discussing the changing importance of hazel over time. As shown in Figure 13, archaeobotanical remains of hazel occur first during the Stone Age (4500–2300 cal BC). Later, such remains occur between 800–0 cal

BC, cal AD 600–950 and cal AD 1050–1630. It should be noted that the number of dates is small. Seven of the ten medieval hazelnut dates originate from a single excavation at Aboa Vetus (Oinonen et al. 2011). It thus might be that hazel was used intermittently, but such a conclusion should be considered tentative and further dates can change the picture.

Nowadays, hazel grows in southern and south-western Finland (Figure 13). Based on palynological studies and geological hazelnut finds, hazel grew further north and was more common during the Holocene thermal maximum. The two southernmost hazel pollen curves presented in Figure 13 show increased proportions of hazel (c. 7000–2000 cal BC). After this period, the amount of hazel decreased, making it more difficult to find hazelnuts.

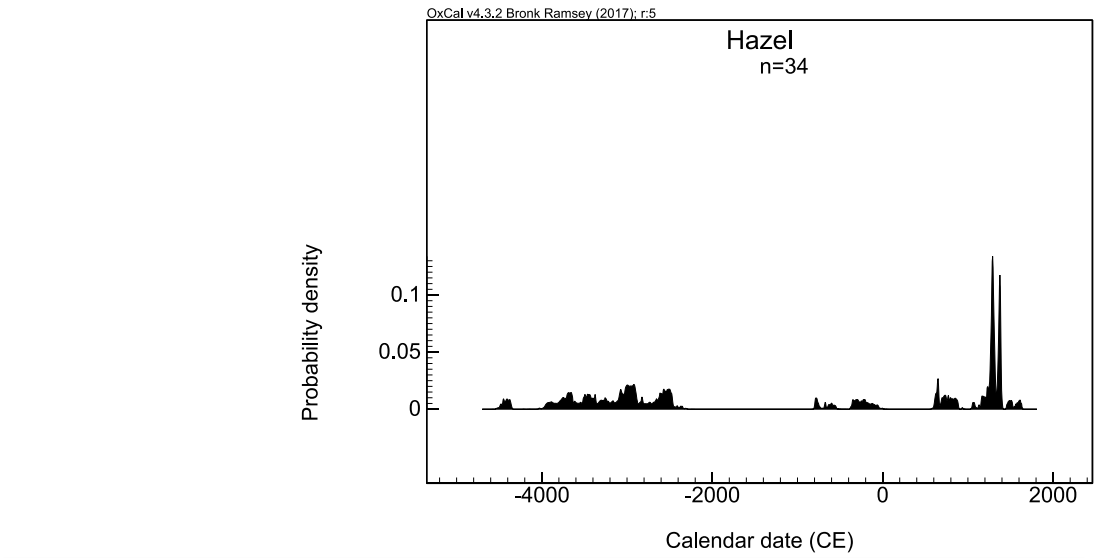
Archaeological finds of hazelnuts led Hertell (2009, 13) to suggest that hazelnut finds increase with increasing population. It has been suggested that the summed probability distribution of radiocarbon dates indicates a population peak during the years 4500–3500 cal BC (Tallavaara et al. 2011, 223). Hertell's suggestion was based on contextually dated finds of hazelnuts (Luoto 1991). The current compilation of AMS-radiocarbon-dated hazelnuts supports the assumption that hazel was used during this period (Figure 13), but whether the amount of hazel use increased with increasing population cannot be concluded with the current data.

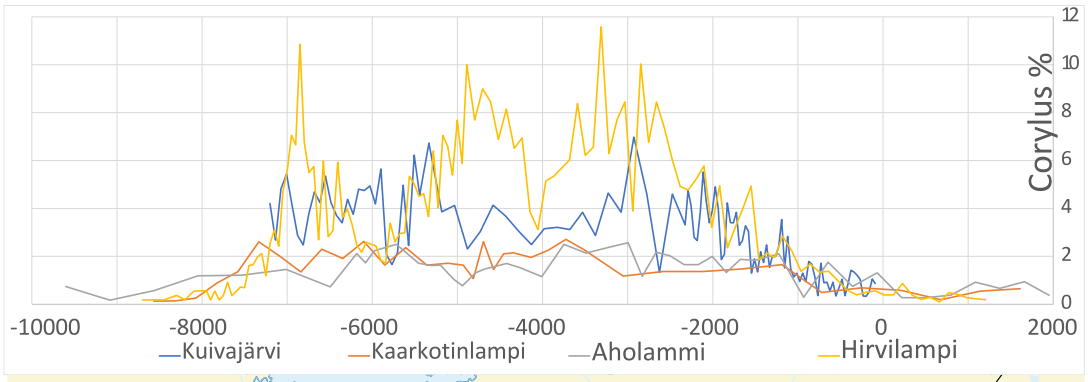
Hazel dates show a hiatus at approximately 2300–800 cal BC. Hazelnut use could indeed have diminished when plant cultivation became more important and hazel became rarer. However, only a few archaeobotanical analyses have been conducted on Bronze Age sites, and only future studies can determine whether the use of hazel actually diminished during that time.

Figure 13 shows that hazelnut dates reappeared during the Late Bronze Age, even though the proportion of hazel pollen had diminished. During the Middle Ages, hazelnuts might even have been imported from abroad. Archaeobotanical evidence shows the import of figs and grapes, and the import of rye is likewise known from written sources (Lempiäinen 2007, 108, 111).

Hazel has been considered an important source of nutrients especially prior to the introduction of agriculture (Mithen et al. 2001; Holst 2010; Regnell 2011). The nuts can be eaten raw, boiled and roasted, and oil can be extracted from the nuts (Bishop et al. 2013, 36–39; Lönnrot et al. 1866). Hazelnuts are rich in fat, containing 61 grams of fat per 100 grams (Unknown 2019). Scholars have discussed whether the charred nuts represent roasted nuts or burned waste from nut processing (Bishop et al. 2013, 36–39; Kubiak-Martens 1999, 123). Roasting indeed improves the taste and preservation of the nuts (Holst 2010, 2874; Bishop et al. 2013, 37). Experiments have, however, shown that if the nut shells are charred during the roasting, the kernel inside is rendered inedible (Mithen et al. 2001 and cited literature). Charring experiments have also shown that it is possible from the archaeobotanical finds of hazelnut shells to discern whether the nuts were opened before or after they were charred (López-Dóriga 2013). It has been suggested that large accumulations of hazelnut shells could represent their intentional preservation (Mithen et al.

2001) and that hazelnut could have contributed substantially to the Mesolithic human diet (Holst 2010). Though such concentrations have not been found in Finland, hazel would indeed have contributed to the diet of local hunter-gatherers and farmers.


OxCal v4.3.2 Bronk Ramsey (2017); r:5
Hazel
n=34
Probability density
0.1
0.05
0
-4000
-2000
0
2000
Calendar date (CE)


Corylus %
12
10
8
6
4
2
0
-10000
-8000
-6000
-4000
-2000
0
2000
Kuivajärvi
Kaarkotinlampi
Aholammi
Hirvilampi

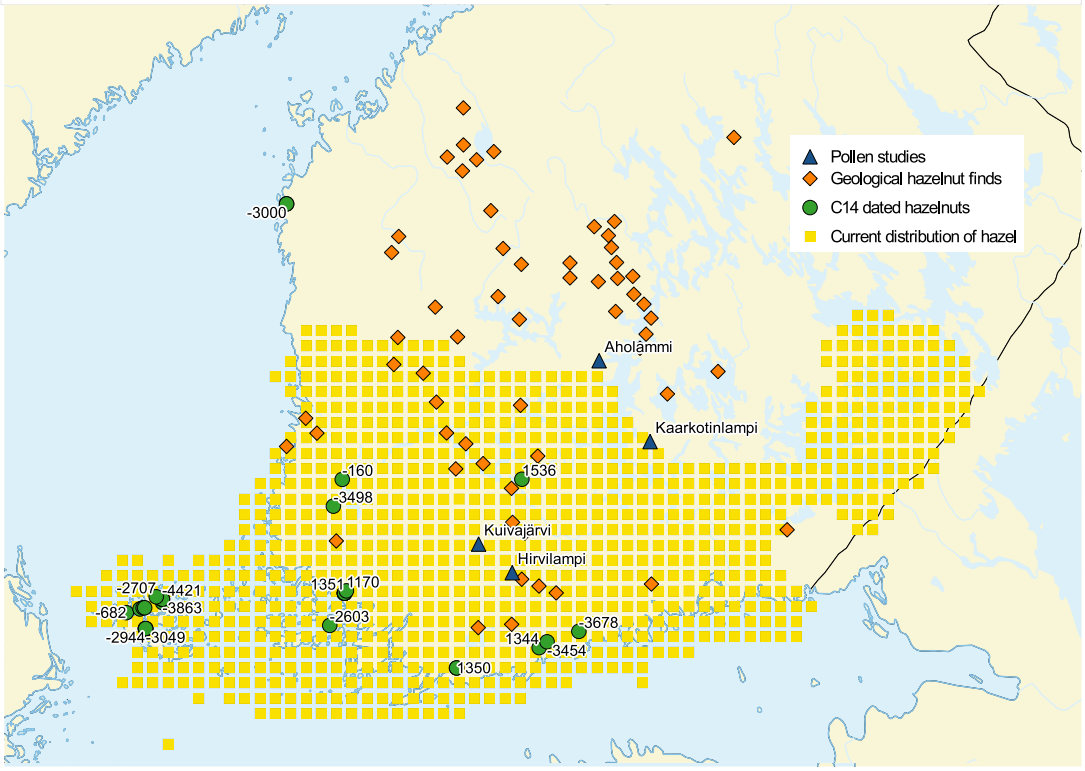

Pollen studies
Geological hazelnut finds
C14 dated hazelnuts
Current distribution of hazel
-3000
Aholammi
Kaarkotinlampi
-160
1536
-3498
Kuivajärvi
Hirvilampi
-2707
-4421
-682
-3863
-2944
-3049
1351
1170
-2603
-3678
1344
-3454
1350

Figure 13 Sum of radiocarbon-dated hazelnuts from Finland (data from Appendix I), four percentage curves of hazel and the location of the sites. Pollen data for Hirvilampi (Rankama et al. 1988), Kuivajärvi (unpublished data), Kaarkotinlampi (Vuorela 1981) and Aholammi (unpublished data) were obtained from the European Pollen Database. Geological finds of hazelnuts were obtained from Eriksson et al. (1991). Median calibrated values of hazelnut dates are marked on the map. Modern distribution of hazel is marked with squares (Lampinen et al. 2016).

Discussion regarding changes in the use of other wild plants relies on contextual dates, because only four such remains have yet been dated to the prehistoric period in southern Finland (south of 66 degrees north) (Appendix I). Stone Age finds from mainland Finland are shown in Table 3 and remains from other Stone Age and later sites in Table 4.

These findings show continuity and change in the long-term use of wild plants. The use of certain plants, such as hazel, raspberry, wild strawberry, juniper, bearberry and bird cherry, continued from the Stone Age until the historical period. It is possible that the use continued because these plants were not collected only for nutritional purposes but were instead collected for their taste or medicinal effects.

It appears that the use of certain plants diminished after the introduction of agriculture. One such plant is water-lily. Yellow and white water-lilies have been found at several Stone Age and some Bronze Age sites, and altogether 127 yellow water-lily seeds were found at the Stone Age site Koskenniska (Paper I; Appendix II). At the sites compiled in Paper I, the remains of yellow and/or white water-lily co-occur with cereals only at the multiperiod site of Böle. Water-lily grows virtually everywhere in Finland, so the use of this plant must have ceased for reasons other than its availability. It is possible that people stopped using water-lilies when they started cultivating cereals. Yellow water-lily seeds have 80 grams of carbohydrates per 100 grams, whereas the roots have 7.1 grams (Unknown 2019). Possibly the carbohydrates obtained from water-lilies were replaced by carbohydrates from cereals. It is also possible that collecting the seeds of water-lilies clashed with an intense period of agricultural work (Nunez 1991, 36).

Both the seeds and the roots of yellow water-lily are edible. The roots of water-lilies have been used as an emergency food (Wallenius 1782, 31). Use of the roots has not been confirmed by archaeobotanical studies, but this might be due to the fact that identifying such remains is not a common procedure during archaeobotanical analyses (Hather et al. 2002, 2). It might also be that the roots had so few carbohydrates that they were only used in extreme need. It has been suggested that large numbers of seeds indicate processing or storage of the plant (Warren et al. 2013, 634). It thus appears that the plant could have served as a staple food during the Stone Age.

Water chestnut occurs at Stone Age sites in southern Finland, but there is no later archaeological evidence of its use. Use of locally grown water chestnut ceased, at the latest, when it became extinct in Finland. A water chestnut remain from an archaeological context in Kårböle folkskola has been

radiocarbon dated to 3634–3358 cal BC (Appendix I) (Lesell 2005, 104). Water chestnut from a detritus mud layer in Karhejärvi has been dated to 5736–5339 cal BC (6620±120 BP) (Alhonen 1964, 195). Pollen and macrofossil studies show that water chestnut grew in Finland at approximately 6600–600 cal BC (Korhola et al. 1997, 43), but the limited number of archaeobotanical finds hamper the effort at making any conclusions on the development of its use.

Finds of charred water chestnut remains from archaeological sites indeed show that the plant was used by prehistoric people. Water chestnut has high calorific content, and the nuts can be roasted so that they can easily be opened (Karg 2006, 129; Tolar et al. 2011, 212). The roasting even improves preservation and the nuts can be preserved throughout winter (Azorin et al. 2014, 75). They can be eaten raw or prepared as flour (Aalto et al. 1985, 175). Aalto (1983, 91) has noted many water chestnuts shells in southern Finland are found broken and therefore probably crushed by humans. Such a practice has been directly demonstrated by wooden mallets shaped like table-tennis bats, found at the waterlogged Stone Age site of Sārnate in Latvia, which were used to open the nuts, as evidenced by the occasional water chestnut shell fragments embedded in them (Bērziņš 2008, 346). The advantage of being able to preserve the nutritious nuts throughout winter, would have made them a desired staple for the Stone Age hunter-gatherers.

7.2 ONSET AND DEVELOPMENT OF PLANT CULTIVATION IN FINLAND

The onset and development of plant cultivation in Finland is discussed here based on a compilation of radiocarbon-dated cultivated plants and site assemblages of cultivated plants (section 6.2.6; Appendixes I–II). In addition, pollen, the bones of domestic animals, agricultural implements and agricultural structures and lipid analyses of ceramics are considered in this section.

7.2.1 THE COMB WARE AND FUNNEL BEAKER CULTURES

Based on palynological studies, it has been suggested that Comb Ware groups practiced small-scale cultivation of buckwheat at approximately 5300 cal BC, barley from approximately 4000 cal BC onwards and hemp between approximately 4400 and 3200 cal BC (Alenius et al. 2013, 17; Alenius, Mökkönen, et al. 2017, 480). However, no AMS-dated macrofossil remains of cultivated plants have been found for the Comb Ceramic groups living in Finland or the Baltic countries (Grikpėdis et al. 2017; Piličiauskas et al. 2017). Macrofossil remains of these plants on mainland Finland date much later: buckwheat to the Late Medieval period (Lempiäinen 2007, 105), barley to the

second millennium BC (Paper II; Vuorela et al. 1988, 36) and hemp to the Late Roman Iron Age (Paper IV).

The earliest cereal grains found in southern Scandinavia date back to approximately 4000 cal BC (Sørensen et al. 2012). Further north, in east-central Sweden, the earliest cereal grains are nearly contemporaneous and date back to approximately 3950–3700 cal BC (Figure 14; Paper II). In east-central Sweden, Early Neolithic (4000–3300 cal BC) securely identified cultivated cereals consist of naked barley, emmer/spelt and naked wheat (Paper II). The spread of cultivation is connected with the Funnel Beaker Culture (Sørensen 2014, 263), which according to a recent ancient DNA study was introduced into Sweden by migrating people from Central Europe (Mittnik et al. 2018).

The currently available, directly dated plant macrofossils of cultivated plants show that cultivated plants have been found in southern Scandinavia and associated with remains of the Funnel Beaker Culture, whereas no finds of cultivated plants in the eastern Baltic have been associated with the Comb Ware Culture. Macrofossil plant remains have, however, been studied much less in the eastern Baltic than in southern Scandinavia, hence future studies can change the current picture.

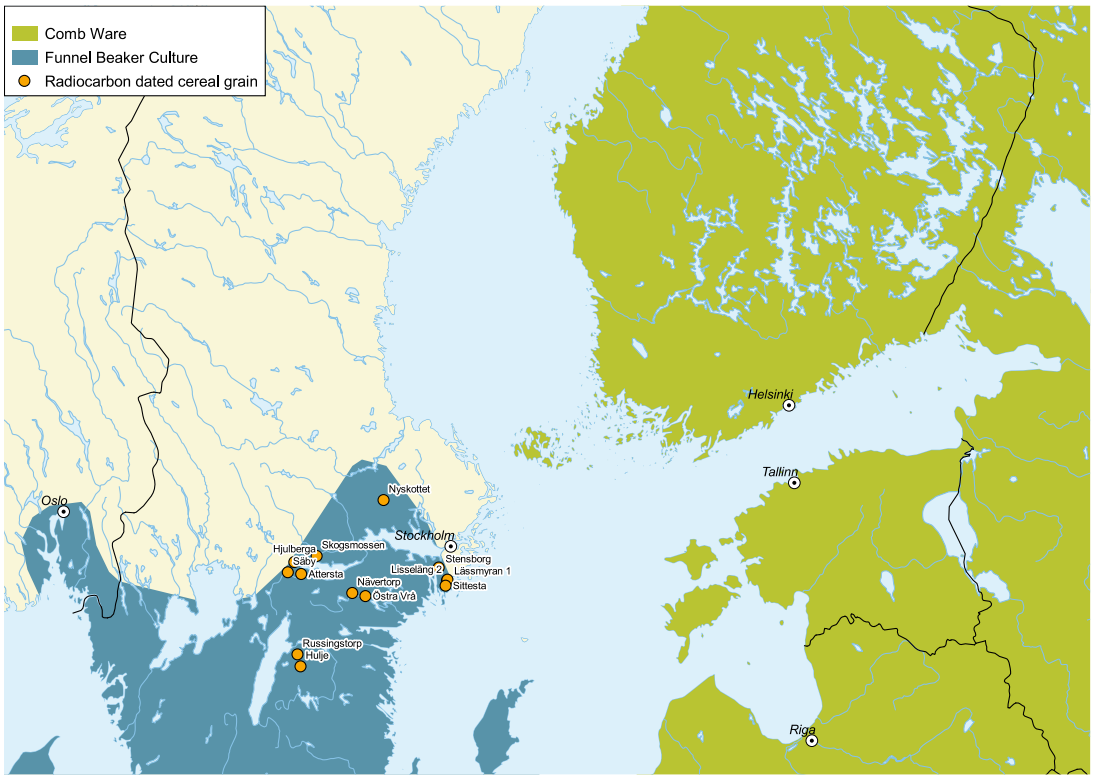


Figure 14 Cereal grains AMS dated to the Swedish Early Neolithic period (4000–3300 cal BC) in the northern Baltic and distribution of the Funnel Beaker Culture (main area of pointed-butted flint axes) (Gron et al. 2018, 961) and Typical Comb Ware (Nordqvist 2018, 102) (dates and a more detailed map are presented in Paper II; data collected NE of Hulje).

7.2.2 THE PITTED WARE CULTURE

Funnel Beaker groups interacted with Mesolithic and Comb Ware groups in east-central Sweden since the first half of the fourth millennium BC, as evidenced by ceramic manufacture, stone technology and means of subsistence (Hallgren 2011; Larsson 2011; Hallgren 2008; Sørensen 2016). This has been suggested to have led to the development of the Pitted Ware Culture (c. 3500 cal BC) (Larsson 2009a, 58; Larsson 2009b, 264). Climatic cooling in the mid-4th millennium BC possibly caused the Funnel Beaker groups to leave east-central Sweden (Warden et al. 2017, 6); during the period 3300–2800 cal BC, Funnel Beaker groups were inhabiting mainly southern Sweden (Figure 15).

According to AMS-radiocarbon-dated cereal grains, cultivated plants occur continuously from the Early (4000–3300 cal BC) to the Middle Neolithic (3300–2300 cal BC) periods in east-central Sweden (Paper II). Funnel Beaker influences on the Pitted Ware Culture and continued cereal use show that these cultures appear to have formed a community of practice, where the Pitted Ware groups learned cereal cultivation from the Funnel Beaker groups.

During the Middle Neolithic period, cereal grains are associated with the Pitted Ware Culture inhabiting maritime locations (Figure 15, Figure 16). The earliest cereal grains occur on Åland (3324–2495 cal BC). Here, no remains of the Funnel Beaker Culture have been discovered (Stenbäck 2003), and thus, the first cultivated plants must have been brought to Åland by Pitted Ware groups.

Did Pitted Ware groups cultivate these cereals themselves? During the Middle Neolithic A (3300–2800 cal BC), cereal grains have been found at the sites of Jettböle I, Sittesta, Åby and Stensborg, located in east-central Sweden and Åland (Figure 15; more detailed maps are provided in Paper II). It has been suggested that Pitted Ware groups could have traded for cereals from Middle Neolithic Funnel Beaker groups, distributed mainly in southern Sweden (Svizzero 2015, 336). Archaeological indications of import from the Funnel Beaker Culture to the Pitted Ware Culture, however, diminished during this period (Malmer 2002, 99). Alvastra is the closest area where Middle Neolithic Funnel Beaker Culture remains have been found, and it is situated approximately 370 km southwest of Åland (Paper II; Figure 1). The transport of cereals would thus have required long-distance journeys.

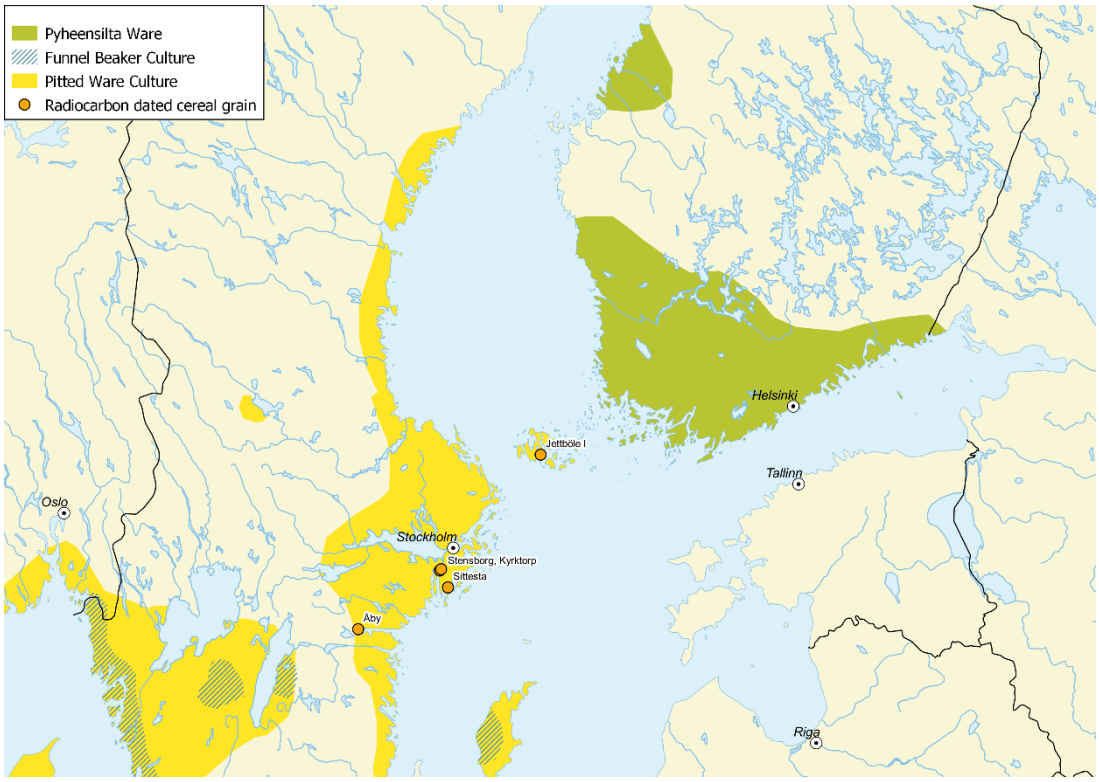


Figure 15 Cereal grains AMS radiocarbon dated to the Swedish Middle Neolithic A (3300–2800 cal BC) and distribution of Pitted Ware Culture (Malmer 2002; Björck 1997), Megalithic Funnel Beaker Culture in Sweden (Malmer 2002) and Pyheensilta Ware culture (Pesonen 1999) (details of AMS-dated cereals are provided in Appendix I and Paper II (east-central Sweden and Åland; The mapped area consists of Finland and east-central Sweden (northeast of Åby)).

During the Middle Neolithic B (2800–2300 cal BC) (Figure 16), the Corded Ware Culture spread into large areas of Europe, also reaching Finland and Sweden. It has been suggested that Corded Ware groups would have provided Pitted Ware groups with cereals and other agricultural products (Welinder 1976, 29–30; Storå 2000, 74). Interactions between these groups are demonstrated by finds of Corded Ware ceramics at Pitted Ware sites and similar ground plans for the so-called death houses of the two groups (Artursson 2007; Larsson 2009a, 411). There are indeed some finds of cultivated plants and plant impressions from Corded Ware sites in east-central Sweden and Estonia (Ahlfont et al. 1995, 156–158; Kriiska 2009, 168), but the small number of such finds makes it difficult to evaluate which groups actually grew the cereals.

Further indications of cultivation by Pitted Ware groups during the Middle Neolithic period include cereal pollen finds in east-central Sweden (Karlsson 2007, 304). In addition, grindstones at Pitted Ware sites on Åland and in east-central Sweden show that the material culture would have been suitable for processing agricultural products (Paper II, Edenmo et al. 1997, 179; Meinander 1964, 19). Further, some domestic animal bones have been found at Pitted Ware sites in east-central Sweden and on Åland, and the osteological

materials indicate relatively sedentary settlements, which demonstrate that people could have been present at these sites during the crop growing season (Storå 2002, 62; Mannermaa 2002, 94; Bäckström 2007).

Only small islands and skerries had risen from the sea prior to the Pitted Ware occupation of the Åland Islands, which were submerged after being pressed down by the continental ice sheet during the last glaciation period. It is possible that the insufficient land area hindered the islands from being occupied by Funnel Beaker groups during the Early Neolithic (4000–3300 cal BC). When the islands were later occupied by Pitted Ware groups (3300 cal BC), the land area with light soils suitable for cultivation had greatly expanded (Paper II). Pitted Ware groups occupying Åland would thus have had enough land area for small-scale cultivation.

In conclusion, the combination of AMS-radiocarbon-dated cereal grains, reduced trade contacts, long trade distances, finds of grindstones, the newly revealed soils on Åland, cereal pollen in east-central Sweden and presence of sedentary settlements make it probable that Pitted Ware groups cultivated their cereals on the Åland Islands and in east-central Sweden during the Middle Neolithic A. This practice appears to have continued during the Middle Neolithic B. As demonstrated by nitrogen and carbon isotope studies of human skeletons, these people had a pronounced maritime diet (eg. Fornander et al. 2008; Eriksson 2004). Cultivation appears thus to have been at a small scale and the products were possibly only used during special occasions, such as feasts (Paper II).

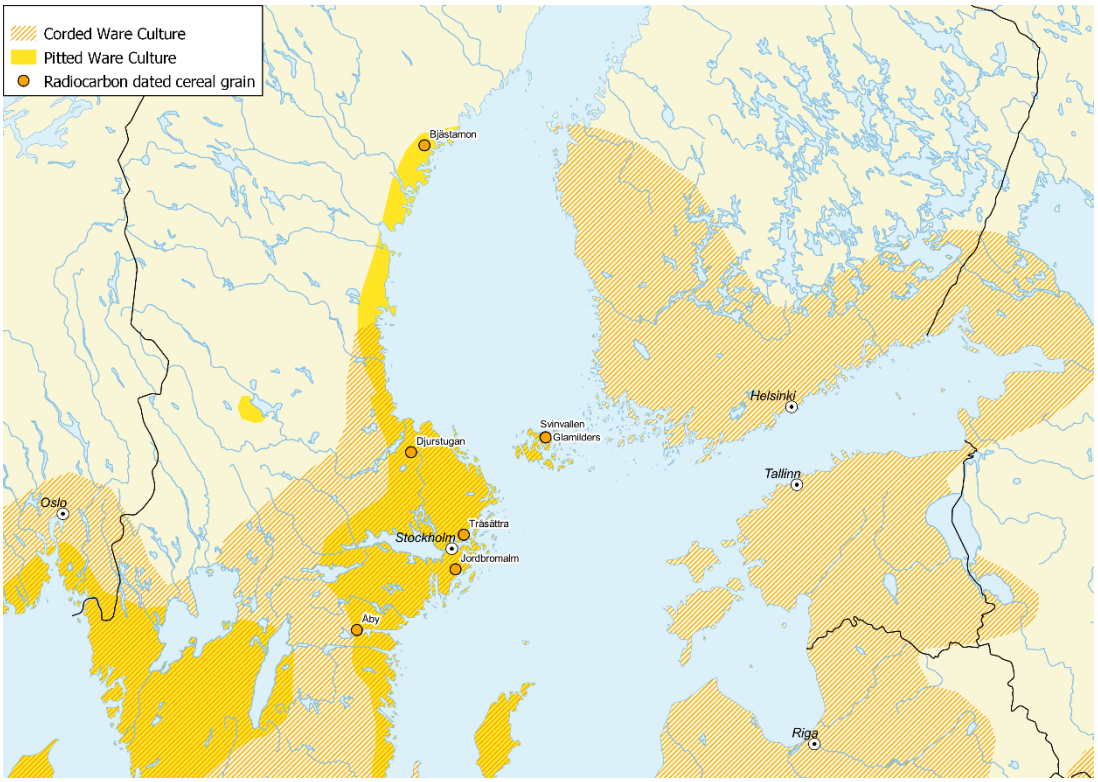


Figure 16 Cereal grains AMS radiocarbon dated to the Swedish Middle Neolithic B (2800–2300 cal BC) and the distribution of Pitted Ware Culture (Malmer 2002; Björck 1997, 22) and Corded Ware Culture (Müller et al. 2009, 126) (details of AMS-dated cereals are provided in Appendix I and Paper II (east-central Sweden and Åland); mapped area consists of Finland and east-central Sweden (northeast of Åby)).

7.2.3 THE CORDED WARE CULTURE

There is approximately a 1000-year hiatus in the dates of cultivated plant remains in Finland and Åland between 2600 cal BC and 1500 cal BC (Figure 10). No cultivated plants have been found among the Corded Ware groups (2800–2300 cal BC) in Finland for the purposes of this thesis or in other studies (Figure 16) (Paper II, Zvelebil 1981; Edgren 1984, 10–11). However, small amounts of cultivated plants have been found in neighbouring areas: a single barley grain and a single barley impression from Estonia (Vassar 1939, 88; Jaanits 1992, 49) and two impressions of naked barley and one impression of emmer or einkorn wheat in east-central Sweden (Ahlfont et al. 1995, 156–158). Dairy fats, ruminant carcass fats and possible marine fats have been discovered in Corded Ware vessels in southern Finland (Cramp et al. 2014). Mineralised goat hairs have been identified in a Corded Ware grave in Ostrobothnia (Ahola et al. 2018). The Corded Ware groups in the region thus had access to domestic plants and animals. These areas had lively exchange networks (Holmqvist et al. 2018), and it is therefore possible, but not shown by archaeobotanical finds, that cultivated plants were also used in Finland. Throughout the area of Corded Ware distribution, it has been difficult to discover evidence of agriculture, but both cereals and domestic animals have been discovered at several locations (Sjögren et al. 2016, 3). It might thus be that the combination of only a few excavations at Corded Ware sites and the difficulty in locating Corded Ware settlements have hindered the discovery of domestic plants.

7.2.4 THE LATE NEOLITHIC

The hiatus in domestic plant finds continued during the period ranging from approximately 2300 to 1800 cal BC. However, the earliest domestic animal bones from Finland date back to approximately 2000 cal BC. These consist of sheep/goat bones from Ostrobothnia and cattle and possibly domestic pig bones found in the Åland Islands (Bläuer et al. 2013, 1651; Storå 2000, 61). Cerealia- and *Hordeum*-type pollen have been discovered in southwestern Finland dating back to approximately 2000–1300 cal BC, which corresponds with the Late Neolithic or Early Bronze Age (Alenius 2008, 579; Asplund et al. 1989, 75). Quern stones have been suggested to have been introduced during the Kiukainen period, but the dating of these is uncertain because they have been discovered from multi-period sites (Asplund 2008, 251–252). Lipid analyses from the Kiukainen Ware indicate the use of ruminant and possibly marine fats with minor signs of milk use, even though it has been suggested

that these people returned to a hunter-gather-fisher lifestyle (Cramp et al. 2014; Pääkkönen et al. 2019). Based on summed radiocarbon dates, population of Finland has been suggested to decline during approximately 3500–2000 cal BC (Tallavaara et al. 2011). Though partly local in its character and characterised by a hunter-gatherer lifestyle, the Late Neolithic period bears some evidence of agriculture. No macrofossils of cultivated plants have been dated to that period in Finland, but there are such finds from the Swedish side of the Bothnian coast (Figure 17).



Figure 17 Cereal grains AMS radiocarbon dated to the Swedish Late Neolithic period (2300–1800 cal BC) (Paper II; mapped area consists of Sweden north of Stockholm and Finland).

7.2.5 THE BRONZE AGE

Directly dated remains of cultivated plants and archaeobotanical assemblages show that plant cultivation was conducted in Finland during the Bronze Age (Figure 18). Barley is thus far the only securely identified cereal crop on the main islands of Åland and mainland Finland, whereas a richer diversity of cultivated and probably imported plants were discovered at the Otterböte site.

Several Cerealia pollen finds in southern Finland typically date back to the Bronze Age (Lahtinen et al. 2016). Cattle, sheep and horse bones show that animal husbandry was practiced on Åland and in southwestern Finland at the time (Bläuer et al. 2013, 1651; Storå 2000, 61). Likewise, lipid analyses indicate dairy milk use in southwestern Finland (Cramp et al. 2014). The earliest securely dated quern stones in mainland Finland appear during the Late

Bronze Age (Asplund 2008, 252). Flint sickles originating from the Mälaren Valley have been mainly discovered in southwestern Finland and the Åland Islands (Salo 1972; Siiriäinen 1984). Agricultural practices are thus indicated by various lines of evidence.

Bronze Age agriculture in Finland might have fourfold origins: from the Mälaren Valley, northern Poland, Russia and the eastern Baltic. Scandinavian Early Bronze Age artefacts have been mainly found in southwestern Finland, southern Ostrobothnia and the Åland Islands (Siiriäinen 1984). Burial cairns made of stones were introduced during this period from Scandinavia (Salo 1984). The appearance of cairns and other artefact finds show that the Mälaren Valley's cultural influence on southwestern Finland continued from the Late Neolithic period onwards (Siiriäinen 1984). Ceramic vessels during the Late Bronze Age show affinities with the eastern Baltic area, and this has been suggested to indicate migration from the area of modern Russia into Baltic countries, Finland and east-central Sweden (Lang 2015). The distribution of flint sickles, bronze artefacts and burial cairns correspond with the main distribution of cereal grains, dairy lipids and the bones of domestic animals dated to the period (Figure 18) (Bläuer et al. 2013; Cramp et al. 2014; Siiriäinen 1984, 54; Salo 1972, 159; Pääkkönen et al. 2019).

Possible agricultural influences from northern Poland are demonstrated by the material studied at Otterböte, a seal hunting station located in the outer archipelago of Åland and dated to approximately 1200 cal BC (Gustavsson 1997). Plant impressions at the site include hulled and naked barley, emmer, possibly einkorn (*Triticum monococcum*), spelt, oat, millet (*Panicum miliaceum*), chick pea (*Cicer arietinum*), grass pea (*Lathyrus sativus*) and various wild plants (Hjelmqvist 1997). The occurrence of thermophilous plants has been interpreted to indicate that the plants were cultivated further south and the ceramics were brought to the island, probably from northern Poland (Hjelmqvist 1997; Gustavsson 1997). Unfortunately, the limited amount of contemporary archaeobotanical materials on mainland Finland and elsewhere in Åland makes it difficult to evaluate how these contacts would have influenced agriculture in Finland.

Palynological (Meinander 1984, 14) and macrofossil results (Lavento 1998, 50) have raised the idea that textile ceramic groups, originating from modern Russia, practiced agriculture as well. One barley grain has been dated to the Bronze Age in the inland region of Finland, where the bronze artefacts and ceramics have eastern origins (ibid.). Currently, there have been no reliable finds of domestic animals at textile ceramic sites (Bläuer et al. 2013). Cultivation by textile ceramic groups appears possible, but very little is still known about it.

In conclusion, evidence for plant cultivation and animal husbandry have been found in coastal areas receiving cultural influences from the Mälaren Valley and the eastern Baltic. Inland areas might have received agricultural influences from the east, but this hypothesis must be studied in more detail. The southern Baltic region might have influenced agricultural development,

but it might also be that these groups did not engage in local cultivation on the islands they visited (Hjelmqvist 1997). It is also possible that cultivation continued from earlier periods, but such a proposition is difficult to evaluate with the current archaeobotanical data.

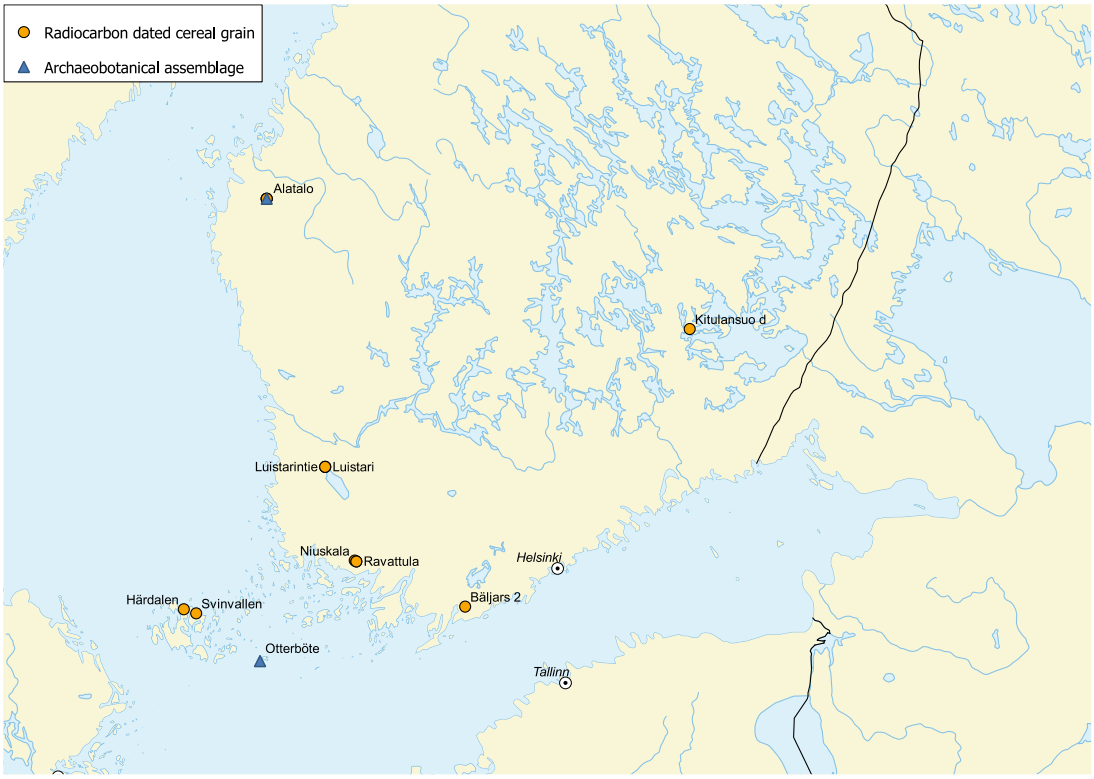


Figure 18 Cereal grains AMS radiocarbon dated to the Bronze Age in Finland, 1500–500 cal BC (Appendix I; Paper II) and locations of archaeobotanical assemblages dated to the period (Figure 12 ; Appendix II) (Otterböte is not included in Figure 12, but discussed instead in the text; mapped area consists of Finland).

7.2.6 THE PRE-ROMAN IRON AGE

Signs of cultivation and animal husbandry occurred in roughly the same areas during the Pre-Roman Iron Age as during the preceding Bronze Age. This evidence of agricultural practices overlaps with the distribution of the Morby Ware pottery style (Figure 19; see more on Morby Ware in Paper III: Fig. 1).

Currently, the archaeobotanical material is so limited that it is impossible to discern distinct changes in cereal cultivation between the Bronze Age and the Pre-Roman Iron Age. In addition to barley, a grain of bread/club wheat dates back to the period (Figure 11), and rye pollen occurs sporadically during the Pre-Roman Iron Age, though some finds date already back to the Late Bronze Age (Alenius 2008, 579; Alenius et al. 2013, 15–16; Vuorela et al. 1988, 40).

Bones of sheep/goat and cattle have been dated to the period (Bläuer et al. 2013). Dairy milk, ruminant and non-ruminant carcass and possibly aquatic product use is shown in Morby vessels found in southern Finland (Cramp et

al. 2014; Pääkkönen et al. 2019). Iron sickles and scythes were found in the Malmsby hoard and represent the earliest agricultural implements made from metal in Finland (Asplund 2008, 243–245).

The Pre-Roman Iron Age shows possibly the first evidence of agricultural land use in the form of clearance cairns and ard marks. Clearance cairns have been discovered in coastal regions, and some of them contain early Iron Age pottery sherds and have provided Pre-Roman Iron Age dates, whereas the cairns mainly date to later periods (Taivainen 2010, 9–12; Taivainen 2004; Forsén et al. 1995, 26–32). The construction of a clearance cairn is difficult to date, and several dates from different layers in the cairns are preferred to attain a convincing chronology (Lagerås et al. 2003, 89). No such studies have yet been conducted in Finland. Ard marks dating most probably back to the Pre-Roman Iron Age were found at Bäljars 2 (Paper III). They consisted of dark linear features organised in a crosswise pattern, which could represent the remains of an ancient field ploughed with a simple ard. The find from Bäljars 2 is possibly the oldest find of an ancient field in Finland. Both clearance cairns and ard marks should be studied in more detail to confirm their age.

Charcoal analysis at Bäljars 2 suggests that fields were cleared to form nutrient rich groves (Paper III). A Bronze Age (R5) context was dominated by ash (*Fraxinus excelsior*) and Norway maple (*Acer platanoides*), with charcoal deriving most probably from their trunks. A later context dated to the Pre-Roman Iron Age (L5) contains a high variety of taxa and charcoal from both trunks and branches dominated by willow (*Salix* sp.) and birch (*Betula* sp.). Material studied in Hamneda, in southern Sweden, has been interpreted as the clearance of oak (*Quercus*), followed by the maintenance clearance of secondary trees, such as birch and hazel (*Corylus avellana*) (Lagerås et al. 2003, 89–90). This might also be the case at Bäljars 2, where forests of ash and Norway maple were cleared for the first cultivation during the Bronze Age. During the Pre-Roman Iron Age, secondary trees, such as willow and birch, were growing in the area, and these trees were then managed with fire.

The results above show that agriculture is increasingly visible in the archaeological record of the Pre-Roman Iron Age, whereas in Uusimaa this is barely reflected in the landscape. Here, Landscape Reconstruction Algorithm modelling shows that only approximately 0.05% of the land was covered by cropland between approximately 500 cal BC and cal AD 950 (Alenius, Haggrén, et al. 2017, 23). It is, however, possible that larger land areas were used for crop growing elsewhere in Finland.



Figure 19 Cereal grains AMS radiocarbon dated to the Pre-Roman Iron Age, 500–0 cal BC (Appendix I; mapped area shows Finland).

7.2.7 THE ROMAN IRON AGE AND MIGRATION PERIOD

Barley was the main cultivated crop during the period, and based on materials studied in Isokylä, both hulled and naked barley were cultivated in roughly equal numbers (Paper IV, sites Ketohaka 1 and 2 and Vanutehtaanmäki 1 in Figure 20). Compared to the preceding periods, the Roman Iron Age and the Migration Period show a diversification of crop cultivation. According to radiocarbon-dated macroremains, rye, spelt/emmer and hemp occur for the first time. Of these macroremains, rye is already evident in pollen finds from earlier periods. Flax has been found at sites dating back to the same period (Aalto 1997). A silicified lentil seed (*Lens esculenta*) was discovered at a Migration Period site (Luoto et al. 1983), but currently it is the only archaeobotanical find of the species in Finland (Lempiäinen 2007). No dated cereal grains or site assemblages have been found on the Åland Islands (Figure 20), where weak pollen signs of agriculture are visible already during the early Iron Age and somewhat continuous cultivation began at cal AD 350–400 (Alenius 2014).

Currently, there are no ard marks indicating ancient fields dating back to the Roman Iron Age or Migration Period in Finland. Based on a single date, a clearance cairn in Hattula could have been used during the Migration Period (Taivainen 2010, 173). In contrast, the amount of agricultural implements increased during the Roman Period, as evidenced by finds of sickles used for

reaping cereals, scythes for collecting hay for animals and billhooks for collecting leaf fodder for animals (Varjola 1969, 66). The number of these implements, however, decreased dramatically during the Migration Period (c. 400–550 AD) (ibid.). Domestic sheep, sheep/goats and cattle have been dated to the period (Bläuer et al. 2013), and the collection of fodder for farmyard animals is demonstrated by finds of meadow and wetland plants (Paper IV).

In conclusion, the amount of cultivated species increased during the Roman Iron Age and Migration Periods, but it must be kept in mind that currently only a few archaeobotanical analyses have been conducted at sites dating back to these periods and preceding periods. Agricultural tools were relatively common during the Roman Period, and bones of domestic animals have been found at some sites, but both these indications of agricultural activities decrease during the Migration Period. The decrease in agricultural implements in graves might, however, be related to changes in ritual traditions. It is also interesting to note that rye grains make up a large proportion of the grains with a median date falling in the first half of the 6th century (Figure 11), which coincides with the Late Antique Little Ice Age (dated c. 536–660 AD) (Büntgen et al. 2016). Rye tolerates cold climates quite well, so its cultivation might have increased during this period.



Figure 20 Early first millennium, cal AD 0–550, cereal grains (Appendix I) and archaeobotanical assemblages (Appendix II, Figure 12).

7.2.8 THE MERONGIAN PERIOD, VIKING AGE AND CRUSADE PERIOD

The largest amount of prehistoric archaeobotanical assemblages is available for the period AD 550–1200. These assemblages show that the cultivated plant spectra changed somewhat during the second half of the first millennium AD (section 6.2.6).

Barley was the main crop. Both naked and hulled barley were cultivated, but based on the current material, the amount of naked barley diminished during the second half of the millennium. It has been proposed that hulled wheats were phased out during the Merongian Period (Onnela et al. 1996, 251), and accordingly there have been no AMS-dated finds of hulled wheats later than the Migration Period, even though emmer has been found in the Merovingian Period cemetery Vainionmäki A (Aalto 1996). Naked wheat cultivation continued. The amount of rye increased in coastal regions during the first centuries of the second millennium AD (Figure 11, Figure 12), which appears to be connected with migration from Sweden to the southern coast of Finland (Lempiäinen-Avci 2019, 26). Oat was present in small numbers. Flax cultivation is demonstrated by Late Iron Age finds from Kungsgård and Retulansaari (Nuñez et al. 1992; Sarkamo 1970, 42; Lempiäinen 2011). Hemp has been discovered at Kungsgård, Orijärvi and Varikkoniemi (Paper V, Lempiäinen 1993; Nuñez et al. 1992; Lempiäinen 1999). A novelty for the period is the oil plant gold-of-pleasure (*Camelina sativa*), found at Kalaschabrännan and Vainionmäki (Engelmark 1991; Aalto 1996).

Arable weeds show possible signs of crop rotation during the second half of the first millennium AD (Paper V). Between approximately AD 400 and 800, animal husbandry spread geographically and the proportion of domestic animals compared to wild animals is higher than during the preceding periods(Bläuer 2013, 46). Unfortunately, this development is poorly understood due to limited osteological materials (Bläuer 2013). Domestic animals occur on Åland, where animal husbandry was important and sheep were more common than cattle (Gustavsson et al. 2014).

Scythes became more common and longer during the Merovingian Period and Viking Age, a development connected to increased cattle keeping and fodder collection, which led to the increased use of manure during the Late Iron Age (Luoto et al. 1985, 119–123; Lehtosalo-Hilander 1982, 54–57; Varjola 1969; Myrdal 1982, 95–101). Fodder collection or animal grazing is evident based on the large amounts of meadow and wetland plants at Orijärvi (Paper V).

Cross-wise ploughed fields, dated to approximately 500–1300 AD, are tangible signs of the spread of permanent field cultivation in southern Finland (Mikkola et al. 2015, 146–147). However, as demonstrated by the finds of ard marks at Bäljars 2, it is possible that ancient fields were introduced during the Pre-Roman Iron Age (Paper III).

Iron shares for ards were introduced in large parts of northern Europe during the second half of the first millennium AD (Myrdal 1982, 82–88), and

the earliest shares date back to the Viking Age in Finland (Brady 1990, 165–174). Iron shares tolerate wear much better than wooden bills, they are more stable and they break soil and remove weeds better (Myrdal 1982, 84–85). The introduction of iron shares could be connected to the onset of broadcast sowing, which enables more effective use of the field area and gives better yields (Myrdal 1982, 101).

The Late Iron Age appears to have been a period of agricultural expansion and intensification in Finland. Several pollen studies show a marked increase in Cerealia and rye pollen during the Late Iron Age or Early Middle Age (Alenius et al. 2013, 16–18; Alenius et al. 2014; Alenius, Haggrén, et al. 2017, 23; Alenius et al. 2007, 180–182; Vuorela 1998; Sarmaja-Korjonen et al. 1991, 149–150; Sarmaja-Korjonen 2003).

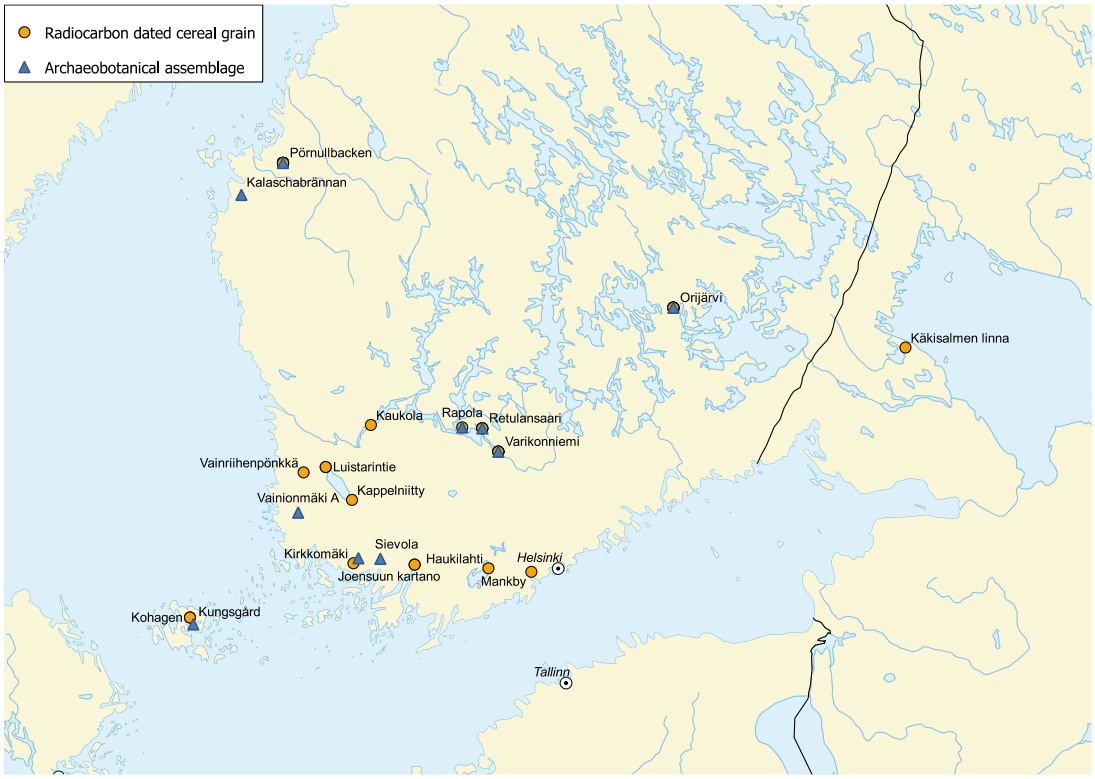


Figure 21 Archaeobotanical assemblages (Figure 12, Appendix II) and AMS-radiocarbon-dated cereal grains (Appendix I) from the late first millennium and early second millennium AD, 550–1200.

7.2.9 CULTIVATION METHODS

Finds of arable weeds at Bäljars 2, Isokylä and Orijärvi have been interpreted to indicate that soils rich in nutrients were cultivated with spring-sown cereals (Papers III–V). In addition, geochemical analyses have suggested the collection of manure at Bäljars 2 (Paper III). These studies thus suggest that manuring was conducted at least since the Pre-Roman Iron Age in southern Finland. Also, the finds of ard marks, indicating prehistoric fields during the

Pre-Roman Iron Age (Paper III) and Late Iron Age (Paper V), clearly show that cultivation was conducted on permanent fields. Barley dominate at all these sites. Scholars have also proposed that barley was cultivated on manured fields during the Bronze Age and Iron Age in Ostrobothnia(Engelmark et al. 2002, 14; Holmblad 2010, 136; Engelmark 1991, 89).

Archaeobotanical analyses conducted for this thesis do not indicate, but neither do they clearly rule out, the practice of slash-and-burn cultivation. Based on pollen analytical studies, slash-and-burn cultivation might well have commenced during the prehistoric period (Vuorela 1986; Tolonen 1987, 367; Huttunen 1980). Rye has been addressed as the most common cereal crop cultivated with slash-and-burn methods in boreal forests (Engelmark 1995, 30–31). As demonstrated above, rye has been present in archaeobotanical assemblages since the early Iron Age, but it became common only at the beginning of the second millennium AD. Whether this increase in rye cultivation was connected with the introduction of slash-and-burn cultivation or a crop rotation system is not clear, but both methods are mentioned in medieval written sources (Orrman 2003, 90–91). In Sweden, the increase in rye, together with finds of indicator arable weeds during the Viking Age, has been taken to show the introduction of a three-field crop rotation type of cultivation (Engelmark 1992, 373). The increase in rye cultivation in Finland during the early second millennium AD has been connected with migration from Sweden (Lempiäinen-Avci 2019, 26). It is thus probable that migrants from Sweden introduced crop rotation for barley and rye to southern Finland.

7.2.10 INTRODUCTION AND CONSOLIDATION OF AGRICULTURE IN FINLAND

How can the onset and consolidation of agriculture be characterised on the basis of the previous chapters? Was this development fast or slow? Did external influences dictate the process, or did local development play a role? When did agricultural products first become main food staples for the people?

Anthropological studies suggest that agricultural practices would not have spread as an idea, but need instead the movement of people or intense contacts with farmers (Sørensen 2016, 211–213). Archaeobotanical, osteological, ancient DNA and other lines of evidence support this kind of model. Agriculture also appears to stick with people (Robb 2013, 669). When they start with it, it is difficult to stop. Agricultural complexes might change in local contexts and new cultures with agricultural elements can be recombined from earlier cultures (Bellwood 2005, 8). How does the development of agriculture appear in Finland when keeping these preconditions in mind?

Finds of pollen from cultivated taxa suggest that Comb Ceramic groups conducted plant cultivation during the period of approximately 5300–3200 BC (Alenius et al. 2013; Alenius, Mökkönen, et al. 2017; Mökkönen 2010). Comb Ceramic cultures originated in the middle Volga-Kama region (Piezonka 2015, 560). However, there is currently no firm evidence for agriculture in this

area of origin until approximately 2500 cal BC (Liu et al. 2019, 23). Therefore, the spread of cultivation cannot be currently reconstructed.

A hybridisation, or recombination, of the agricultural practices of the Funnel Beaker Culture and the hunter-gatherer practices of the Comb Ceramic and Slate cultures appears to have occurred in the Mälaren Valley in the middle of the 4th millennium BC (Paper II). Here, agriculture was first brought by migrants at approximately 4000 BC and then adopted by locals via intense contacts. In this process, a new economy was established, one which was mainly based on maritime prey but also included the 'sticky' agriculture, though only as a minor element. The Pitted Ware Culture, the result of this hybridisation process, migrated around the Baltic Sea and into the Åland Islands from 3300 BC onwards. Thus, these cultivation practices would have come to Finland with the migrants.

After the Pitted Ware Culture had remained in Åland for around 500 years, a new cultural group, called the Corded Ware Culture, migrated from the south, apparently via the Baltic countries around 2800 BC. It has been proposed that the Corded Ware Culture emerged, similarly as the Pitted Ware Culture, through hybridisation, this time as a result of a combination of the Yamnaja culture from the Eurasian steppe and the earlier Neolithic cultures of southern continental Europe (Sjögren et al. 2016). Corded Ware groups migrated into vast areas of Europe. Cattle breeding was important, but they also cultivated crops (Sjögren et al. 2016). In Finland, this cultural group settled in coastal areas, which had previously been settled by hunter-gatherers, and even on the Åland Islands to some extent. These migrants thus brought animal husbandry and possibly even crop cultivation to mainland Finland.

Hybridisation between the Corded Ware Culture and Pyheensilta Ware culture resulted in the creation of the Kiukainen Ware culture at approximately 2300 BC. Similarly as with the Pitted Ware Culture, this cultural group appears to have mainly relied on hunting and gathering, but they nonetheless retained some 'sticky' agricultural elements, as evidenced by the finds of bones from domestic animals.

Around 1500 BC, the culture in coastal Finland changed. Though not shown by ancient DNA, new forms of bronze artefacts, burials in cairns and house types suggest that this culture was brought into Finland by migrants from the Mälaren Valley (Siiriäinen 1984, 55; Salo 1984, 168–169). Additional waves of influences came from the south and east during the Bronze Age. Southern influence from the eastern Baltic since around 1200 cal BC might have influenced agricultural practices. Additionally, Textile Ceramic cultural groups originating from the east could have practiced agriculture, but the practices are poorly known.

A continuous record of cultivated plants occurs after approximately 1500 cal BC. Prior to this date, a positive correlation is shown between pollen-based temperature reconstruction and population estimates based on summed radiocarbon probabilities (Tallavaara et al. 2011, 218). This correlation ends at approximately 1500 BC, when the reconstructed population begins to

demonstrate a long-term increasing trend, possibly caused by increased reliance on agricultural products (Tallavaara 2015, 61). It is thus possible that reliance on domestic products started by the onset of the Bronze Age, when people for the first time succeeded in continuously carrying out agricultural practices.

The Pre-Roman Iron Age shows again the local development of agriculture, and in the coastal areas, the local Morby Ware was produced. Even the first millennium AD seems mostly to show local development in agricultural practices, though the appearance of hemp could be connected with external influences. Agricultural practices penetrate further inland during the Late Iron Age, as shown by finds from Orijärvi. Increased rye cultivation during the early second millennium AD could have been connected with migrants from Sweden introducing new cultivation methods to southern Finland.

The onset and development of agriculture in Finland can be described as a series of migration events followed by periods of local development. Local developments diluted the reliance on agriculture, such as the development of the Funnel Beaker Culture into the Pitted Ware Culture and the development of the Corded Ware Culture into Kiukainen culture. People could have tried to stick with agricultural practices, but they would have had a difficult time doing so at the farming extreme of the north. Apparently, the first culture that succeeded in rooting agricultural practices in Finland was the migrating Scandinavian Bronze Age culture. The development from a hunter-gatherer society into an agricultural society was a process that required many trials and errors during a prolonged period of time.

7.3 RELIABILITY AND VALIDITY

Archaeobotany has become an established research method in Finnish archaeology. Archaeobotanical analyses can be applied to materials from all prehistoric and historic time periods. This study reviews the current stage of research by providing a framework for the development of plant gathering and cultivation in prehistoric Finland. It demonstrates that knowledge of these issues is limited and that several time periods still remain understudied. Certain time periods are covered by only a few sites or else have not been studied at all. For example, the material from the Bronze Age and Pre-Roman Iron Age comes from only a handful of sites. Chronological control of Stone Age sites is poor, and it is hardly possible to discuss the development of plant use during the Stone Age. Material from the first half of the first millennium AD is based on a small number of assemblages, and it is impossible to discuss regional differences. It is probable that we have not yet found the earliest remains of cultivated species.

Archaeobotanical studies have, however, created a solid foundation for future research. Identified macrofossil remains, whose age has been confirmed via radiocarbon dates or other dating methods, form a material

group that can easily be compared within a Nordic, European and global context. The data can be used for large-scale studies on plant gathering, the spread of cultivation, trade, and so forth. The location of Finland makes it an interesting area to study cereal cultivation. Here, at such a northern extreme, cultivation was established late and was possibly a gradual process.

That we find cereals within the Pitted Ware Culture remains is noteworthy because only rarely has it been possible to convincingly demonstrate that predominantly hunter-gatherer groups would have conducted cereal cultivation. This blurs the divide between pure hunter-gatherers and famers and shows that it is possible for such a hunter-gatherer society to adopt small-scale cultivation. Similar studies in other agriculturally marginal areas can benefit from the Pitted Ware case.

7.4 RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies should continue expanding the archaeobotanical dataset. Archaeobotanical studies should deal with all time periods, from the earliest Mesolithic to the modern era. Archaeobotanical studies should concentrate on acquiring an adequate number of soil samples of sufficient volume. Good chronological control should be pursued in these studies.

It would be beneficial to conduct a large campaign to study plant impressions on clay vessels from different periods combined with radiocarbon dates from ceramic crusts. The study would not require new excavations and would provide us with a framework of prehistoric cultivation history.

The anthracological study presented in this thesis gave good results. Thus far, anthracology has been applied only at a very few sites in Finland, even though it is a precise and versatile method. Anthracological analyses could be used to study many different types of questions regarding niche construction, environmental change, human adaptation and use of fuels.

The Stone Age should not be seen as stagnant period, and neither should it be assumed that plant gathering remained unchanged throughout the Stone Age (Alenius, Mökkönen, et al. 2017). Different periods of the Stone Age have revealed that the use of clay, stones, means of subsistence and habitation changed (Mökkönen 2008; Nordqvist 2018; Mökkönen et al. 2019), so there is no reason to assume that plant use remained unchanged.

The material studied in this thesis showed that Pitted Ware groups cultivated plants on Åland. Small amounts of Pitted Ware remains have also been found on mainland Finland. Could such contacts and cultivation also be discerned in the archaeobotanical material on mainland Finland?

Radiocarbon-dated cultivated plant remains show that cultivation practices were conducted continuously in coastal Finland since approximately 1500 cal BC. Cultivation practices in inland regions have been detected, but macrofossil material has only been studied from one settlement site. Bronze Age cultures in the inland area of Finland have eastern origins. It would be

interesting to study whether cultivation practices were also brought into Finland by these cultural groups and whether these groups cultivated different species than in the west, or if they had different cultivation methods.

Finland's location at the extreme north of the agricultural zone makes it a suitable arena to study the relationship between agricultural and hunter-gatherer livelihoods. What was the relationship between plant cultivation, plant gathering, animal husbandry, fishing and hunting over time? How were these practices interconnected with those in surrounding regions? Such adaptation can be studied not only for the Pitted Ware Culture, but also for the different Comb Ceramic groups, Corded Ware, Kiukainen Ware, Bronze Age, Iron Age, and even later periods. Several groups migrated and brought new know-how about foraging and agricultural technologies. How were these applied and how did people adapt to the local environment?

Archaeology should include archaeobotanical analyses throughout the process of conducting excavations and research. This would be beneficial for both archaeological and archaeobotanical studies.

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8 APPENDICES

APPENDIX I: RADIOCARBON DATED PLANT REMAINS FROM FINLAND

*Compilation of radiocarbon-dated plant remains (uncharred remains marked with Asterix *). Unpublished materials published with the permission by Jenni Lucenius and Henrik Jansson.*

Lab code	BP	±	Delta	cal date (2 sigma)	Species	Commune	Site name	Source
?	4080	140		3008–2205 cal BC	Arctostaphylos uva-ursi	Pieksämäki	Tahinniemi	(Jussila 1992)
Ua-10447	4040	55		2862–2462 cal BC	Arctostaphylos uva-ursi	Inari	Siuttavaara W	(Halinen 2005)
Ua-4714	3995	75		2861–2289 cal BC	Arctostaphylos uva-ursi	Enontekiö	Näkkäläjärvi E2	(Halinen 2005)
Ua-4705	3200	75		1642–1284 cal BC	Arctostaphylos uva-ursi	Enontekiö	Tuorkottajajärvi N	(Halinen 2005)
Ua-10443	2745	55		1009–806 cal BC	Arctostaphylos uva-ursi	Inari	Komsijärvi	(Halinen 2005)
Ua-10441	2395	100		793–231 cal BC	Arctostaphylos uva-ursi	Inari	Suolisjärvi	(Halinen 2005)
Tua-964	2265	70		512–117 cal BC	Arctostaphylos uva-ursi	Enontekiö	Näkkälävaara W 71	(Halinen 2005)
Ua-3904	2155	55		361–54 cal BC	Arctostaphylos uva-ursi	Enontekiö	Näkkälävaara W 71	(Halinen 2005)
?	1780	120		cal AD - 21-538	Arctostaphylos uva-ursi	Pieksämäki	Tahinniemi	(Jussila 1992)
Hela-1177	740	40	-25.5	cal AD 1215–1382	Arctostaphylos uva-ursi	Taipalsaari	Valkeisaari	(Lahelma 2008)
Ua-4709	3825	65		2470–2052 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Enontekiö	Vaaranväli 1	(Halinen 2005)
Ua-43683	3747	35	-27.9	2281–2036 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Ii	Keelaharju	(Mökkönen 2013)
Ua-4712	3620	75		2199–1771 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Enontekiö	Näkkälävaara N 5	(Halinen 2005)
Ua-10444	3555	55		2036–1703 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Inari	Komsijärvi	(Halinen 2005)
Ua-10445	3120	70		1596–1135 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Inari	Vuomajoen silta	(Halinen 2005)

Ua-4706	3005	55		1408–1058 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Enontekiö	Vaaranväli 2	(Halinen 2005)
Ua-10446	2905	75		1374–903 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Inari	Ampumaradan tausta	(Halinen 2005)
Ua-4995	2410	75		772–386 cal BC	Arctostaphylos uva-ursi/Empetrum nigrum	Enontekiö	Valkeajärvi E	(Halinen 2005)
Ua-4992	1820	75		cal AD 52–386	Arctostaphylos uva-ursi/Empetrum nigrum	Enontekiö	Museotontti	(Halinen 2005)
Poz-8000	710	30		cal AD 1256–1385	Avena sativa	Espoo	Kauklahti, Saka	(Haggrén 2005)
Ua-34506	2455	40		757–413 cal BC	Avena sp.	Laihia	Alatalo	(Holmblad 2010)
Ua-32389	585	40		cal AD 1296–1420	Avena sp.	Hanko	Gunnarsängen	(Jansson et al. 2010)
Hela-1994	480	35		cal AD 1400–1465	Avena sp.	Vantaa	Gubbacka	(Oinonen et al. 2010)
Poz-16725	335	30		cal AD 1475–1641	Avena sp.	Hattula	Retulansaari	(Ranta et al. 2009)
Poz-87888	1675	30		cal AD 258–425	Cannabis sativa	Salo	Ketohaka 2	Paper IV
Hela-2221	2240	33	-23.6	392–204 cal BC	Cerealia	Raasepori	Bäljars 2	Paper III
Ua-33352	1115	35	-25	cal AD 778–1015	Cerealia	Saltvik	Kohagen	Unpublished, Lucenius
Ua-33354	885	35	-24.4	cal AD 1039–1220	Cerealia	Saltvik	Kohagen	Unpublished, Lucenius
Ua-33353	830	35	-25.9	cal AD 1059–1271	Cerealia	Saltvik	Kohagen	Unpublished, Lucenius
Hela-2099	520	30	-22	cal AD 1324–1443	Cerealia	Hanko	Gunnarsängen	Unpublished, Jansson
Hela-3338	248	35		cal AD 1521–...	Cerealia (Avena cf. sativa, Hordeum vulgare, Secale cereale)	Naantali	Naantali cloister	(Alanko 2017)
Hela-2100	369	33	-22.9	cal AD 1447–1635	Cerealia (Hordeum vulgare, cerealia)	Hanko	Hangonkylä	Unpublished, Jansson
Hela-3340	297	33		cal AD 1488–1660	Cerealia (Hordeum vulgare, Secale cereale)	Naantali	Naantali cloister	(Alanko 2017)
Poz-66814	2880	30		1192–939 cal BC	Charred crust (Hordeum vulgare)	Kaarina	Ravattula	Paper II

Hela-2141	353	30		cal AD 1455–1635	Chenopodium album*	Helsinki	Kumpula botanical garden	(Alanko 2017)
Hela-3347	210	28		cal AD 1646–...	Chenopodium album*	Helsinki	Kumpula botanical garden	(Alanko 2017)
Poz-72226	180	30		cal AD 1652–...	Chenopodium album*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-72224	170	30		cal AD 1659–...	Chenopodium album*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Ua-47506	5600	40	-25.4	4504–4351 cal BC	Corylus avellana	Saltvik	Västra Jansmyra	(Helminen et al. 2014)
Ua-17853	5075	75	-26	4038–3702 cal BC	Corylus avellana	Saltvik	Östra Jansmyra I	(Stenbäck 2003)
Ua-17852	4925	75	-26.1	3943–3536 cal BC	Corylus avellana	Saltvik	Östra Jansmyra I	(Stenbäck 2003)
Hela-32	4885	60	-25.3	3798–3525 cal BC	Corylus avellana	Vantaa	Jokiniemi	(Edgren et al. 1996)
Hela-650	4710	55	-23,7	3635–3370 cal BC	Corylus avellana	Eura	Kolmhaara	(Ranta et al. 2012)
Poz-68376	4655	35		3619–3361 cal BC	Corylus avellana	Espoo	Grävabacka	(Rosendahl et al. 2015)
Hela-461	4545	70	-26.7	3510–3021 cal BC	Corylus avellana	Kristiinankaupunki	Rävåsen	(Hertell et al. 2006)
Ua-15870	4390	75	-23.2	3336–2892 cal BC	Corylus avellana	Jomala	Jettböle Bergmanstorp	(Stenbäck et al. 2000)
Ua-15881	4375	75	-24.1	3335–2885 cal BC	Corylus avellana	Jomala	Jettböle I	(Stenbäck 2003)
Hela-337	4355	70	-29.2	3331–2877 cal BC	Corylus avellana	Kristiinankaupunki	Rävåsen	(Miettinen 2005)
Ua-15880	4340	70	-23.9	3331–2777 cal BC	Corylus avellana	Jomala	Jettböle I	(Stenbäck 2003)
Ua-15879	4305	75	-26.6	3322–2669 cal BC	Corylus avellana	Jomala	Jettböle I	(Stenbäck 2003)
Ua-4927	4120	60	-27	2881–2497 cal BC	Corylus avellana	Saltvik	Åsgårda 34.20	(Lidén et al. 1996)
GrA-14033	4060	45		2858–2474 cal BC	Corylus avellana	Parainen	Fagervik	(Asplund 2008)
Ua-23508	4035	40	-26.1	2836–2468 cal BC	Corylus avellana	Saltvik	Glamilders	(Lucenius 2008)
Ua-19513	3970	45	-23.5	2617–2309 cal BC	Corylus avellana	Jomala	Jettböle II	(Stenbäck 2003)

Ua-45418	2554	43	-23.9	809–541 cal BC	Corylus avellana	Hammarland	Prästgården	Unpublished, Lucenius
Hela-2225	2211	32	-27.4	375–198 cal BC	Corylus avellana	Raasepori	Bäljars 2	Paper III
Hela-212	2125	55	-25	360–3 cal BC	Corylus avellana	Eura	Luistari	(Lehtosalo-Hilander 1999)
Ua-33360	1400	30	-27.4	cal AD 597–670	Corylus avellana	Finström	Svartsmara	Unpublished, Lucenius
Ua-37184	1260	30	-23,5	cal AD 669–865	Corylus avellana	Finström	Prästgården	Unpublished, Lucenius
Ua-37183	1200	30	-28–6	cal AD 715–940	Corylus avellana	Finström	Strömsvik	Unpublished, Lucenius
Poz-10831	875	30		cal AD 1043–1241	Corylus avellana	Turku	Kirkkomäki	(Asplund et al. 2007)
Poz-8001	660	25		cal AD 1279–1391	Corylus avellana	Espoo	Kauklahti, Saka	(Haggrén 2005)
Hela-2224	617	30	-26.2	cal AD 1293–1401	Corylus avellana	Raasepori	Bäljars 2	Paper III
Poz-1723	360	30		cal AD 1450–1635	Corylus avellana	Hattula	Retulansaari	(Taivainen 2004)
Hela-2336	774	31	-25.8	cal AD 1212–1283	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2334	727	31	-25.3	cal AD 1224–1380	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2337	700	34	-25.7	cal AD 1257–1389	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2649	689	27	-24.2	cal AD 1267–1388	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2335	669	32	-24.7	cal AD 1274–1392	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2482	660	25	-24.1	cal AD 1279–1391	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2650	638	26	-25.5	cal AD 1285–1395	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Hela-2483	624	27	-24.2	cal AD 1290–1399	Corylus avellana*	Turku	Aboa Vetus	(Oinonen et al. 2011)
Poz-72223	275	30		cal AD 1514–1798	Datura stramonium*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-72225	245	30		cal AD 1523–...	Datura stramonium*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-72237	190	30		cal AD 1648–...	Datura stramonium*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-72227	85	30		cal AD 1688–1927	Datura stramonium*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)

Ua-10436	4955	115		4032–3386 cal BC	Empetrum nigrum	Enontekiö	Paalojärvi NW	(Halinen 2005)
Ua-4845	4675	80		3646–3121 cal BC	Empetrum nigrum	Enontekiö	Näkkäläjärvi W	(Halinen 2005)
Ua-10440	4345	90		3343–2705 cal BC	Empetrum nigrum	Inari	Pahtusjärvi N	(Halinen 2005)
Ua-4847	4000	80		2865–2289 cal BC	Empetrum nigrum	Enontekiö	Jierstivaara W	(Halinen 2005)
Ua-10448	3880	60		2559–2149 cal BC	Empetrum nigrum	Inari	Pahtusjärvi N	(Halinen 2005)
Ua-4704	3875	85		2575–2055 cal BC	Empetrum nigrum	Enontekiö	Pöyrisjärventie	(Halinen 2005)
Ua-4843	3855	70		2557–2061 cal BC	Empetrum nigrum	Enontekiö	Näkkälävaara N2	(Halinen 2005)
Ua-4842	3850	80		2564–2044 cal BC	Empetrum nigrum	Enontekiö	Näkkälävaara W 25	(Halinen 2005)
Ua-4846	3815	90		2549–1981 cal BC	Empetrum nigrum	Enontekiö	Näkkäläjärvi W2	(Halinen 2005)
Ua-4708	3745	60		2345–1961 cal BC	Empetrum nigrum	Enontekiö	Vaaranväli 3	(Halinen 2005)
Ua-4716	3730	75		2433–1923 cal BC	Empetrum nigrum	Enontekiö	Paalojärvi SW	(Halinen 2005)
Ua-4715	3650	75		2278–1777 cal BC	Empetrum nigrum	Enontekiö	Näkkälävaara W2	(Halinen 2005)
Ua-4707	3590	55		2132–1771 cal BC	Empetrum nigrum	Enontekiö	Näkkälävaara N 6	(Halinen 2005)
Ua-4844	3525	70		2036–1665 cal BC	Empetrum nigrum	Enontekiö	Vaaranväli 4	(Halinen 2005)
Ua-4711	3515	70		2029–1665 cal BC	Empetrum nigrum	Enontekiö	Sammaljärvi N	(Halinen 2005)
Ua-4713	3455	70		1955–1611 cal BC	Empetrum nigrum	Enontekiö	Näkkäläjärvi SW	(Halinen 2005)
Tua-1259	3245	90		1744–1299 cal BC	Empetrum nigrum	Enontekiö	Sammaljärvi N	(Halinen 2005)
Ua-10442	2890	90		1374–844 cal BC	Empetrum nigrum	Inari	Iivanasvaara SW	(Halinen 2005)
Ua-10437	2740	75		1083–794 cal BC	Empetrum nigrum	Inari	Pahtusjärvi S	(Halinen 2005)
Ua-10439	2635	75		976–541 cal BC	Empetrum nigrum	Inari	Kaltojärvet	(Halinen 2005)
Ua-10438	2245	75		475–59 cal BC	Empetrum nigrum	Inari	Tupavaara 2	(Halinen 2005)
Ua-4997	4420	100		3364–2889 cal BC	Empetrum nigrum?	Enontekiö	Suonttajoensuu W1	(Halinen 2005)

Ua-4996	3900	90		2828–2057 cal BC	Empetrum nigrum?	Enontekiö	Suonttajoki E	(Halinen 2005)
Ua-4990	3015	75		1431–1036 cal BC	Empetrum nigrum?	Enontekiö	Hetan kota NW	(Halinen 2005)
Ua-4994	2810	90		1210–809 cal BC	Empetrum nigrum?	Enontekiö	Jyppyrä S	(Halinen 2005)
Ua-4991	2600	70		911–516 cal BC	Empetrum nigrum?	Enontekiö	Saamen museo	(Halinen 2005)
Ua-4993	1250	70		cal AD 652–951	Empetrum nigrum?	Enontekiö	Paavontalo	(Halinen 2005)
Ua-53760	4167	31	-25.5	2881–2634 cal BC	Hordeum vulgare	Saltvik	Glamilders	Paper II
Ua-53762	4139	31	-24.7	2875–2620 cal BC	Hordeum vulgare	Saltvik	Glamilders	Paper II
Poz-66757	3090	35		1431–1264 cal BC	Hordeum vulgare	Raasepori	Bäljars 2	Paper II
Hela-167	3010	80	-25.6	1431–1016 cal BC	Hordeum vulgare	Ristiina	Kitulansuo d	(Lavento 1998)
Poz-23351	2785	30		1007–845 cal BC	Hordeum vulgare	Laihia	Alatalo	(Holmblad 2010)
Hela-3328	2641	31		894–786 cal BC	Hordeum vulgare	Eura	Luistarintie	(Lempiäinen et al. n.d.)
Ua-33250	2590	40		832–553 cal BC	Hordeum vulgare	Laihia	Alatalo	(Holmblad 2010)
Hela-208	2560	55	-26.7	824–516 cal BC	Hordeum vulgare	Eura	Luistari	(Lehtosalo-Hilander 1999)
Hela-3525	2447	33	-24.7	754–410 cal BC	Hordeum vulgare	Kaarina	Ravattula	Paper II
Hela-3408	2419	49		755–400 cal BC	Hordeum vulgare	Eura	Luistarintie	(Lempiäinen et al. n.d.)
Hela-3981	2285	44		409–206 cal BC	Hordeum vulgare	Rauma	Ellinniitty	(Lempiäinen et al. n.d.)
Hela-3414	2281	54		471–195 cal BC	Hordeum vulgare	Eura	Luistarintie	(Lempiäinen et al. n.d.)
Poz-16695	2225	30		380–203 cal BC	Hordeum vulgare	Hattula	Retulansaari	Paper III
Ua-38388	2208	32		376–196 cal BC	Hordeum vulgare	Laihia	Välikorpi	(Holmblad 2010)
GrA-14134	2180	35		366–118 cal BC	Hordeum vulgare	Turku	Riihivainio Orhinkarsina	(Asplund 2008)
Ua-14032	1855	80		36 cal BC–cal AD 377	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Poz-87880	1825	30		cal AD 88–317	Hordeum vulgare	Salo	Ketohaka 1	Paper IV
Ua-14030	1750	60		cal AD 131–406	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-14035	1730	80		cal AD 87–534	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-285	1725	70	-24.5	cal AD 128–530	Hordeum vulgare	Lempäälä	Naarankalmanmäki	(Raike et al. 2005)
Ua-14029	1690	55		cal AD 222–535	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)

Hela-286	1685	70	-26.1	cal AD 145–542	Hordeum vulgare	Lempäälä	Naarankalmanmäki	(Raike et al. 2005)
Beta-84095	1680	60		cal AD 233–536	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-14037	1640	55		cal AD 256–546	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-14033	1610	65		cal AD 259–595	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Beta-110633	1600	30		cal AD 399–539	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-16454	1560	60	-25	cal AD 385–623	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-53044	1556	29	-27.4	cal AD 422–566	Hordeum vulgare	Tammela	Lepokallio	(Nyman 2015)
Hela-1619	1455	35	-26.5	cal AD 550–652	Hordeum vulgare	Lappi	Vainriihenpönkkä	(Lehtonen et al. 2010)
Beta-110634	1450	30		cal AD 561–651	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-16452	1440	65	-24.9	cal AD 428–684	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-14038	1435	55		cal AD 434–679	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-14036	1430	55		cal AD 435–684	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Beta-98961	1380	50		cal AD 571–766	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Beta-98963	1360	50		cal AD 595–770	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Beta-88792	1350	40		cal AD 615–768	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-592	1335	60	-26.4	cal AD 595–865	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	(Mikkola 2005)
Beta-110632	1330	30		cal AD 649–767	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-15532	1330	65	-26.4	cal AD 598–871	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-2227	1324	30	-25.8	cal AD 651–768	Hordeum vulgare	Lohja	Haukilahti	(Alenius et al. 2014)
Ua-14034	1315	70		cal AD 607–882	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Beta-98962	1270	50		cal AD 660–876	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-210	1270	55	-26.4	cal AD 658–881	Hordeum vulgare	Eura	Luistari	(Lehtosalo-Hilander 1999)
Hela-206	1255	80	-26.5	cal AD 646-968	Hordeum vulgare	Hämeenlinna	Varikonniemi	(Schulz 1998)
Ua-16451	1235	65	-25.4	cal AD 660–952	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-16450	1230	60	-25.5	cal AD 663–950	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-16453	1225	65	-25	cal AD 665–962	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-594	1200	60	-25.5	cal AD 682–969	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	(Mikkola 2005)
Hela-203	1200	75	-26.2	cal AD 673–978	Hordeum vulgare	Hämeenlinna	Varikonniemi	(Schulz 1998)

Hela-593	1195	55	-26.8	cal AD 688–969	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	(Mikkola 2005)
Hela-1428	1145	30	-27.5	cal AD 776–975	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Ua-15534	1130	55	-24.2	cal AD 772–1015	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Ua-15531	1125	60	-25.8	cal AD 770–1020	Hordeum vulgare	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-1427	1100	30	-27.1	cal AD 887–1013	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Poz-1719	1070	30		cal AD 895–1021	Hordeum vulgare	Hattula	Retulansaari	(Taivainen 2004)
Hela-3402	1065	40		cal AD 891–1026	Hordeum vulgare	Eura	Luistarintie	(Lempiäinen et al. n.d.)
Hela-1431	1065	30	-27.7	cal AD 896–1023	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Hela-1448	1055	30	-26	cal AD 898–1025	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Hela-205	1040	60	-26.9	cal AD 783–1158	Hordeum vulgare	Hämeenlinna	Varikonniemi	(Schulz 1998)
Ua-55015	1035	29	-25.9	cal AD 901–1036	Hordeum vulgare	Sastamala	Kaukola	(Nyman 2016)
Hela-1426	1030	30	-26.8	cal AD 901–1116	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Hela-207	970	55	-25.8	cal AD 979–1204	Hordeum vulgare	Hämeenlinna	Varikonniemi	(Schulz 1998)
Hela-13	910	75	-23.6	cal AD 998–1261	Hordeum vulgare	Käkisalmi	Käkisalmen linna	(Uino 1997)
Hela-202	895	55	-25.1	cal AD 1025–1245	Hordeum vulgare	Hämeenlinna	Varikonniemi	(Schulz 1998)
Ua-32390	815	40		cal AD 1155–1279	Hordeum vulgare	Hanko	Gunnarsängen	(Jansson et al. 2010)
Ua-32388	755	40		cal AD 1191–1297	Hordeum vulgare	Hanko	Gunnarsängen	(Jansson et al. 2010)
Hela-2608	742	23	-26.4	cal AD 1227–1289	Hordeum vulgare	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-2610	687	24	-24.4	cal AD 1270–1386	Hordeum vulgare	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-595	665	50	-24.9	cal AD 1267–1400	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	(Mikkola 2005)
Poz-70145	630	30		cal AD 1287–1399	Hordeum vulgare	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-1954	560	55		cal AD 1296–1438	Hordeum vulgare	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70139	485	30		cal AD 1406–1451	Hordeum vulgare	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-2092	427	30	-24.2	cal AD 1423–1616	Hordeum vulgare	Inkoo	Petars	Unpublished, Jansson

Hela-1430	400	25	-25.2	cal AD 1439–1619	Hordeum vulgare	Mikkeli	Orijärvi Kihlinpelto	Paper V
Poz-72294	220	30		cal AD 1642–...	Hordeum vulgare	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Hela-3405	195	47		cal AD 1641–...	Hordeum vulgare	Nastola	Kilpisaari 2	(Saipio 2015)
Poz-16692	150	30		cal AD 1667–...	Hordeum vulgare	Hattula	Retulansaari	(Ranta et al. 2009)
Hela-3547	118	20		cal AD 1682–1936	Hordeum vulgare	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-1721	1260	35		cal AD 668–868	Hordeum vulgare cf nudum	Hattula	Retulansaari	(Taivainen 2004)
Hela-338	3200	170		1890–1021 cal BC	Hordeum vulgare cf. nudum	Turku	Niuskala	(Vuorela et al. 1988)
Poz-87882	1810	30		cal AD 128–323	Hordeum vulgare hulled	Salo	Ketohaka 2	Paper IV
Poz-87881	1785	30		cal AD 135–332	Hordeum vulgare hulled	Salo	Ketohaka 2	Paper IV
Poz-87877	1740	30		cal AD 236–386	Hordeum vulgare hulled	Salo	Ketohaka 1	Paper IV
Poz-87883	1650	30		cal AD 264–533	Hordeum vulgare hulled	Salo	Vanutehtaanmäki 1	Paper IV
Ua-53765	4424	31	-24.9	3324–2923 cal BC	Hordeum vulgare var. nudum	Jomala	Jettböle I	Paper II
Ua-35045	4145	35	-25.1	2877–2620 cal BC	Hordeum vulgare var. nudum	Saltvik	Glamilders	Paper II
Ua-53761	4102	31	-24.4	2864–2503 cal BC	Hordeum vulgare var. nudum	Saltvik	Glamilders	Paper II
Ua-53764	2707	29	-23.9	907–808 cal BC	Hordeum vulgare var. nudum	Saltvik	Härdalen	Paper II
Ua-53758	2652	72	-25	997–551 cal BC	Hordeum vulgare var. nudum	Saltvik	Svinvallen	Paper II
Ua-53763	2403	29	-24	731–400 cal BC	Hordeum vulgare var. nudum	Saltvik	Härdalen	Paper II
Ua-40229	2228	30		382–204 cal BC	Hordeum vulgare var. nudum	Kemiönsaari	Kåddböle	(Asplund et al. 2013)
Hela-2929	443	31		cal AD 1415–1609	Hordeum vulgare var. vulgare	Vantaa	Gubbacka	(Vanhanen et al. 2013)
Hela-31	880	50	-25.9	cal AD 1035–1248	Juniperus communis	Vantaa	Jokiniemi	(Edgren et al. 1996)
Hela-3341	696	36		cal AD 1258–1390	Juniperus communis	Naantali	Naantali cloister	(Alanko 2017)
Hela-3339	384	34		cal AD 1441–1633	Juniperus communis	Naantali	Naantali cloister	(Alanko 2017)

Poz-76093	275	30		cal AD 1514–1798	Juniperus communis	Salo	Halikon Kirkkomäki	Material dated by author
Hel-794	290	90		cal AD 1436–...	Quercus sp.	Vantaa	Kilteri	(Leskinen et al. 2008)
Hela-925	295	35		cal AD 1485–1663	Rubus idaeus*	Lappeenranta	Kappelinmäki	(Lempiäinen-Avci et al. 2017)
Hela-3549	167	20		cal AD 1665–...	Rubus idaeus*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Hela-3548	98	19		cal AD 1691–1923	Rubus idaeus*	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Hela-283	1975	175	-22.8	397 cal BC–cal AD 403	Secale cereale	Lempäälä	Naarankalmanmäki	(Raike et al. 2005)
Poz-87885	1575	30		cal AD 413–551	Secale cereale	Salo	Vanutehtaanmäki 1	Paper IV
Ua-14031	1545	70		cal AD 386–646	Secale cereale	Vöyri	Pörnullbacken	(Engelmark et al. 2002)
Hela-287	1525	70	-24.1	cal AD 401–648	Secale cereale	Lempäälä	Naarankalmanmäki	(Raike et al. 2005)
Hela-1996	1515	40		cal AD 427–622	Secale cereale	Vantaa	Gubbacka	(Oinonen et al. 2010)
Hela-1447	1090	30	-25.8	cal AD 892–1014	Secale cereale	Mikkeli	Orijärvi Kihlinpelto	Paper V
Poz-1720	1060	35		cal AD 895–1025	Secale cereale	Hattula	Retulansaari	(Taivainen 2004)
Hela-2612	1011	33	-14.7	cal AD 970–1152	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-1429	970	25	-24.5	cal AD 1016–1155	Secale cereale	Mikkeli	Orijärvi Kihlinpelto	Paper V
Poz-16694	850	30		cal AD 1052–1260	Secale cereale	Hattula	Retulansaari	(Ranta et al. 2009)
Hela-2609	782	32	-20.1	cal AD 1193–1282	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-2611	724	24	-22.7	cal AD 1256–1297	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-3518	688	39		cal AD 1260–1393	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-1955	685	60		cal AD 1224–1403	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70147	680	30		cal AD 1270–1390	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70146	675	30		cal AD 1271–1391	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-76092	665	30		cal AD 1276–1392	Secale cereale	Salo	Halikon Kirkkomäki	Material dated by author
Poz-8004	660	30		cal AD 1277–1393	Secale cereale	Espoo	Kauklahti, Saka	(Haggrén 2005)

Poz-70148	630	30		cal AD 1287–1399	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70143	620	35		cal AD 1290–1403	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70141	615	30		cal AD 1295–1401	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-8002	605	25		cal AD 1297–1405	Secale cereale	Espoo	Kauklahti, Saka	(Haggrén 2005)
Poz-70142	590	30		cal AD 1299–1413	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Poz-70138	565	30		cal AD 1306–1426	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-2090	549	30	-22.6	cal AD 1312–1434	Secale cereale	Inkoo	Gammelby	Unpublished, Jansson
Hela-2927	488	30		cal AD 1405–1450	Secale cereale	Vantaa	Gubbacka	(Vanhanen et al. 2013)
Hela-3519	466	32		cal AD 1409–1466	Secale cereale	Espoo	Mankby	(Lempiäinen-Avci et al. 2017)
Hela-1823	430	30	-25.8	cal AD 1421–1616	Secale cereale	Uukuniemi	Papinniemi	(Laakso 2014)
Hela-1564	330	25	-24.2	cal AD 1482–1642	Secale cereale	Espoo	Suomenoja	Unpublished, Jansson
Hela-3346	266	28		cal AD 1520–1799	Secale cereale	Helsinki	Kumpula Manor	(Alanko et al. 2015)
Hela-3345	258	28		cal AD 1521–...	Secale cereale	Helsinki	Kumpula Manor	(Alanko et al. 2015)
Hela-209	225	55	-24.2	cal AD 1499–...	Secale cereale	Eura	Luistari	(Lehtosalo-Hilander 1999)
Poz-16693	195	30		cal AD 1648–...	Secale cereale	Hattula	Retulansaari	(Ranta et al. 2009)
Hela-3546	113	22		cal AD 1682–1935	Secale cereale	Helsinki	Kaisaniemi botanical garden	(Alanko 2017)
Poz-10829	950	30		cal AD 1024–1155	Secale cereale*	Turku	Kirkkomäki	(Asplund et al. 2007)
Hela-109	625	65	-27.5	cal AD 1274–1421	Secale cereale*	Mikkeli	Tuukkala	(Mikkola 2009)
Hela-160	4680	60	-26.4	3634–3358 cal BC	Trapa natans	Helsinki	Kårböle folkskola	(Lesell 2005)
Hela-3980	2341	37		540–259 cal BC	Triticum aestivum	Rauma	Ellinniitty	(Lempiäinen et al. n.d.)
Hela-3410	338	41		cal AD 1461–1643	Triticum aestivum	Eura	Luistarintie	(Lempiäinen et al. n.d.)
Ua-53759	4082	31	-25	2859–2495 cal BC	Triticum aestivum s.l.	Saltvik	Svinvallen	Paper II

Hela-2096	657	36	-23.8	cal AD 1275–1397	Triticum aestivum subsb. compactum	Hanko	Gunnarsängen	Unpublished, Jansson
Ua-3398	925	50		cal AD 1021–1214	Triticum cf. aestivum	Valkeakoski	Rapola	(Vikkula et al. 1994)
Ua-4149	1975	80		177 cal BC–cal AD 224	Triticum compactum	Valkeakoski	Rapola	(Vikkula et al. 1994)
Hela-596	1270	80	-28.1	cal AD 637–966	Triticum compactum	Mikkeli	Orijärvi Kihlinpelto	(Mikkola 2005)
Hela-1440	1215	30	-24	cal AD 694–889	Triticum compactum	Salo	Joensuun kartano	(Uotila 2009)
Ua-3006	1170	100		cal AD 662–1024	Triticum compactum	Yläne	Kappelniitty	(Roeck Hansen et al. 1995)
Hela-1439	925	35	-24.3	cal AD 1025–1185	Triticum compactum	Salo	Joensuun kartano	(Uotila 2009)
Poz-66756	1820	30		cal AD 90–321	Triticum dicoccum/spelta	Raasepori	Bäljars 2	(Alenius, Haggrén, et al. 2017)
Poz-87879	1815	35		cal AD 90–326	Triticum dicoccum/spelta	Salo	Ketohaka 1	Paper IV
Hela-204	1045	60	-25.4	cal AD 780–1156	Triticum sp.	Hämeenlinna	Varikonniemi	(Schulz 1998)
Poz-87884	100	30		cal AD 1682–1935	Vitis vinifera*	Salo	Vanutehtaanmäki 1	Paper IV

APPENDIX II: SITE ASSEMBLAGES

Site	Dating	Avena sp.	Hordeum vulgare var. vulgare	Hordeum vulgare var. nudum	Hordeum vulgare	Secale cereale	Triticum aestivum s.l.	Triticum dicoccum	Camelina sativa	Cannabis sativa	Linum usitatissimum	Pisum sativum/Pisum sp.	Vicia faba	Source
Alatalo	800–300 cal BC	1	9		10									(Holmblad 2007)
Naarankalmanmäki	cal AD 0–500				45	21								(Raike et al. 2005)
Ketohaka 1	cal AD 200–300	9	13	12	72			8			1			Paper IV
Ketohaka 2	cal AD 200–400	4	56	11	69			1		1				Paper IV
Vanuhtetaanmäki 1	cal AD 400–500	20	81	45	165	14	1	9		4				Paper IV
Pörnullbacken	cal AD 150–900	8			765	2								(Engelmark et al. 2002)
Rapola	cal AD 0–1100	1			18	1	3							(Vikkula et al. 1994)
Kalaschabrännan	MIG-MP	3			42	5			2					(Engelmark 1991)
Retulansaari	MP	23			205	39		1				16	1	(Aalto 1997)
Vainionmäki A	MP	12			27	5	5	5	5		16	3	3	(Aalto 1996)
Pahka	AD 700–900	15			4530	1228	19					21		(Onnela et al. 1996)
Kungsgård	AD 500–1000	5			118					3	1			(Nuñez et al. 1992)
Orijärvi	cal AD 700–1450	30	44	6	86	20	5			1	1			Paper I
Varikkoniemi	AD 900–1300	34			2240	150	10			4		11		(Lempiäinen 1993)
Rähälä	cal AD 1184	1		4	52	2167	1							(Lempiäinen 1996)
Sievola	c. AD 1000	1	12		35	82	7					1		(Seppä-Heikka 1983)