OF SOIL AND SEED

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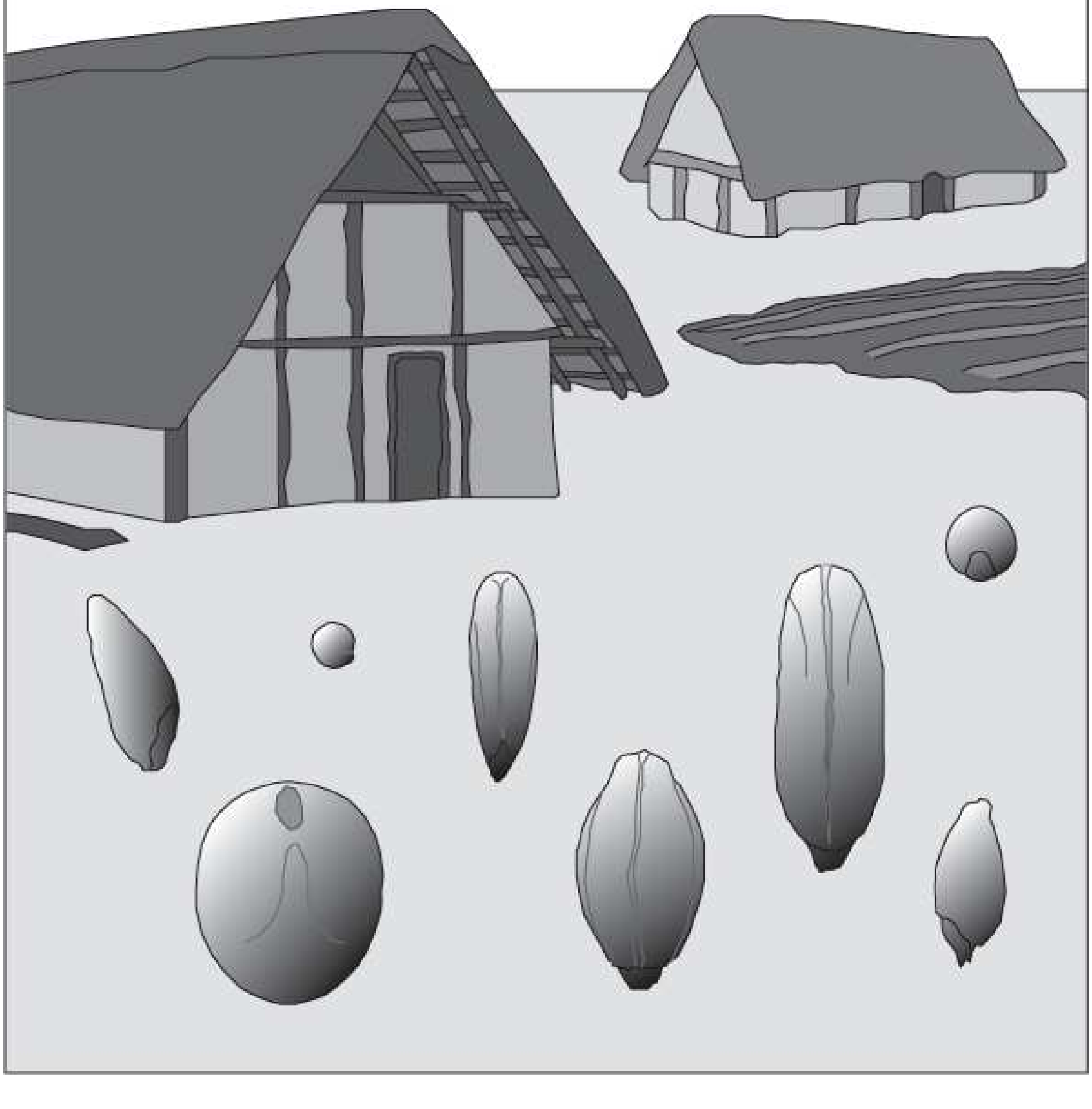
Y.F. van Amerongen MSc



Front: Artwork by author, pictures used of seeds are from the Digital Seedatlas (http://seeds.eldoc.ub.rug.nl) and pictures of buildings from http://www.projectenbankcultuurhistorie.nl and http://home.zonnet.nl/postbus/vlaanderen-a.html.

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Research on the Linear Bandkeramik and late Iron Age charred botanical remains from the excavation of De Heidekampweg, Stein, The Netherlands.

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Contents

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Finally, the support of my parents and boyfriend have not gone unnoticed: thank you!

1 General introduction

1.1 Outline of the research area

This research will focus on two prehistoric time periods. The first is the Neolithic, and then focusing especially on the Linear Bandkeramik (LBK) culture, which existed in the Netherlands from 5300-4900 BC. The LBK culture was widespread across Europe, and followed the loess-covered lands (Fig. 1). It originated in Hungary and gradually spread further west as far as the north of France, and as far east as Moldova (Bakels 2009, 29). The people of this culture arrived and lived in the Netherlands in the province of Limburg, (the only place where loess existed/exists) and they are considered to be the first farmers in the Netherlands.

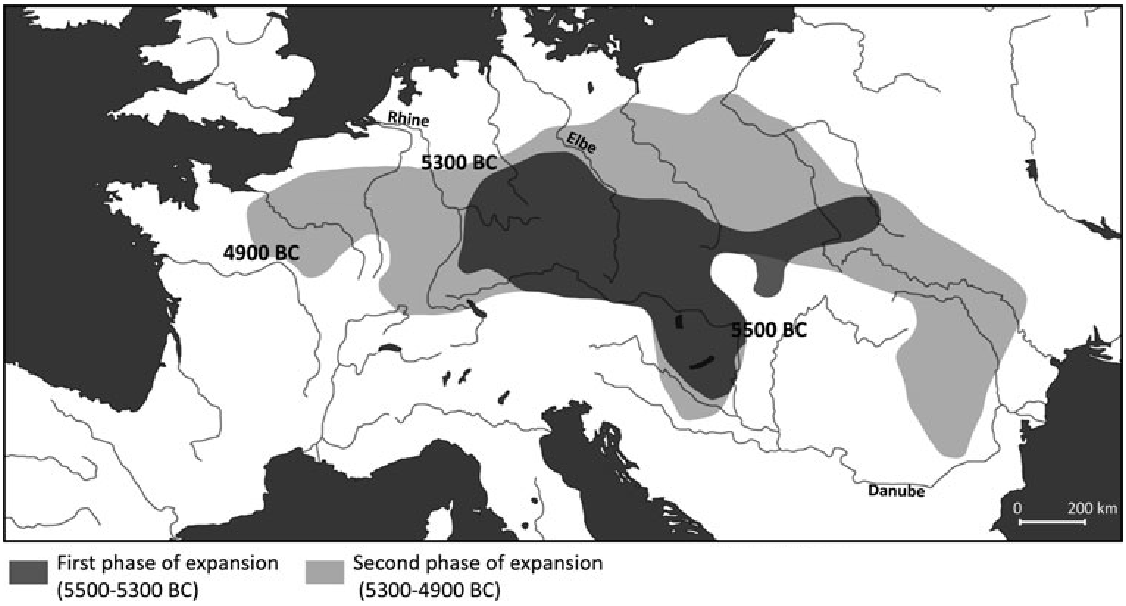


Figure 1. Map of the expansion of the LBK culture across the loess belt of Europe. LBK farmers arrived in the Netherlands with the second phase of expansion, around 5300 BC (after Lüning 2000, 14).

The second period, the late Iron Age (IA), spans the time period of approximately 250-12 BC in the Netherlands. Throughout the Bronze and Iron Age, generally both crop and animal husbandry are practiced on one farm, and these farms can now also be found in western and northern parts of the Netherlands on different soil types (Brinkkemper 2005). This is in contrast with the LBK, which is only found on loess grounds (fig. 2).

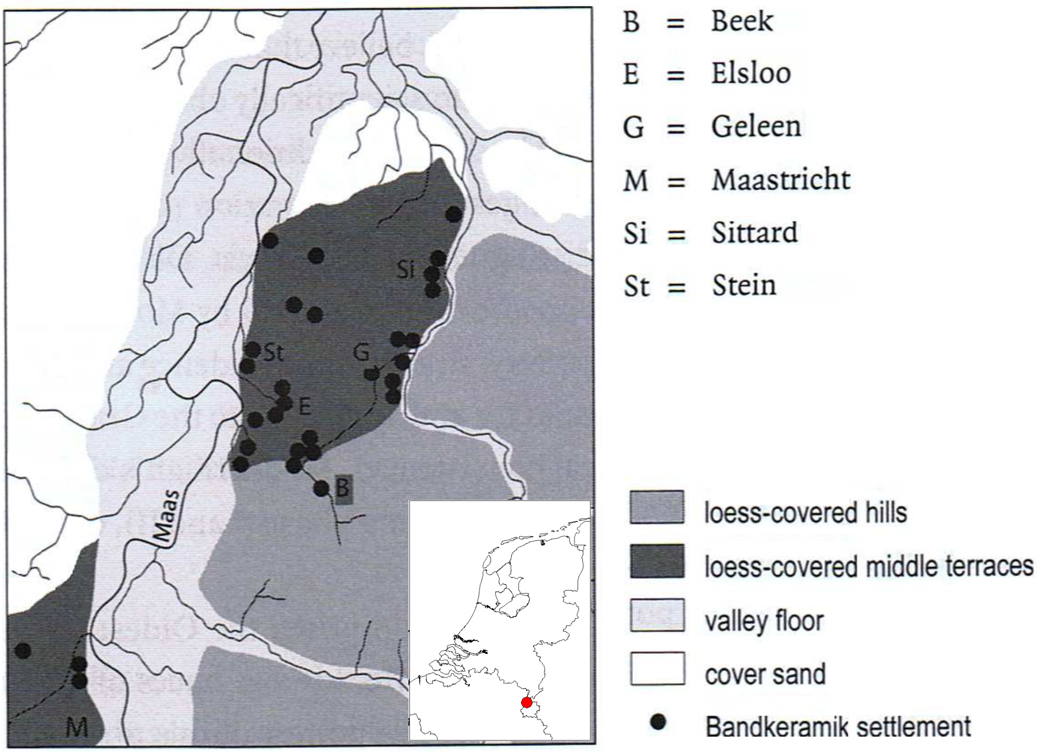


Figure 2. Overview map of the loess plateau in southern Limburg. As can be seen, the middle terraces of the loess were densely inhabited in LBK times and most sites lie at the borders of the loess. The whole loess area of southern Limburg may be considered as lying at the expansion front of the LBK culture (figure adapted from De Grooth and Van de Velde 2008, 219).

In this research, I focus on Stein, located in the south of the province of Limburg, the Netherlands. This area is the only part of the Netherlands where both LBK and late Iron Age remains have been found in the same excavation. Through comparison of these periods, there is a potential to shed light on the (differences in) agricultural practices and surroundings of the LBK and late Iron Age, as well as getting new information on late Iron Age farms in the area in general. In southern Limburg, many LBK sites have been uncovered, especially in the area of the cities of Stein, Elsloo, Sittard, and Geleen (fig. 3). Iron Age settlements have also been found (fig 4), although late Iron Age settlement remains have rarely been uncovered.

The excavation in Stein which will be discussed in this thesis was recently performed by Archol B.V. and both LBK and IA periods were indeed found at the excavation, which took place next to the highway A2, on De Heidekampweg (Figure 3 and 4). It was an emergency excavation, because the A2 highway will be widened in that area, hence the limited range and size of the trenches.

In order to compare LBK and IA agricultural practices and their surroundings, I will look at the botanical remains from sampled features. All the remains that can be found will consist of charred material. This is the only material that can be preserved in areas where the groundwater level is very low, like in southern Limburg. All other types of botanical material will have degraded by taphonomic processes and will not have been preserved. When certain botanical plant remains are found, their aspects such as preferred soil quality, growth conditions and ecological area of appearance can be used to answer specific questions with regard to present LBK and IA palaeobotanical debates.
The locations of the botanical samples taken from the site, which are being researched here, are summarized in Figure 5.

1.2 Material and methods

The locations of the botanical samples were selected in the field and subsequently collected by putting the soil into plastic containers and sealing them. Of the botanical samples taken, 22 were selected for further analysis. The late Iron Age samples, number 75, 76, 79, 80, 112, and 278 are mostly from postholes and small isolated features.
The LBK samples, number 99, 129, 132, 141, 145, 148, 149, 271, 273, 286, 299, 319, 323, and 327, are almost all from (long) pits next to structures. Number 325 and 326 are from split tree trunk post holes. Features will be discussed in more detail in the individual LBK and IA parts. For more detailed overviews of feature maps, see appendix. NB: the use of the word ‘seed’ in this thesis comprises both the terms seed and fruit out of convenience. Samples were all sieved under running tap water through 1.0mm, 0.5mm, and 0.25mm sieves in order to separate the different sized seeds.

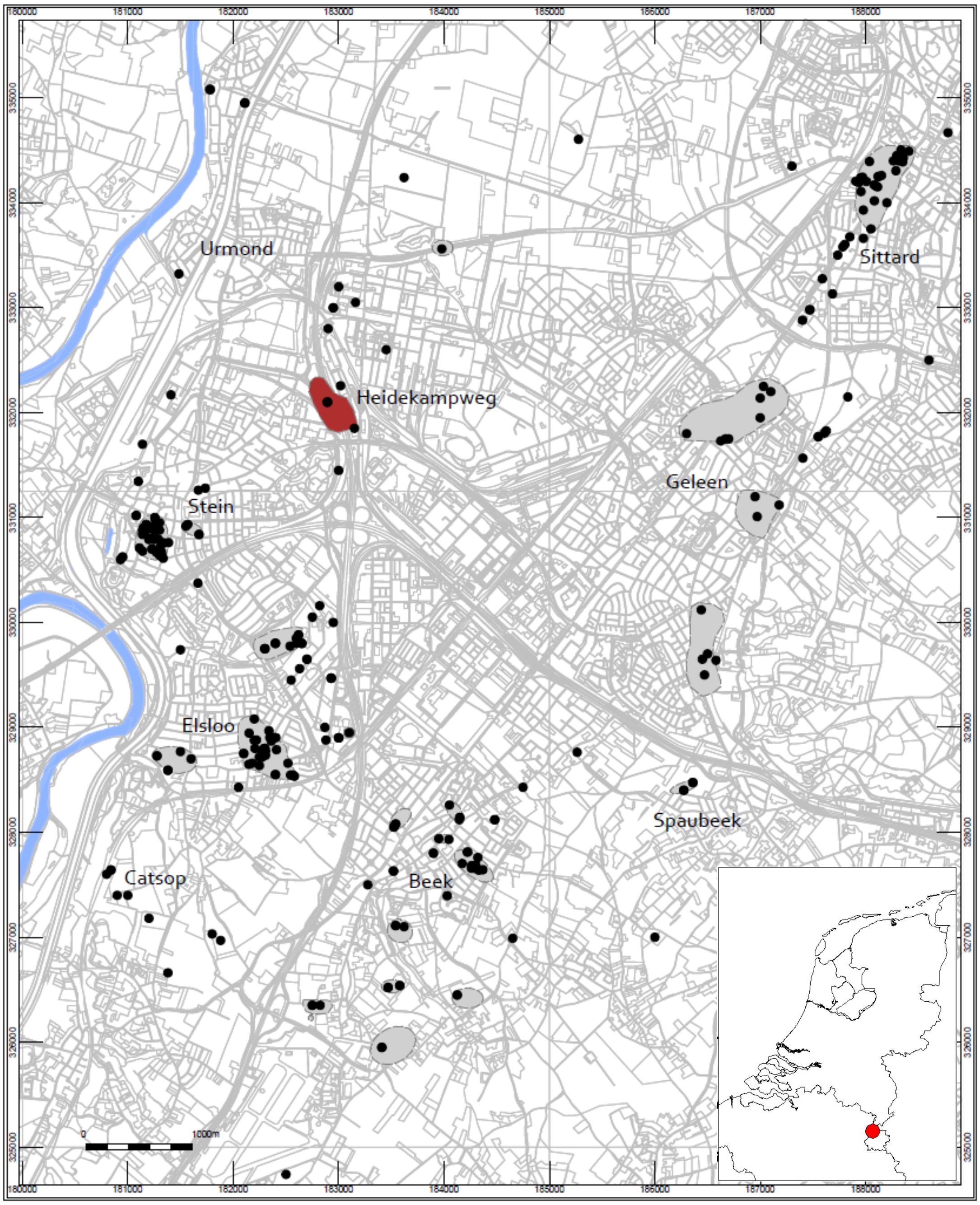


Figure 3. Map of the location of the excavation of De Heidekampweg in Stein, Limburg, The Netherlands, denoted by the red area. Black dots indicate LBK sites

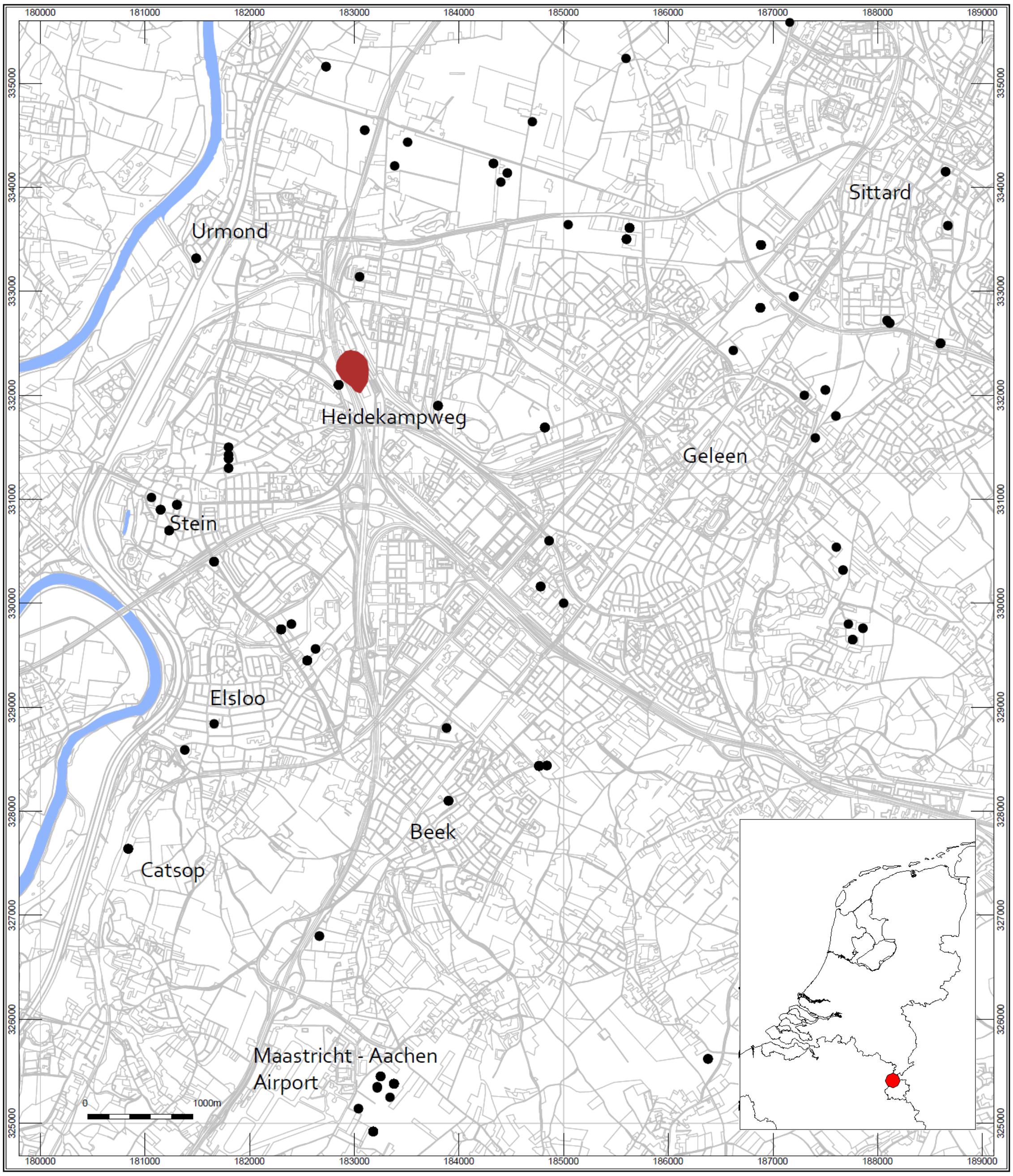


Figure 4. Map of the location of the excavation of De Heidekampweg in Stein, Limburg, The Netherlands, denoted by the red area. Black dots indicate IA sites.

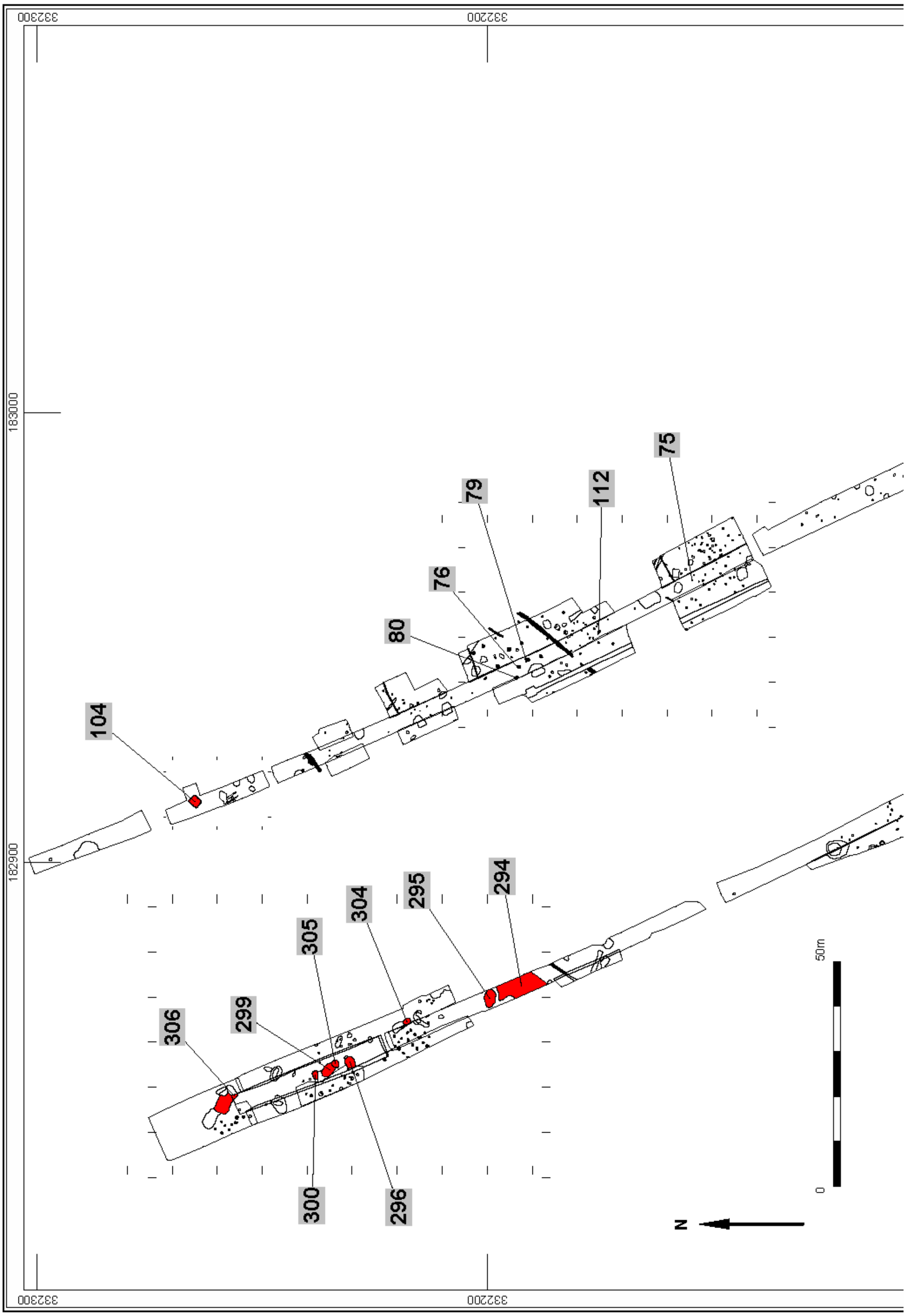
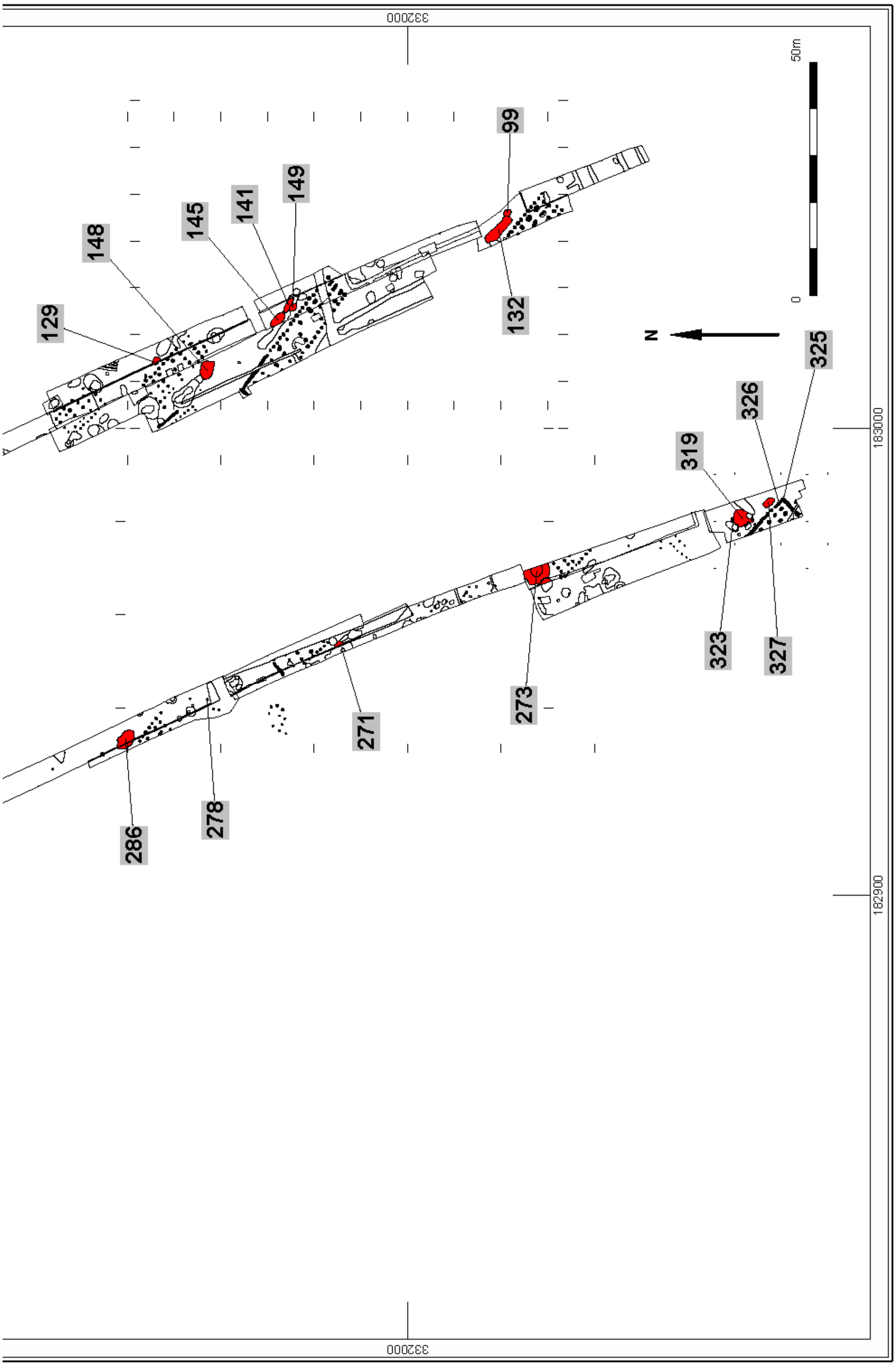


Figure 5. Overview of the botanical samples taken at excavation at De Heidekampweg, in Stein, The Netherlands. Numbers 75, 76, 79, 80, 112, and 278 represent the late Iron Age samples



researched. Numbers 99, 129, 132, 141, 145, 148, 149, 271, 273, 286, 299, 319, 323, 325, 326 and 327 are the samples researched of the LBK period.

Afterwards, they were dried and it was checked whether they contained any charred seed remains under a incident light stereomicroscope. Where possible, remains were individually identified, mostly to the species level. Photographs of *Panicum miliaceum* were taken with a Nikon Microscopy Digital Camera. The statistics performed were sadly only limited to frequency tables. Further statistics, such as Principal Component Analysis (PCA) and Correspondence Analysis (CA) were impossible to perform because of the too limited amount of features sampled at the site. Numbers of appendix Tables and Figures are preceded by an "A".

1.3 Layout of the thesis

Since this thesis comprises two main subjects, they are each given their own separate introductions, formulation of problems within the research field, and methods with which this thesis seeks to answer them. The layout is as follows:

Chapter 2 will give a more detailed introduction of the LBK culture within the Netherlands with regard to crops, cultivation and farm life. Also, a main issue within the field of LBK research will be put forward that will be researched further in this thesis.

In Chapter 3, results of the LBK research will be presented. The LBK features sampled will be discussed in more detail, and separate paragraphs will deal with the (special) finds found and the statistics performed. The detailed introduction for the Iron Age will be given in Chapter 4, in which the same subjects are dealt with as in Chapter 2 for the LBK. The results for the Iron Age are presented in Chapter 5, where again the features are described in more detail and separate paragraphs are made for the finds and statistics. Chapter 6 gives a summary and short discussion of the results of both the LBK and IA periods. For the LBK, a short insight into the farmers' year cycle based on the results will be discussed. In addition, since the LBK and Iron Age features are in close proximity in Stein, this chapter will try to give a comparison of the two time periods with regard to several cultural and environmental factors. Finally, Chapter 7 will try to assess whether the hypotheses put forward for both periods have been answered satisfactorily and it will also give the conclusions of this research.

2 Farming in the Early Neolithic Netherlands

2.1 Introduction

The people of the LBK are considered to be the first culture to introduce farming to the Netherlands. Preferring loess for their agricultural practices, they travelled along the loess belt, roughly spanning from Hungary to northern France, arriving in Limburg, the Netherlands, around 5300 BC (Bakels 2009, 29). From there, it is believed that the Neolithisation process spread to the west and south-west of the Netherlands in the next millennia. The LBK culture in the southern Netherlands finally disappeared around 4900 BC (Bakels 2009; Louwe Kooijmans 2009). As sedentary communities, LBK farmers most likely practised both animal and crop husbandry. A typical community consisted of a hamlet with an average of 5 houses, each of which could provide shelter to around 10 people (depending on the size of the farm) (Bakels 2009; 45, 50). Strikingly, LBK houses always have a fixed orientation (northwest-southeast) and usually measure around 6m wide. Their length however, can range from 6 m to 35 m long. The floor plan of an LBK house is indicative for the time in which it was used. For example, a special configuration of post(hole)s in the centre of the house, denoted as a Y-shape, indicates an older way of building LBK houses as opposed to the later tradition lacking this shape (De Grooth and Van de Velde 2008, 226). Livestock consisted of cattle, sheep, goats, and pigs. Surrounding a farmhouse, several pits are found, which would have had different purposes. Long pits, which line the long sides of the house, were probably used for the construction of loam walls. Other pits, lying further from the building, are sometimes found to have been underground silos. These pits have a distinct flat bottom, straight walls and sporadically even contain a layer of charred crop remains. The charred remains from these silos can provide greater insight into whether the grain found in them would have been used for long-term storage, or whether it was the result of a failed cooking incident related to daily use. The list of charred seeds found at an LBK site is always fairly consistent. The major cultivated crops from the LBK in the Netherlands, starting around 5300 BC, are the hulled cereals emmer wheat (*Triticum dicoccum*) and einkorn wheat (*Triticum monococcum*), the pulses pea (*Pisum sativum*) and lentil (*Lens culinaris*),

and the oil seeds linseed (*Linum usitatissimum*) and poppy (Papaver *somniferum var. setigerum*).
None of the abovementioned crops used by LBK farmers originate from the area. The majority derive from the Near East, whereas poppy comes from the Mediterranean basin and is not found in the eastern part of the LBK region. The consistently small variety of weeds found in LBK sites, has given rise to the idea that perhaps there was a specific cereal weed plant community for LBK times, the *Bromo-Lapsanetum praehistoricum* (Knörzer, 1971a).
A plant which is not considered a crop, but one that is also often found in LBK settlements, is rye-brome (*Bromus secalinus*). This plant is more common in archaeobotanical samples than other wild plants and might have been collected as a semi-cereal. It would then be the first LBK cereal not ultimately originating from the Near East (Bakels 2009, 32). Also not considered a crop but possibly an important plant is *Chenopodium album*, of which many (unripe) seeds occur in archaeobotanical samples. The amount and state (ripe vs. unripe) of the seeds has given rise to the idea that it might have been collected as a vegetable (Bakels 1971, 287).
Since both charred cereal and weed remains are often found in the same samples it is assumed that they have been charred during the same process (Hillman 1983, 27).
To harvest, LBK farmers most likely used sickles, with which cereals are reaped relatively high on the stalk (Kreuz 2011, 334). This means that smaller weeds are excluded from the harvested assemblage, as seen from the fact that most of the crops and weeds found in LBK sites grow seeds at the same height of the cereals or higher. Twining weeds such as *Fallopia convolvulus* in particular are hard to avoid during harvest and that is why they are often found in the charred remains as well, even though they are not extraordinarily tall plants. The actual farming fields from the LBK period have not been found and there has been much debate on size and type used by a single farm. The type of land use by LBK farmers can therefore not (as of yet) be really established. Two possible major crop husbandry models for Neolithic farmers are put forward by Amy Bogaard (2004): floodplain cultivation and intensive garden cultivation. Floodplain cultivation is performed on locations where the fields flood in wintertime, which brings in new nutrients, but prevents successful autumn sowing. The other proposed method, intensive

garden cultivation, is more generally accepted and is characterized by high input of labour with spring and/or autumn sowing, on a relatively small scale. This type of crop cultivation would however require stable environmental conditions for a longer period of time. When we indeed accept that intensive garden cultivation is the most likely form of land use in the LBK period, we are still left with the problem whether cereals were sown in autumn or spring time, which are both possibilities within this model, and which both have their own implications for the farmer's year cycle.

2.2 Autumn versus spring sowing

In a year, a farmer needs to plan when and how he performs his agricultural practices. Pulses can only be sown and grown from the springtime onwards. Cereals however, can have varieties that can be sown in autumn or spring, that therefore also differ in growth time and harvest yield. Whether sowing of cereals took place in spring, autumn, or both, remains one of the main problems in LBK farming life reconstruction at present. When we can find out at what time cereals and other crops were sown, we can gain more insight into the life of LBK farmers and what the resulting consequences could be for the planning of their year cycle. Two authors recently published two conflicting ideas within this matter. In her PhD dissertation, Bogaard (2004) researches the problem statistically and concludes that intensive garden cultivation with autumn cereal sowing is the most plausible crop husbandry model. She bases this on the weed seed assemblage in LBK , which she finds indicative for autumn cereals and on the fact that autumn cereal sowing was performed in the Near East as well. This cultivation method would have been continued across the loess belt into Western Europe. Since autumn sown cereals have a longer period of time to grow, they have higher yields, which could have been advantageous for farmers as well as leaving them with more time for sowing other food plants such as pulses in spring. A direct effect of this separated time of sowing cereals and pulses is that the autumn would then be needed for both harvesting and sowing. This would leave less time for hunting and the collection of fruits and nuts.

Angela Kreuz (2011) on the other hand, assumes that farmers must have cultivated only spring-sown summer cereals. She bases on the fact that her samples contain almost no winter-annuals, which are thought to co-exist primarily with autumn-sown cereals. She suggests farmers might have selected summer varieties of cereals normally sown in autumn, such as einkorn and emmer, along the way from Southwest Asia to Western Central Europe to adapt to the colder and wetter climate of North-Western Europe. Furthermore, Kreuz argues that: “Summer-crop growing had the positive consequence of keeping the autumn free for collection of wild fruits and nuts and hunting, and all in all fieldwork was better distributed over the year. In addition livestock could graze the fields from autumn until field preparation in early spring, in the meantime manuring the soil”.

2.3 Research questions

The abovementioned assumed cultivation methods, conflicting ideas on sowing time, and the recent excavation of the LBK settlement in Stein have provided the opportunity to investigate whether any new contributions can be made to this area of research.. The following research questions will hopefully be answered in this part of the thesis:

- o What was the quality of the soil and how was the land used ? Are the generally accepted models for land type and land use also reflected in the finds of Stein, an area on the borders of the loess?
  - - What was the performed method of land use by LBK farmers from Stein, who are probably part of one of the earliest groups of LBK farmers in the Netherlands? Was it already intensive garden cultivation?
  - - What was the general soil quality of the fields of LBK farmers in Stein? Is there reason to believe that they also had access to/used soils that were very fertile, or are differences in soil quality seen?
- o How was food produced/collected during the LBK in Stein?
  - - How can finds be interpreted with regard to the living regime of LBK farmers? Can contributions of collected foods be seen in addition to the harvested food? What is the added value of gathering food for farmers and what could be possible reasons for performing this act?
  - - Based on the results of Stein, what can be said about the sowing regime that LBK farmers used there? Is autumn and/or spring sowing the most likely candidate? Can the results from Stein give any insight in the debate between Bogaard and Kreuz and possibly be in favour of one of the two theories?

3 Results LBK

3.1 Feature description

The features sampled from the LBK site in Stein were shortly mentioned in the general introduction. Here, a more detailed review of the individual aspects and locations of the sampled features will be given (see also Fig. 6). To prevent confusion with numbers, the features will be described by the number of the sample taken from them. Each feature was given an approximate dating on the basis of ceramics recovered from it. Sample 299 is from a cluster in the north-west of the excavation and seems to represent a younger phase than the other LBK features/structures. For sections of features, see appendix.

Sample 99: small round pit on the north side of structure 1, possibly a silo (Fig. 6)
Sample 129: small pit on the north side of structure 3 (Fig. 6)
Sample 132: long pit on the north side of structure 1 (Fig. 6)
Sample 141: pit on the north side of structure 2 (Fig. 6)
Sample 145: long pit on the north side of structure 2 (Fig. 6)
Sample 148: large pit on the south side of structure 3 (Fig. 6)
Sample 149: small pit on the north side of structure 2 (Fig. 6)
Sample 271: pit on the south side of structure 9 (Fig. 7)
Sample 273: pit between structure 6 and 9 (Fig. 7)
Sample 286: large pit on the north side of structure 11, possibly a long pit (Fig. 7)
Sample 299: large pit on the north side of structure 13, possibly a long pit (Fig. 8)
Sample 319: large pit on the north side of structure 6 (Fig. 9)
Sample 323: burnt red loam concentration in sample nr. 319 (Fig. 9)
Sample 325: split tree trunk feature of structure 6 (Fig. 9)
Sample 326: split tree trunk feature of structure 6 (Fig. 9)
Sample 327: small pit on the north of structure 6 (Fig. 9)

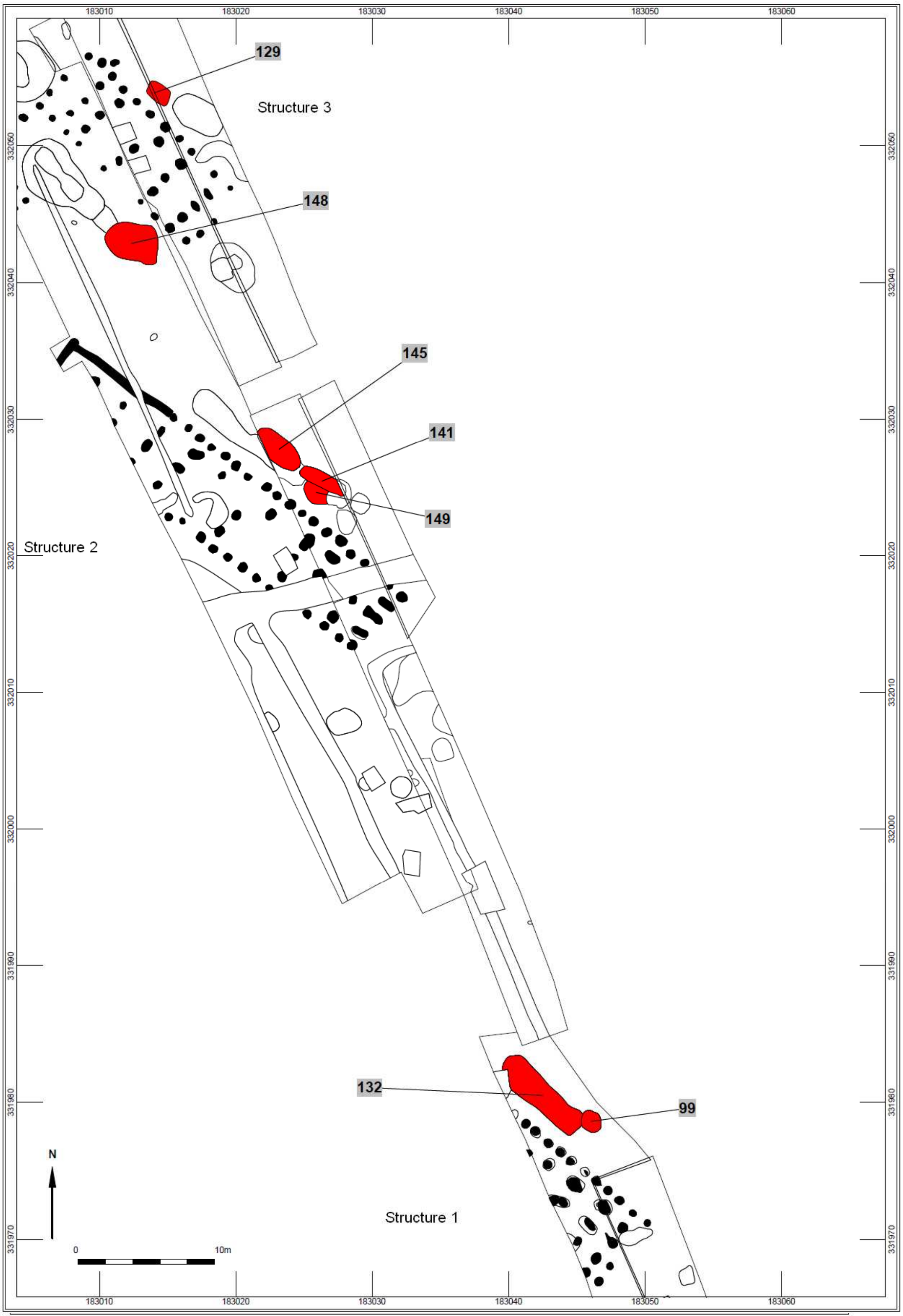


Figure 6. Overview of the botanical samples taken from the LBK features 99, 129, 132, 141, 145, 148 and 149.

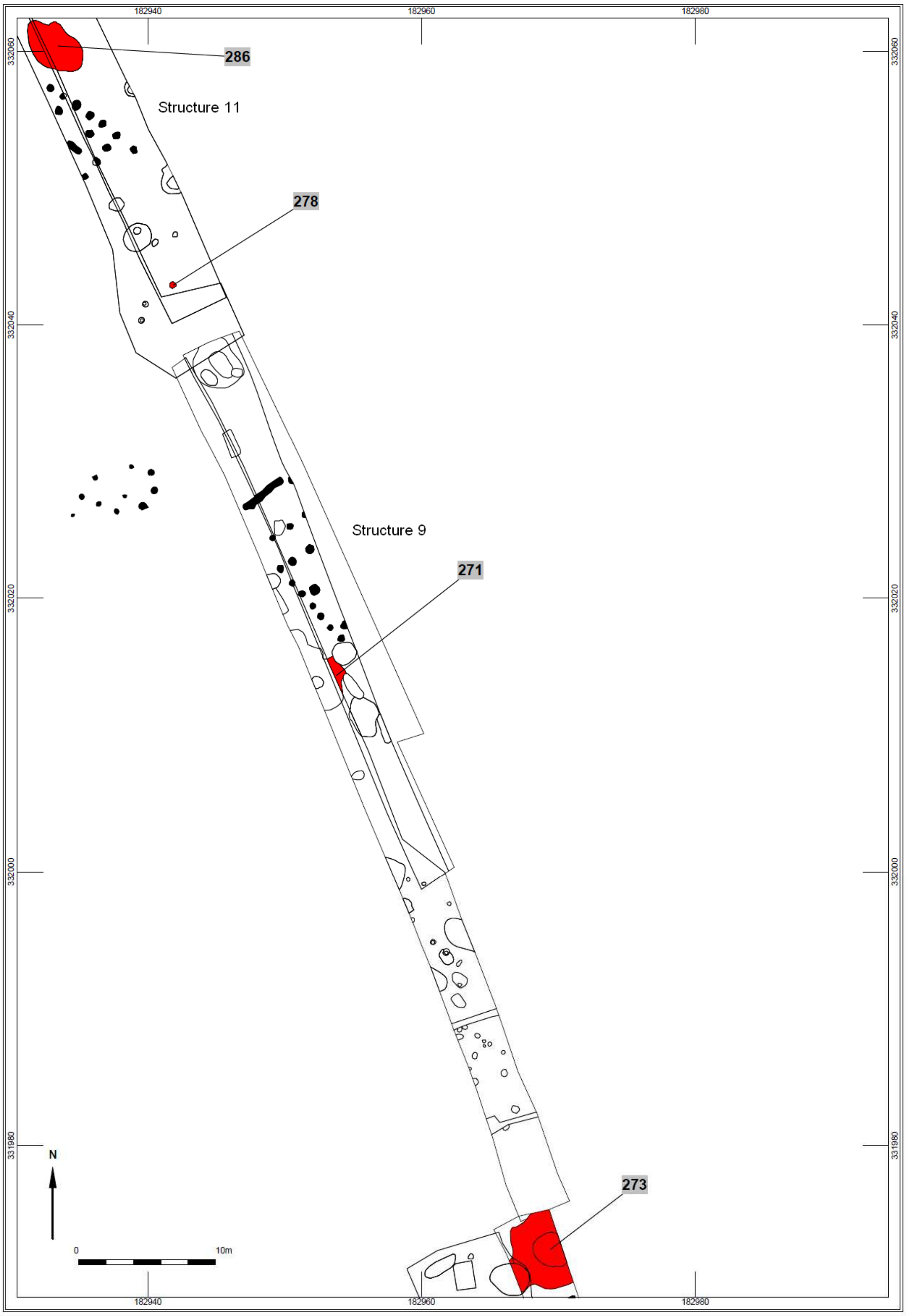


Figure 7. Overview of the botanical samples taken from the LBK features 271, 273, and 286. Feature 278 was dated to the late IA.

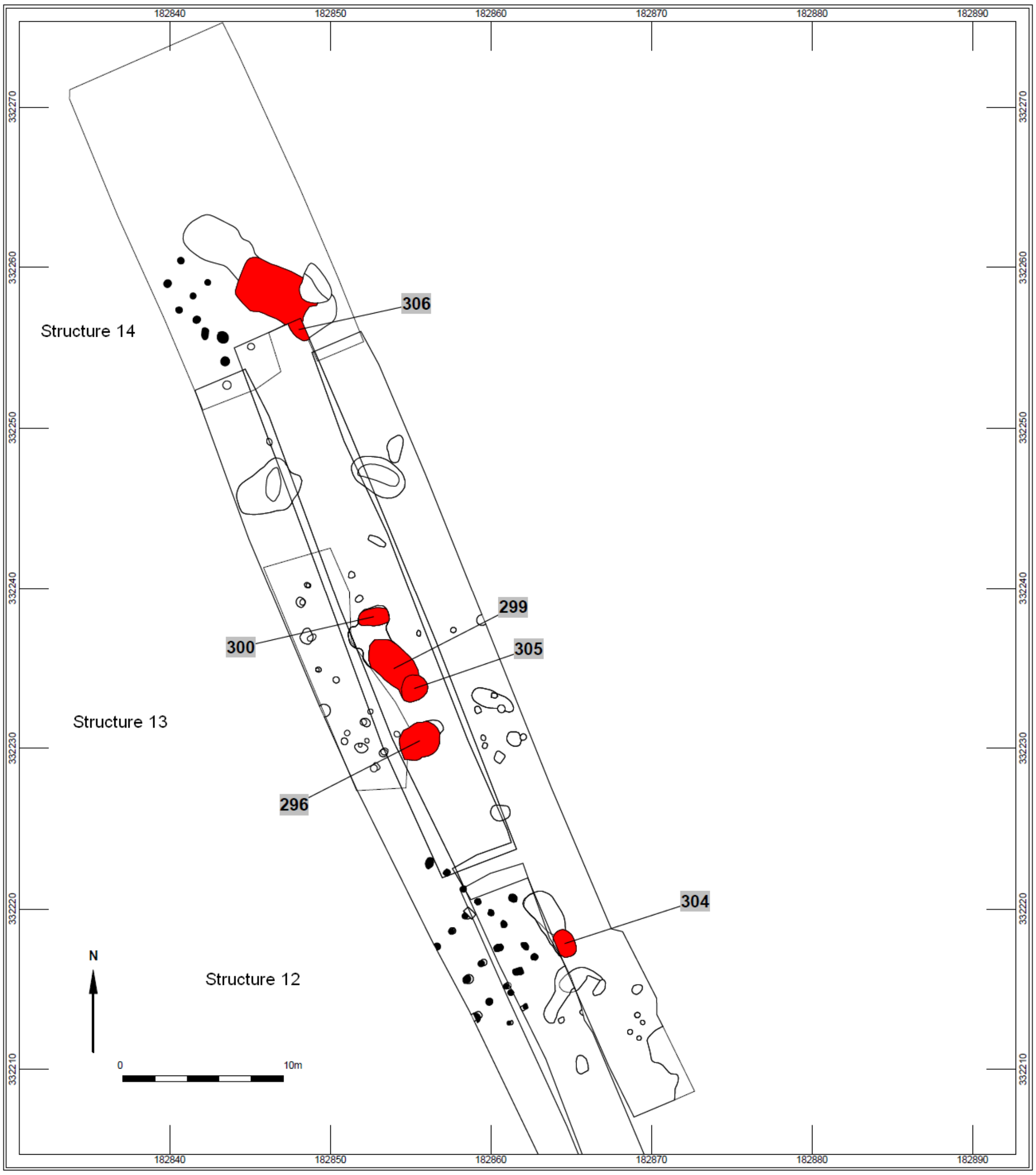


Figure 8. Overview of the botanical sample taken from the LBK feature 299.

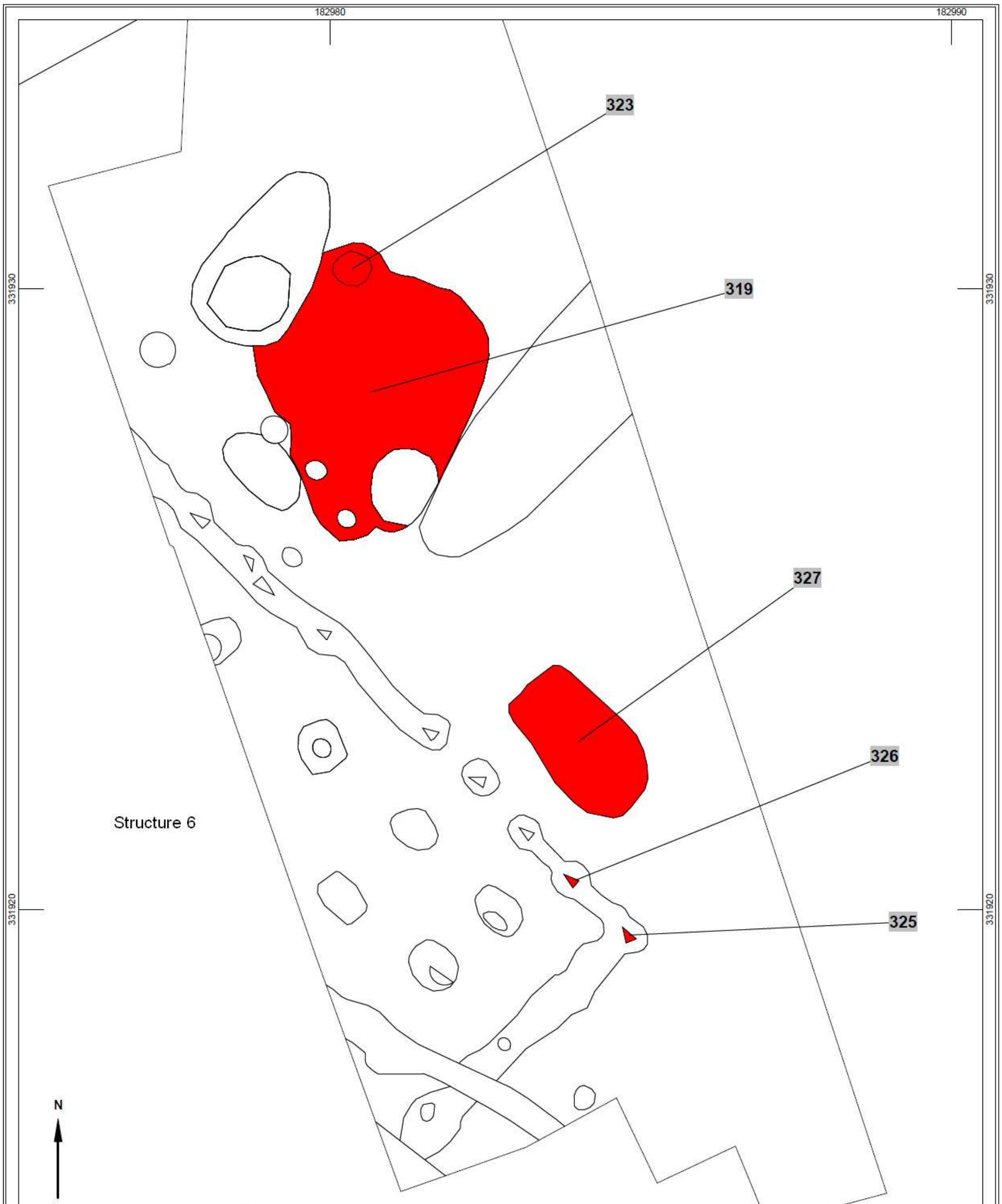


Figure 9. Overview of the botanical samples taken from the LBK features 319, 323, 325, 326, and 327.

3.2 Finds

As mentioned before, all the plant remains found in Stein are charred, since the groundwater level is too low to preserve other plant remains. All the charred remains recovered from the samples are summarized in Table 1. In the table, the amount of charred botanical fragments per sample was given.

There are several ways of interpreting what these fragments represent. One way is to make an estimate of how many whole seeds could have been represented by the fragments. This is done by making groups of fragments per plant species and assessing what the minimal amount of seeds could have been, based on the size of the fragments and the size of the whole seed. The problem with this approach is that you assume that all the fragments (per species) found in the sample are related. Even if this was the case, for example when they are discarded during a single event, not all seeds will have charred. In addition, taphonomic processes could have treated seeds differently so that just parts would have survived. The resulting fragments found can therefore not conclusively be part of each other and/or represent the actual minimal amount of seeds, which results in an under-representation.

Another way of interpreting fragments is to assume that every fragment belonged to a single individual seed. This might over-represent the amount of seeds slightly, but it is a more safe and realistic approach to what is found. A parallel can be found in pottery. When shards are found at an excavation, they usually cannot be reconstructed as belonging to entire pots based just on the amount and size of shards. We need other characteristics, such as colour, thickness, shape, etc., to see whether shards belong to the same pot. And still, when not all shards of a pot are found, it remains uncertain whether they did not belong to separate similar pots. Since with charred remains it is sometimes nearly impossible to see any characteristics of a seed at all, it is better to assume that all fragments have derived from separate seeds. The real number of seeds will lie somewhere between these minimum and maximum amounts.

It must be noted, that in the case of bulk disposal, the probability of fragments of seeds belonging to the same whole seed will be higher than in samples where seeds casually arrived in the archaeological record. In Table A1 in the appendix, both minimal amount and number of fragments are given, for comparative purposes.

Table 1. Overview of the researched LBK botanical samples from Stein with their corresponding charred remains. Charred remains are given in number of fragments per litre. Amounts of chaff from samples containing only *Triticum dicoccum* were converted to number of glume bases, where one spikelet fork represents two glume bases. Latin names are consistent with Heukels' Flora (van der Meijden, 2005).

Sample nrs	**99**	**129**	**132**	**141**	**145**	**148**	**149**	**271**	**273**	**286**	**299**	**319**	**323**	**325**	**326**	**327**
Taxa																
CEREALS AND CROPS																
Cerealia	56	1	1	1	19	1		3	1	8	9	7	3	30	12	
Panicum miliaceum					1											
Pisum sativum						2										
Triticum dicoccum	28			1	3			1			1	1				
Triticum monococcum					1											
Triticum spec.			1	1												
Triticum spec. (chaff)	87	4			1	4	3	4	6	3	2		4	1	1	
COLLECTED PLANTS																
Corylus avellana	183		2		8					2						
WEEDS																
Bromus secalinus-type	3			1	1	1			3					4	8	
Bromus spec.				1		1		2		1						
Chenopodium album	55	1	1	1	1	3		2		5		3		3	8	
Chenopodium/Atriplex spec						1										
Echinochloa crus-galli	9															
cf. Echinochloa/Panicum					1											
Fallopia convolvulus	1					1		1	1	2				1	1	
Fallopia/Polygonum spec.																1
Setaria verticillata/viridis	2															
Solanum cf. nigrum	1															
Vicia hirsuta/tetrasperma						1										
TOTAL	425	6	5	6	36	15	3	13	11	21	12	11	7	40	30	1

Most of the crop species and common weeds were found in Stein, as would be expected from a LBK site, with the exception of lentil, linseed and poppy. As a comparison, at Geleen-Janskamperveld, another LBK site only 4 km away from Stein, a more elaborate composition of plants was found. There, all the six major crop species and several weeds were found, with in addition some apple and sloe plum remains (Bakels 2008, 91-92). What we find in Stein seems to be a depleted version of the multitude of finds from Geleen. This can be explained by the fact that a lot more samples were taken in Geleen, which results in a better overview of plant remains.

A few exceptions to the normal LBK composition of plant remains were found in Stein. First of all, *Panicum miliaceum* was found for the first time in the LBK period in the Netherlands. Secondly, higher amounts of *Corylus avellana* shells were retrieved from one of the samples. The presence of *Solanum nigrum* finally is also uncommon in the western LBK area. Each of these special finds are given their own paragraphs below, where they will be discussed in more detail. NB. *Vicia hirsuta/tetrasperma* is also a special weed in the sense of its height, since it only grows to about 50 cm high. However, it is also a twining weed, so it could have attached to cereals quite easily and have entered the settlement via that route.

3.2.1 *Panicum miliaceum*

The most surprising find from Stein from feature 145 was *Panicum miliaceum*, also called common millet, proso millet or broomcorn millet (Fig. 10).

Figure 10. *Panicum miliaceum*, better known as common millet.

This Eurasian plant is a quick-maturing summer cereal which is adapted to areas with less fertile soils and poorer growing conditions, such as intense heat and low rainfall (Web reference 1). It takes only about 70 days to reach maturity and due to its late sowing time

(May-July), it can be used for double cropping, which means planting one crop after the other on the same field. When looking at the origin of the species *P.miliaceum*, it is fairly uncertain where it came from. It appears contemporaneously in China and Europe before 5000 BC (Hunt 2008, 15) and it has been speculated that the separate branch of millet dispersal leading into Europe might have occurred from southwest Russia (Lüning et al, 1989). Other areas where *Panicum miliaceum* has been found around 6000-5000 BC are, amongst others, Bulgaria, Greece, The Czech Republic, Slovakia, and Germany (Hunt, 2008).

P. miliaceum has not been found in LBK sites in the Netherlands before. The nearest area where it has been found is in Germany, although sparsely (Kreuz 1990, 2). To make sure that this find was not a contamination from younger periods, where *Panicum miliaceum* is a much more common cereal, several things were checked. As can be seen in the drawing from the section (appendix), the feature from which sample 145 was taken is undisturbed by younger periods. Also, it was verified that there were no finds of younger periods in the LBK feature. Finally, the feature is not located in an environment where younger periods are found as well. Based on these facts, it can be concluded that the presence of *Panicum miliaceum* in Stein must be genuine. Although partly damaged, the positive identification of *P. miliaceum* was established based on the identification key of Knörzer (1971b). The two factors that led to the identification of the seed as *Panicum miliaceum* were that the hilum (seed coat scar) is almost round, and that the scutellum (is a tissue within the seed that is specialized to absorb stored nutrients) is at most half as long as the whole kernel (Fig 11).

Panicum miliaceum is not considered to be a cultivated cereal in LBK Europe, due to its isolated finds. Kreuz et al. (2005, 243) have suggested that *P. miliaceum* seeds might have been a weed in LBK times. They state that it might have acted as a weed of the larger cereals such as einkorn and emmer, and arrived at the fields through the seedcorn. Indeed, in addition to millet, also *Cerealia spec.*, einkorn and emmer are found in sample 145, as well as an additional *Echinochloa/Panicum* seed. This could possibly be a second *Panicum miliaceum* seed, but because of severe damage, could not be identified with enough confidence. However, the possibility remains that common millet was indeed a weed in LBK times.

One way of looking for a possibility why *P. miliaceum* could have been used as a cereal instead in LBK times, comes from another point of view. Perhaps *P. miliaceum* is not often found in LBK sites because it was a “Plan B” for when other harvests (einkorn, emmer) failed due to unfavourable growing conditions that millet does withstand. Conversely, usually if *Panicum miliaceum* is found on a LBK site, there are only one or a few seeds (Kreuz 1990, 2), which is very low when we consider millet as a cereal. One of the reasons for low amounts of charred remains could be that *P. miliaceum* is hard to harvest. It is very prone to shattering (losing seeds upon handling the plant) and lodging (toppling over of plants). Alternatively, threshing of the harvest might have taken place on the fields instead, to limit the harvest loss. Afterwards, the seeds could have been relocated to the settlement. Still, we would then have expected to find more seeds at the site to verify the amount used by people for consumption. It seems therefore most likely that *P. miliaceum* was indeed a weed in LBK times, although we must remain open for ideas such as a “Plan B” scenario, which cannot entirely be discarded since it would only be scarcely used (i.e. in times of need).

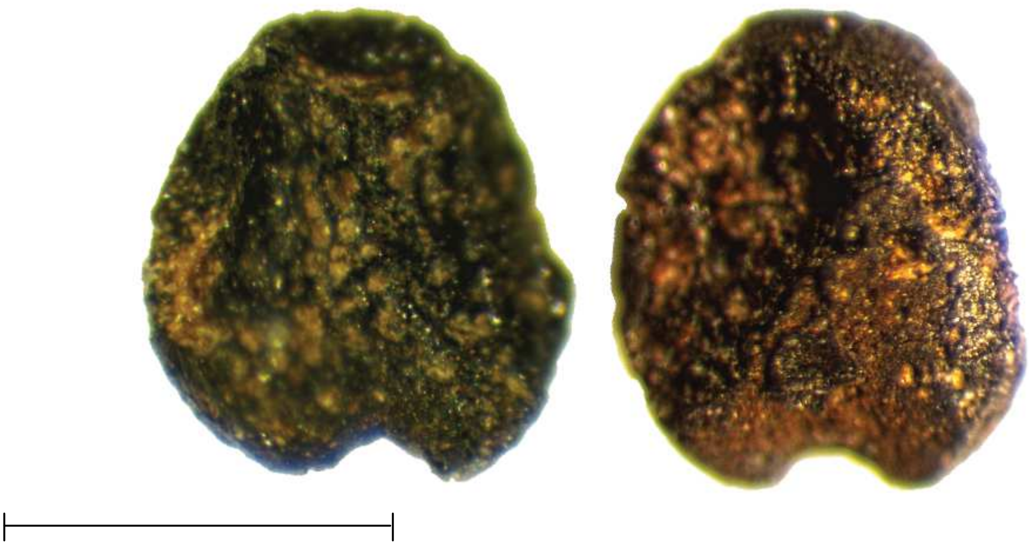


Figure 11. Photographs of the *Panicum miliaceum* seed from sample 145. Left: ventral side with *hilum* (heavily damaged surface; ‘compartments’ seen are not part of the normal surface, but the result of charring and breaking). Right: dorsal side with *scutellum* (partly damaged on left; on the *scutellum* is a black ‘patch’ which is also a result of the charring process). Scale bar: 1 mm, actual size of seed: 1.25x1.05x0.6 mm.

3.2.2 *Corylus avellana*

In sample 99, another interesting find turned up. Here, a higher amount of hazelnut (*Corylus avellana*, Fig. 12) shell fragments was present than is usually found in LBK sites in The Netherlands (Table A1). Following the logic mentioned in paragraph 3.2 that it is better to assume that each fragment found represents as single individual seed, these fragments could have belonged to a maximum of 183 hazelnuts.

Figure 12. *Corylus avellana*, or common hazel.

Hazelnut shrubs occur mainly at the edges of woodland and can bear nuts two times a year (Van der Meijden 2005). In order to be worth collecting by LBK people, a sufficient amount of woodland borders needs to have been present in the surroundings. It is imaginable that the collecting of these types of food must have been most important for newly colonized areas or new families at the edges of existing settlements, which both suffer from land that is not (yet) suitable for providing full harvests. Hazelnuts can be collected as a staple crop, since they are easily stored throughout the winter months. In the process of new land reclamation, life would have been hard and additional food might have been needed in the form of fruit and nuts.

Although Dutch sites scarcely have higher amounts of hazelnut, an area in which hazelnut is reported more frequently is Belgium. The LBK occupation in Belgium lasted no more than two centuries, from ca. 5200-5000 B.C. (Salavert 2011, 321), and Belgian LBK sites are mainly found at the moving front of the LBK expansion towards the west. Several sites in central Belgium have extensively been excavated and have yielded high amounts of charred remains (Salavert 2011). Three of the sites researched (Darion-Colia, Blicquy-La Petite Rosière, and Aubechies-Coron-Maton) had notably more hazelnut remains than others (Salavert 2011, 324). Since it is assumed that hazelnuts were eaten by LBK people, they can be interpreted as the remains of gathering activities, and the shells are therefore discarded as household waste.

Interestingly, the hazelnut-rich sites in Belgium all seem to be located at the source of (small) rivers. Possibly, the surroundings around river sources are more varied in their composition and may have provided enough space for hazelnuts to grow which could be exploited by the LBK farmers in this expanding front area in Belgium.

In Stein, the site is not located at the source of a river and neither is Geleen-Janskamperveld. What then can be the reason for finding many fruits and nuts here? These sites contain many hazelnut shells and apple and sloe plum remains, respectively. Much the same as hazelnuts, apple and sloe plum can both also be dried and stored. The fact that we find them all back charred in a feature is thus probably because the drying had failed in this case and the food got burnt. But the question remains why full fledged farmers would have need for many fruits and nuts as staple food throughout the winter months? They were not necessary if they had enough cereals. Conversely, possible reasons for gathering could be a failed or poor harvest, which could have different causes. Weather could have an influence on crop failure, but it could also be the result of farmers working on newly exposed fields, which are not at their maximum crop yield yet. It is hard to assess whether weather was the main factor towards gathering activities. In the very least, one would then expect higher amounts of gathered food remains found, since all farmers would equally be affected by the weather and have equal need for other food supplies. Therefore, the idea arises that the gathering and possible storage of fruits and nuts would be performed by new families in the existing settlement, that cannot yet solely rely on their harvest for food. Since there is a expansion front during the LBK in Belgium and in The Netherlands, it seems that new families in these expanding societies need additional food gathering when they first start farming in a settlement. In contrast with

hazelnut, apple and sloe plum do not have to be at the edges of forests to grow. So, when needed, new families could gather fruit from the forest or its edge as extra food for when their harvest was poor or insufficient. In Geleen, hazelnut shells were found frequently, although concentrations of these remains are absent (Bakels 2008, 91-92). It can therefore not be assessed whether the amounts of hazelnut found there are extraordinary as well.
In Stein, the charred remains were found in a concentrated carbonized layer of a feature (see drawing of section 99 in the appendix). The shape of this feature resembles an underground silo. If this feature indeed was a silo, it most likely was not at the time of hazelnut shell disposal, since hazelnut shells are considered part of the house-hold waste. A possibility is that the feature was initially used as a silo, but was used for waste disposal in a later stage. That is also in concurrence with the idea of a new family, who would not have a surplus of harvest to store, and perhaps did have much waste from other food sources so that a waste pit would be more appropriate for them.

3.2.3 *Solanum nigrum*

Another relatively uncommon find of sample 99 was the presence of *Solanum nigrum*, or European black nightshade (Fig. 13). Two factors make this weed an unusual find, at least in the western LBK. Firstly, it is a very small plant, reaching only 7 – 30 cm in height (Bakels 2009, 37, Table A3), whereas all the other plants found in this feature (and in LBK sites in general) usually measure at least up to 1.20 meters. Since LBK farmers probably harvested cereals high on the stalk, it is odd that such a small weed ended up in a silo/waste pit. One possibility could be that it was collected selectively for food, but since its berries are very toxic, it seems unlikely.

Figure 13. *Solanum nigrum*, also known as black nightshade.

Black nightshade potentially has diverse medicinal properties due to the alkaloids it contains (mainly solanine). Alkaloids are secondary metabolites of organisms that are usually toxic, but also have pharmacological effects and are often used in medicines (e.g. morphine, quinine). Whether LBK farmers also used this plant for medicinal purposes is impossible to say. It does seem as unlikely as the food argument, since only the leaves and sometimes flowers are found to have some healing properties, but berries contain the seeds we find (Edmonds 1997, 59).

The second factor why *S. nigrum* is uncommon in the Neolithic in the Netherlands, is its soil preference. It is an indicator of highly fertile soils which can only be reached through the addition of fertilizers (Bakels 2009, 113). However, since it is unknown whether manuring/fertilizing in LBK times was common practice (Bakels 2009, 39), this plant remains a mystery.

3.3 Statistics, soil and sowing

3.3.1 Statistics

Statistical research into the composition of features was performed next. Charred remains found in LBK sites can generally be divided into two categories. Those that have been discarded in a single event, and those that have casually accumulated over a longer period of time. To be able to differentiate between these two types, a column graph was generated that shows the density of remains in samples per litre against the frequency with which those densities occur (Fig. 14). In the graphs, both the amount of fragments of seeds found as well as the minimal amount of seeds that can be reconstructed from those fragments are shown. Thus, both ends of the spectrum can be considered.
Typical for LBK remains is the fact that small amounts prevail and that larger amounts are scarce. Low densities of remains are indicative of casual, independent accumulation, which follows the Poisson distribution (Bakels 1991, 281). High densities are considered to have been a part of a single event, are thus dependent and are therefore not part of the Poisson distribution. As can be seen in Fig. 14, almost all of the samples fall into the low density categories. Only one sample, sample 99, has a high density of charred remains. In both the amount of fragments as well as the minimal amount of remains found, this sample is outside of the Poisson distribution and is therefore considered to be discarded in bulk. This sample is seen at the right of both graphs.

Both the scattered waste and bulk samples will be considered separately. In this way, more insight can be gained into their main components, the used harvest processing steps, and the field use of the field where they derived from.
First, the scattered waste component will be discussed. In Table 2, the individual taxa from the left side of the graphs in Figure 14 are sorted by frequency, i.e. the abundance with which they appear in the samples belonging to the scattered waste. By sorting the taxa in this way, the quantity of remains per sample is ignored, and the focus is on in how many samples the taxa are present, which provides a better way of comparison. What immediately stands out is that grains such as *Cerealia spec.*, *Triticum dicoccum* and the chaff of *Triticum spec.* are most prevalent, together with *Bromus* and *Fallopia*.

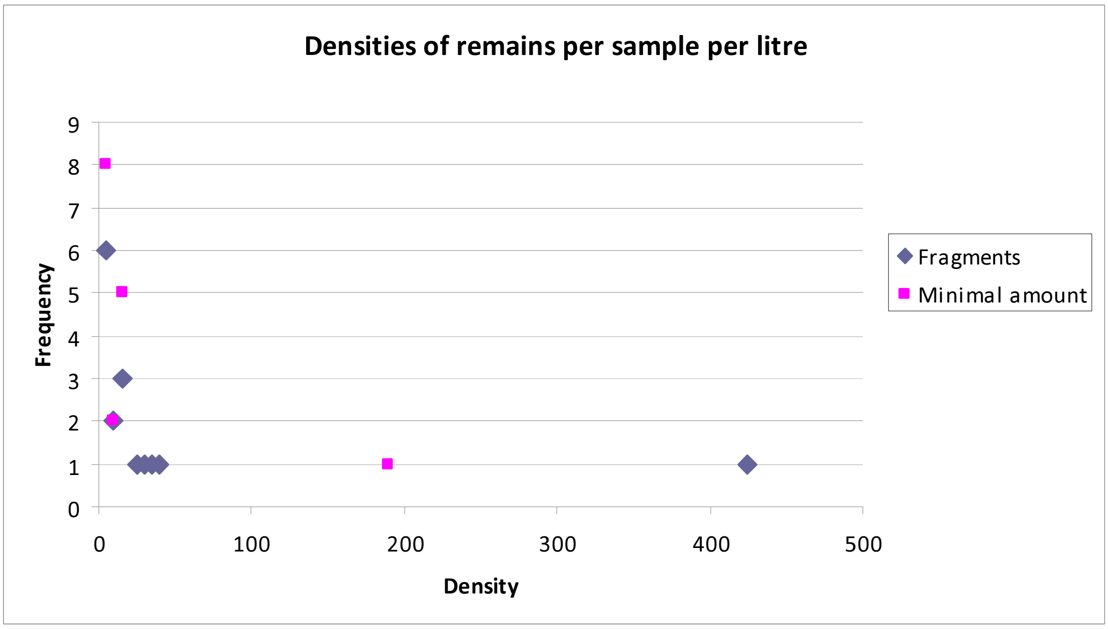


Figure 14. Graphs that show the densities of LBK charred remains from Stein per sample per litre against their frequency. Low densities are indicative of scattered waste, whereas high densities represent samples that have probably been discarded in a single event. The purple graph shows the densities of the number of seed fragments found. The pink graph shows the minimal amount of seeds that can be reconstructed from these fragments. Both follow the Poisson distribution quite reasonably, considering the small amount of samples that could be researched.

These taxa all belong to either the cereal or cereal weed group. Therefore, agrarian waste seems to be the main component of the scattered waste. Another abundant component in the frequency list is *Corylus avellana*, the unusually high frequency of which was discussed in paragraph 3.2.2. The remaining taxa are mostly weeds and since agrarian waste is the main component here, these are considered to have arrived in the settlement with the harvest from the fields. *Pisum sativum* and *Triticum monococcum* will have been harvested as a crop and cereal and their presence in the scattered waste is not unusual.

When the bulk sample (from the right side of the graphs in Fig. 14) is added to the frequency table, it clearly does not alter the order of the highly frequent taxa which are seen when only the scattered waste is considered (right side of Table 2). Therefore, the general composition of the feature of which sample 99 was taken is similar to the other samples and is thus considered to be agrarian waste as well.

Table 2. Frequencies of taxa of samples that are considered to be part of scattered waste and bulk. On the left side are the scattered waste samples, and on the right side of the table, bulk sample 99 was included. The total number of samples used for this was 16. Taxa which are more common in the samples are thought to have played a more common role in daily life. Latin names are consistent with Heukels' Flora (van der Meijden, 2005).

Taxa	Freq. in samples	Taxa	Freq. in samples + bulk
Cerealia spec.	13	*Cerealia spec.*	14
Triticum spec. (chaff)	11	*Triticum spec. (chaff)*	12
Chenopodium album	10	*Chenopodium album*	11
Bromus secalinus-type	6	*Bromus secalinus-type*	7
Fallopia convolvulus	6	*Fallopia convolvulus*	7
Triticum dicoccum	5	*Triticum dicoccum*	6
Bromus spec.	4	*Bromus spec.*	4
Corylus avellana	3	*Corylus avellana*	4
Chenopodium/Atriplex spec	1	*Chenopodium/Atriplex spec*	1
cf. Echinochloa/Panicum	1	*Echinochloa crus-galli*	1
Fallopia/Polygonum spec.	1	*cf. Echinochloa/Panicum*	1
Panicum miliaceum	1	*Fallopia/Polygonum spec.*	1
Pisum sativum	1	*Panicum miliaceum*	1
Setaria verticillata/viridis	1	*Pisum sativum*	1
Triticum monococcum	1	*Setaria verticillata/viridis*	1
Triticum spec.	1	*Solanum cf. nigrum*	1
Vicia hirsuta/tetrasperma	1	*Triticum monococcum*	1
Echinochloa crus-galli	0	*Triticum spec.*	1
Solanum cf. nigrum	0	*Vicia hirsuta/tetrasperma*	1

Although the composition of sample 99 and the other samples is similar, it is still interesting to look at what was discarded together to gain insight in food handling. Because this sample has a relatively high quantity of charred remains, it is most likely a concentration of waste that has been discarded in one event, perhaps as household waste. To find out more about at what stage of harvest and food processing the remains from sample 99 were burnt, the individual numbers of fragments of remains can provide information. The composition of remains of the bulk sample 99 is shown in Table 3.

Table 3. The composition of sample number 99. It is broken up into categories that shed light on the harvesting processing steps and the type of waste. The amounts shown represent the number of fragments found per category.

	Grain	Chaff	*Chenopodium album*	*Bromus secalinus*	*Corylus avellana*	Other weeds
Sample 99	84	87	55	3	183	13

In order to say something about the time of burning of the remains, it is useful to look at the grain first, since it is the main constituent of the harvest. The ratio of chaff vs. grain kernels can give an idea of the type of harvest processing performed. It can be seen in Table 3 that the categories “Grain” and “Chaff” both have a similar amount of remains. *Triticum dicoccum*, the main cereal found, is a species that contains two grain kernels per spikelet fork. Each spikelet fork consists of two glume bases, so every glume base can account for one kernel (Fig. 15). Therefore, the ratio of grain kernels:chaff on a *Triticum dicoccum* plant is 1:1. When we find this ratio in a sample, it is most likely grain which has been burnt with the chaff still on it, and indeed this seems the case with sample 99. Now we must look at the possible harvest processing stages where fire is needed (to explain the charred remains), and where the grain is still in its chaff (to explain the ratio of chaff and grain). When consulting Hillman’s article on harvest processing, it becomes clear that the burning must have happened in one of the early stages of harvest processing, before the pounding and winnowing; stages wherein the chaff and grain are separated (Hillman 1983, 5).

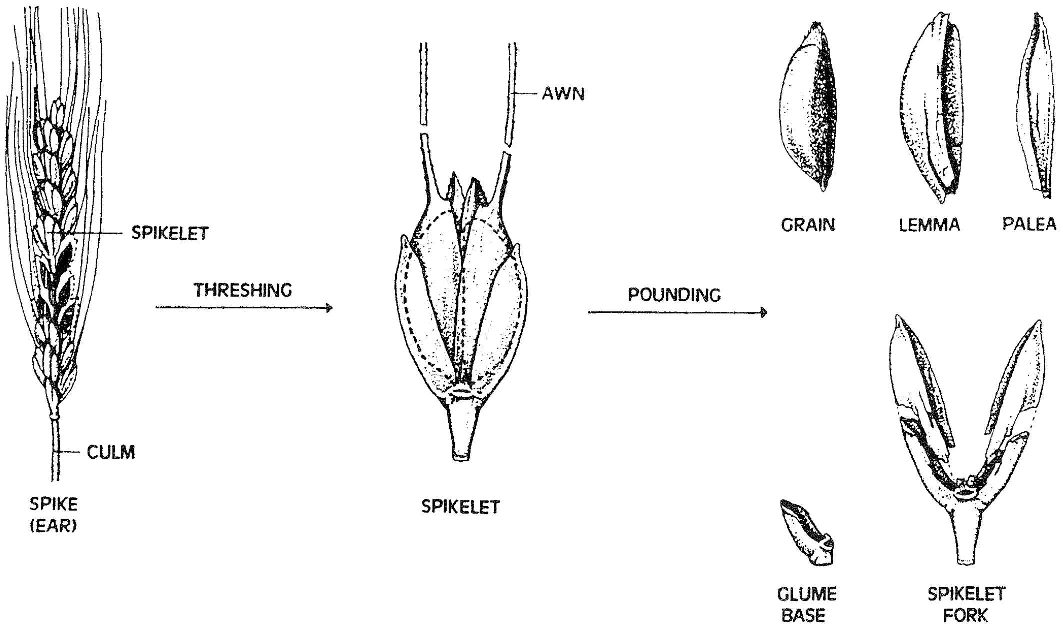


Figure 15. Schematic representation of the build-up of a *Triticum dicoccum* ear (after Hillman 1996, 196).

The steps involving fire at an early stage which are most likely for the results seen, can be narrowed down to two options. The first is the drying of grain to avoid spoilage in storage, the second is parching, used to render chaff brittle for easier release of chaff during subsequent pounding and winnowing steps. Both are used in wet climates, since grain in these environments has a higher chance to spoil due to moisture, and cannot dry well enough on its own for further harvest processing. Parching is a step performed on a daily basis to provide food for the family, drying is only used for long-term storage. Because we want to see which of these options is more plausible for Stein, and because the amount of grain and chaff recovered from only 1 litre of sample is relatively high, it is interesting to see whether the remains have the appropriate amount for drying for daily use or for bulk storage. Judging by the shape of the feature from which sample 99 was taken (see drawing of feature 99 in the appendix and Fig. 6), it once was used as a silo. In case the grain from sample 99 was used for bulk storage, it most likely did not derive from this silo, since it was not used as such at the time of bulk disposal of this agrarian waste. To find out of what type the carbonized grain from sample 99 really was, the total amount of grain in the sampled layer was extrapolated.

It was checked how far the carbonized layer reached into the feature and whether it was homogeneous. From this, it was established that the layer could be represented by a half cylinder (i.e. half of the feature). Its volume was calculated as such and this resulted in approximately 17 dm^3 or 17 litres of soil. When the amount of grains retrieved from one litre of soil was then incorporated into the calculation (i.e. 84), the maximum number of grains in 17 litres would have been approximately 1428 grains burnt in the chaff in the whole layer. At first sight, this seems a lot, but when the average weight of a thousand emmer kernels is used (Jantsch 1995), the 1428 grains only amount to about 83 grams worth of grains before charring. This is only a hand full of grains, which is not enough for a family meal, let alone be used for bulk storage, unless only a part was burnt.

In addition, it must be taken into account that the shape of the actual layer is not ideally a half cylinder. The grains might have been distributed unevenly over the layer, and the calculated amount of grains and chaff is therefore the absolute maximum. This means that the order of magnitude of the amount of grain found could not have been for bulk storage, since the amounts would have been much higher.

Another abundant component of sample 99 is *Chenopodium album*. It is thought that this plant might have been collected as a vegetable in LBK times. In order to be stored for later use, the seeds of *Chenopodium album* can be dried much the same as grains. It is therefore possible that these seeds got spoiled by burning together with the grains for the same meal. Still, the amount of seeds is still too limited to be very nutritious.
It is now clear that although the remains found in sample 99 appear many, the actual amount which could have been used for cooking is low. This is general factor to be taken into account when looking at (charred) botanical remains. The low amount could for example point towards a low harvest yield or a failed meal for one.
The relatively high amount of hazelnut shells found can perhaps be a sign that a poor harvest was complimented with gathered food from the surroundings, a point also made in paragraph 3.2.2. New families would have to rely on other food sources than just their harvest in the beginning of their settling.
The appearance of the layers in the section of this feature gives rise to the idea that the feature was used over multiple periods of time. There seem to be three main layers: one from the absolute bottom to the charred layer, and one reaching from the charred layer to the final darker layer on the top. The bottom of the feature will have been the bottom of a silo. After a while, it filled up and it can also be seen in Fig. A7 that the right side of the middle layer collapsed at one point (lighter part), which might explain why the silo was ultimately used as a waste pit in a later period of time.

3.3.2 Soil quality

The remains found cannot only give an indication of the presence of certain plants, they can also give an indirect insight in the soil quality of the fields they originated from. Since the charred weeds were almost always found in combination with cereal remains, they are considered to have derived from the fields where the cereals were grown. From the weed seeds found from LBK features, three stand out with regard to their preferred soil conditions. *Echinochloa crus-galli* and *Setaria verticillata/viridis* are both indicators for acidic, dry, nutrient poor soils (Schaminée 1998, 241). It is always assumed that LBK farmers lived on the most fertile (loess) soils available to them. These plants indicate however, that at least the condition of the soil of one of the fields used was probably more acidic than usual. The third plant, *Solanum nigrum,* is unusual in that it likes highly nutrient rich soils, which usually can only be achieved through the addition of fertilizer/manure, of which it is uncertain whether LBK farmers performed it. When we look at in which samples these remains occur, it can be narrowed down to one sample: again sample 99. All three remains found fit into the idea of new families in the settlement discussed before. It makes sense that a new family would need their own new land to use for agriculture and this land might not be (the most fertile land) available. Other families might have the ownership of the best land patches, since they had the first pick. A new family would have to cope with lower quality soils of available land patches or would have to clear an area of forest in order to create new land. Both kinds of land have specific soil chemical properties (e.g. more acidic) that would take a while before becoming optimal for agriculture, if possible at all. These factors would provide a possible explanation for the unusual plants found in sample 99.

3.3.3 Crop husbandry

Harvest

Sickle harvesting and intensive garden cultivation are the generally accepted models used in LBK agriculture. It was researched whether the same can be concluded for Stein based on the finds.

Different methods of cultivation and harvesting can be reflected in the variety of (seeds of) plants found. For example, during the LBK period in the Netherlands the most used harvest method was probably sickle harvesting, performed mostly halfway or higher up the stalk of the plants. As stated in paragraph 2.1, this means that generally, weeds smaller than half the average height of the cereal should not be represented. Most plants fit this theory. One exception from sample 99 however, is again *Solanum nigrum* (Table A3). This plant has a height ranging from 7-30 cm, which is much lower than the average cereal height, reaching around 90 cm. Since *Solanum nigrum* is not considered a cereal weed, other possibilities for its presence could include selective picking for food or medicine (unlikely, see paragraph 3.2.1), seeds deriving from flowers for decoration, or casual arrival through adherence to feet, etc. (Hilllman 1983, 19). In all, it seems that generally the proposed harvesting method for the LBK is confirmed.

Cultivation type

To gain more insight into the cultivation type of fields, several plant characteristics can be used: whether direct or indirect human influence is needed for the arrival and persistence of weeds, whether the plant is an annual or perennial, and which type of environment a plant prefers. The characteristics per plant species were obtained from Kreuz (2011) and were used to make the graphs for the LBK period (Fig. 16 and 17). All the charred seed remains found in the samples of the LBK from Stein are directly or indirectly dependent on human influence, so no graph was made. This need of plants for human interventions might be one indication for an intensive use of land. Furthermore, most seeds derive from annual weeds (Fig. 16). Unlike perennials, annual weeds do not need undisturbed, stable environments for longer periods of time. Because fields that are cared for with attention are more likely to be disturbed by agricultural practices, this is another argument for intensive land use (Kreuz 2011, 346). When looking finally at the environment types found (Fig. 17), the range is limited. All seeds fall under the category of ruderal/segetal vegetation, weeds of hoed fields and gardens, or cereal weeds. These categories are all close to or part of cultivated fields, which again makes the intensive garden cultivation model proposed by Bogaard (2004) for the LBK the most plausible explanation.

3.3.4 Spring or autumn cereal sowing?

The main question for the LBK period of this research, which was also mentioned in paragraph 2.2, is the likelihood of spring cereal sowing (Kreuz, 2011) versus autumn cereal sowing (Bogaard, 2004). The main statements of both authors on the subject are summarized in Table 4. According to Bogaard, the transition to farming in temperate Europe was fast and hunting-gathering was replaced more and more. People would have become full-fledged farmers with some occasional collecting of nuts and fruits, leaving enough time in the autumn for cereal sowing. Kreuz on the other hand, argues that by sowing in spring time, LBK people would have had more time for hunting and gathering in the autumn and could therefore practice both agriculture as well as (partly) being hunter-gatherers.

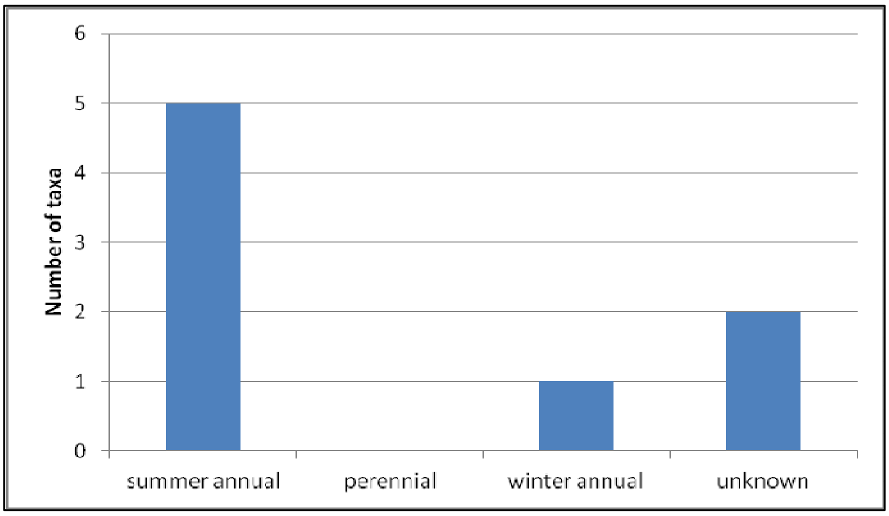


Figure 16. In this graph, the trend of summer annual versus perennial weeds found in the LBK samples is shown. One winter annual was found; all the other weeds found are summer annuals.

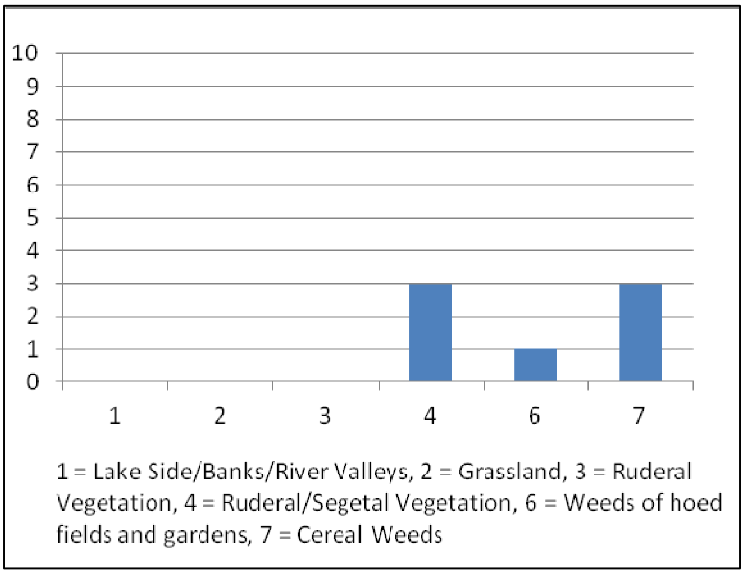


Figure 17. Here, the ecological groups to which the found weeds belong to are shown for the LBK. Only ruderal/segetal weeds, weeds of hoed fields and gardens, and cereal weeds are found.

Table 4. Short summary of the views of both Bogaard (2004) and Kreuz (2011) on whether spring or autumn cereal sowing was performed by LBK farmers.

<table>
<tr><td colspan="5">Kreuz 2011: spring cereal sowing
+ work on the agricultural field is better distributed throughout the year
o selection of summer varieties of Near East autumn cereals</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td></td><td>Autumn</td><td>Winter</td><td>Spring</td><td>Summer</td></tr>
<tr><td>Kreuz</td><td>Collecting fruits/nuts
Hunting</td><td>Grazing of livestock
+ manuring</td><td>Cereal sowing
Pulse sowing</td><td>Harvest</td></tr>
<tr><td>Bogaard</td><td>Cereal sowing</td><td>Germination</td><td>Pulse sowing</td><td>Harvest</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Bogaard 2004: autumn cereal sowing
+ higher yields
+ more time for spring sowing of other crops, such as pulses
o tradition of Near East continued
o less gathering and hunting due to lack of time in autumn</td></tr>
</table>

If indeed LBK people were fulltime farmers and therefore sacrificed the autumn months for cereal sowing rather than elaborate hunting and collecting of food, it should be reflected in the finds.

In the LBK samples from Stein, most of the charred weed seed remains belonged to summer annuals, which, according to Kreuz (2011) would indicate summer cereals.

One weed species however, *Vicia hirsuta/tetrasperma*, is reason for some debate. Kreuz (2011) states in her article that *V. hirsuta/tetrasperma* is "probably a summer annual". Bakels (2009, 37) however, gives it the annotation "winter annual", and Schaminée (1998; 229, 233) states that it is found in winter cereal fields on relatively acidic soils. In addition, germination of *V. hirsuta/tetrasperma* takes place in autumn and it emerges in winter/early spring. In present times, the weed is often found together with winter wheat, but scarcely in summer (Juroszek 2002, 244-245). It seems therefore more likely that *V. hirsuta/tetrasperma* is in fact a winter annual, which would mean autumn cereal sowing is in this respect a more plausible theory. To support this argument, Bakels (2009, 38) mentions that when sowing is performed in holes or rows, it would, in the case of autumn sowing, be possible that winter annuals and summer annuals appear together.

A second distinction in the articles and views of Bogaard and Kreuz is the fact whether LBK farmers had the time to collect nuts and fruits next to their farming practices. If Bogaard's argument for autumn cereal sowing is true, it would leave less time for collecting. In Stein, (large) amounts of hazelnut shells were found in more than one feature next to three different house structures. This entails that people did at least collect some nuts. One possibility is, that if autumn cereal sowing did take place, that for example children collected nuts, or that it was not done on a grand scale or regular basis. Another possibility already mentioned several times above is that new families in a settlement would need and have more time for collecting nuts due to poor harvest in their initial years as farmers. In Geleen-Janskamperveld in addition to nuts, remains of apple (*Malus sylvestris*) and sloe plum (*Prunus spinosa*) were found (Bakels 2008, 92), which indicate a greater variety in collecting. This does not prove that it was collected in large amounts, but it does indicate that there, also some collecting was still practiced, perhaps for storing in dried form for the winter months.
However, because LBK charred remains are so scarce, it is impossible to support either sowing theory based on the limited information the remains provide. If fruits and nuts were collected rigorously in autumn, which is implied in Kreuz' article, it does not have to be reflected in the finds. The fruit and nuts collected do not need to have been in contact with fire to be edible, and casual consumption is possible. For storage indeed drying is needed, however, there are no indications that they were stored underground en masse. Therefore, these results cannot say anything conclusive on this part of the problem.

Looking at the spring versus autumn matter from a different angle, another factor contributing to the separate views of Bogaard and Kreuz is the fact whether fields are used for grazing during the autumn and winter months or not. In her article, Kreuz mentions that if fields were being grazed on from the autumn until early spring, one would expect more species found that are resistant to trampling and grazing (2011, 342). She states that: " Interestingly the number of species belonging to the Ecological Group 2

“Grassland” increases over time and these species are mostly able to tolerate mowing by people and browsing and trampling by animals or they are at least indifferent to such disturbances”. The questions remain then, how these seeds made it to the settlements if cattle grazed on fields further away, and whether the increase of these species is a valid argument for grazing.

The two species in the LBK period on Kreuz’ species list that are numerous enough to be mentionable and resistant to trampling and grazing of animals are *Solanum nigrum* and *Phleum pratense*.

As mentioned before in paragraph 3.2.1, *Solanum nigrum* is poisonous, so logically it is not eaten and therefore resistant to grazing. *Phleum pratense* however, is indeed grazed in present-day farms by cattle and sheep. A likely explanation for the presence of *Phleum pratense* is that seeds ended up in settlements together with the harvest, since it develops seeds around mid-summer (Web reference 2). The fact that *Phleum pratense* occurs together with remains of the harvest, however, is not a convincing in saying that grazing took place in LBK times as well. Obviously, when it is found together with seeds of cereals, it is not located on a field where cattle would graze. If cattle were to graze the field after the harvest or on other fields, it seems hard to reconstruct why these seeds would eventually end up in an assemblage together with cereals.

It is clear that the presence of *P. pratense* in the settlement could have more than one cause and this does not simply prove whether cattle actually grazed the fields.

Coming back to the results of Stein, neither *Phleum pratense*, other perennials, nor grazing and trampling tolerant species were found. Therefore, the results from Stein cannot provide conclusive results in favour of either theory here either.

Finally, a factor worth mentioning which is not discussed by Kreuz or Bogaard, but might provide an elaboration on the problem is *Bromus secalinus*-type. Mostly, this plant is seen as a cereal weed. However, recent research performed by dr. J. Meurers-Balke and dr. A.J. Kalis in the Lower Rhine area shows that this winter annual was present in such high number and frequency there, that it has to be considered a cultivated crop. LBK farmers there did not clean their cereal seed from this crop, so it may even have been a maslin crop. Since this plant is a winter annual, this means that it must have been sown together with winter cereals (Kalis, pers. comm.).

A last possible addition to the debate could be *Panicum miliaceum*. If it was indeed a (semi-)cereal, it could have been used as a last resort when other harvests failed due to possible unfavourable environmental or soil conditions. This would mean that if autumn cereal sowing was practiced in the LBK, still an element of spring cereal sowing could have been incorporated to ensure enough food was being produced. It remains a question however whether *P. miliaceum* really was a (semi-)cereal and if it was, why so little seeds are recovered from sites.

Some aspects of Kreuz' theory for spring sowing are not very likely and nothing really supports them either. One of them is that increased numbers of trampling resistant plants would indicate grazing of cattle, which is not necessarily so. Another unlikely aspect is that she states that summer annuals would be indicative of spring cereal sowing, in combination with that the fact that she denotes *Vicia* as a summer annual, when it is generally accepted that it is a winter annual. At present, the results found and arguments given by Bogaard are more plausible and are (partly) supported by the results from Stein. Therefore, autumn cereal sowing with spring pulse sowing and possibly the addition of *Panicum miliaceum* as a summer cereal when other harvests fail make up the image for Stein LBK farming based on the results presented here.

4 Farming in Iron Age

4.1 Introduction

The Iron Age in the Netherlands started around 800 BC. However, from 1800 BC onwards, several changes had already occurred, but the Netherlands remained a country that was based on agriculture. The small hamlets from the Bronze Age gradually developed into villages, and the settlement patterns were very different than before. People started living on single farmsteads that consisted of the main farm building, one or more other smaller buildings (e.g. granaries) and land for agricultural use expanded further and further. The farms grew in size, and stables make their appearance (Verhart 1993). The floor plans of Iron Age houses on loess, however, are far from uniform (Bakels 2009; 141). In general, house plans are small, with a maximum of 8 x 4m, with one aisle and a couple of outhouses (Simons 1989, 106-107). Other consistent factors in the houses are that farms could have housed around eight to ten people, were timber-built, and walls were made of wattle and daub (similar to LBK farms); the length generally varied from 11 to 15 m. Livestock consisted of cattle, sheep/goat, pigs, chicken and horse. Another new development during the Iron Age with respect to the Neolithic habitation, was that the occupation time on a farmstead was greatly diminished. Where LBK farmers would live at the same location for long periods of time, Iron Age farmers would use a farmstead for about 30-60 years before the new generation would build an entire new farm at a new location (Bakels 2009; 105).

The use of the land itself had also undergone a major change in the Iron Age. The crop husbandry model most likely used by LBK farmers, intensive garden cultivation, had made way for a more mobile form of land use: shifting cultivation. Because many millennia of agriculture exhausted the fields, it is assumed that after fields were exhausted and no place for new fields could be found, an entirely different location for both farm and field was sought where cultivation could start anew. It could explain why farmsteads were short-lived in this period, however, most of the time the shift to a new location was not that large (i.e. several hundreds of metres) (Bakels 2009, 148). To prevent this exhaustion of farmland, parts of it were kept unused (i.e. lain fallow) and fields were fertilized with manure (Verhart 1993). The actual size and shape of the fields is unknown for the loess area.

Cereal and pulse species found more or less consistently in the Iron Age include emmer wheat (*Triticum dicoccum*), spelt wheat (*Triticum spelta*), hulled barley (*Hordeum vulgare var. vulgare*), horse bean (*Vicia faba var. minor*), and pea (*Pisum sativum*). Some of these are sometimes found in a mixture, which may point to the practicing of maslin cultivation. This entails growing two or more crops in a mixture on one field. One of the most common maslins found is emmer wheat/hulled barley.

A difference in the way the land was used in the Iron Age as opposed to the Neolithic was marked by the use of metal utensils. Where LBK farmers will have used flint sickles and probably several wooden tools, Iron Age farmers had iron sickles at their disposal. In this period, the number of weed species in botanical samples increases; a phenomenon which could be explained by the fact that cereals are now being reaped lower on the stalk, which means lower growing weed species are also included in the harvest. Although reasons for low reaping are uncertain, one possibility is that the economical importance of straw in the Iron Age was held higher than in the Neolithic. Straw could have been used as roofing material or perhaps as fodder. Since we find stables as part of the farms in the Iron Age, the opportunity was there to keep animals inside the house in for example the winter time. In this case, the animals could not roam free to find their own food, so they would need fodder given to them by humans. The nutritional value of barley and wheat straw alone is not high enough to feed animals with. When it is supplemented with for example grains it can however be sufficient for cattle to feed on (Web reference 3). Whether straw was used as fodder and if so, at what scale this was possible remains a big question for the Iron Age.

4.2 Intensive versus extensive cultivation

Sadly, the issue of the importance of straw in the Iron Age cannot be sufficiently investigated here, due to a limited amount of sample data. Another debate for the Iron Age however, focuses on the land use, especially on whether cultivation is intensively and/or extensively practiced. The major proposed model for Iron Age farming in the Netherlands is shifting cultivation (see paragraph 4.1). In her PhD dissertation, Bogaard

(2004) states that: “the weed floras in experimental plots managed as in a shifting cultivation regime (...) were dominated by perennial weeds”. This means that experiments show that more perennials as opposed to annual weeds, which dominate permanent cultivation plots, are expected in shifting cultivation. When we assume that this is the correct model, we would expect relatively higher amounts of perennial weeds in the Iron Age samples of Stein.

According to Anne de Hingh (2000) however, the ratio annuals:perennials shifts towards a lower frequency of perennials, which would imply that an intensive farming regime became more dominant during this time, but some variation in cultivation regimes could have existed.

Bakels finally, suggests that intensive cultivation could have taken place close to the settlement/house, whereas extensive cultivation, meaning either short-lived or looked after with less care or both, could have taken place further away (Bakels 2009, 113). The data so far have proven too limited to provide more detailed information.

4.3 Research questions

The assumed cultivation method, the disagreement on intensiveness of land use, and the recent excavation of the late Iron Age remains in Stein have provided the opportunity to look further into the problems faced in this area of research. The following research questions will hopefully be answered in this part of the thesis:

- What was the quality of the soil and how was the land used ? Is the generally accepted model for land use also reflected in the finds of Stein?
  - What was the performed method of land use by late IA farmers from Stein?
  - What indications for the assumed exhausted soils/ deterioration of soil quality are present?
  - What indications for intensive and/or extensive land use can be obtained from the botanical remains of Stein?
- How was food produced/collected in the late Iron Age in Stein?
  - What is the contribution of collected foods in addition to the harvest?

5 Results Iron Age

5.1 Feature description

The IA features that were sampled from the site in Stein were already briefly mentioned in the general introduction. They were dated to the late Iron Age (250-12 BC), based on ceramics. Again, a more detailed review of the individual aspects and locations of the features will be given here. The sample numbers are used for the description of features, to prevent confusion. The features can be seen in Figure 18 and Figure 7. The sections of the sampled features can be found in the appendix.

Sample 75: post hole of southern structure (Fig. 18)
Sample 76: post hole of northern structure (Fig. 18)
Sample 79: post hole of northern structure (Fig. 18)
Sample 80: post hole of northern structure (Fig. 18)
Sample 112: small pit in between the two structures (Fig. 18)
Sample 278: post hole between structure (Fig. 7)

5.2 Finds

The charred remains found in abovementioned sampled features with all cereals and weeds found are shown in Table 5 below. Sample 80 did not contain any (prehistoric) remains, and was therefore omitted from further analyses.

As can be seen, three types of cereals are present in the samples: *Triticum dicoccum* (emmer wheat), *Panicum miliaceum* (common millet), and *Hordeum vulgare var. vulgare* (hulled barley), a species that has become more common since the Bronze Age. In paragraph 4.1, it is stated that one of the most common maslins found in the Iron Age is hulled barley with emmer wheat. It may have been the case that maslin crop cultivation took place in Stein, however, since the amount of samples as well as the sample volume were very low, it is not directly reflected in the results.

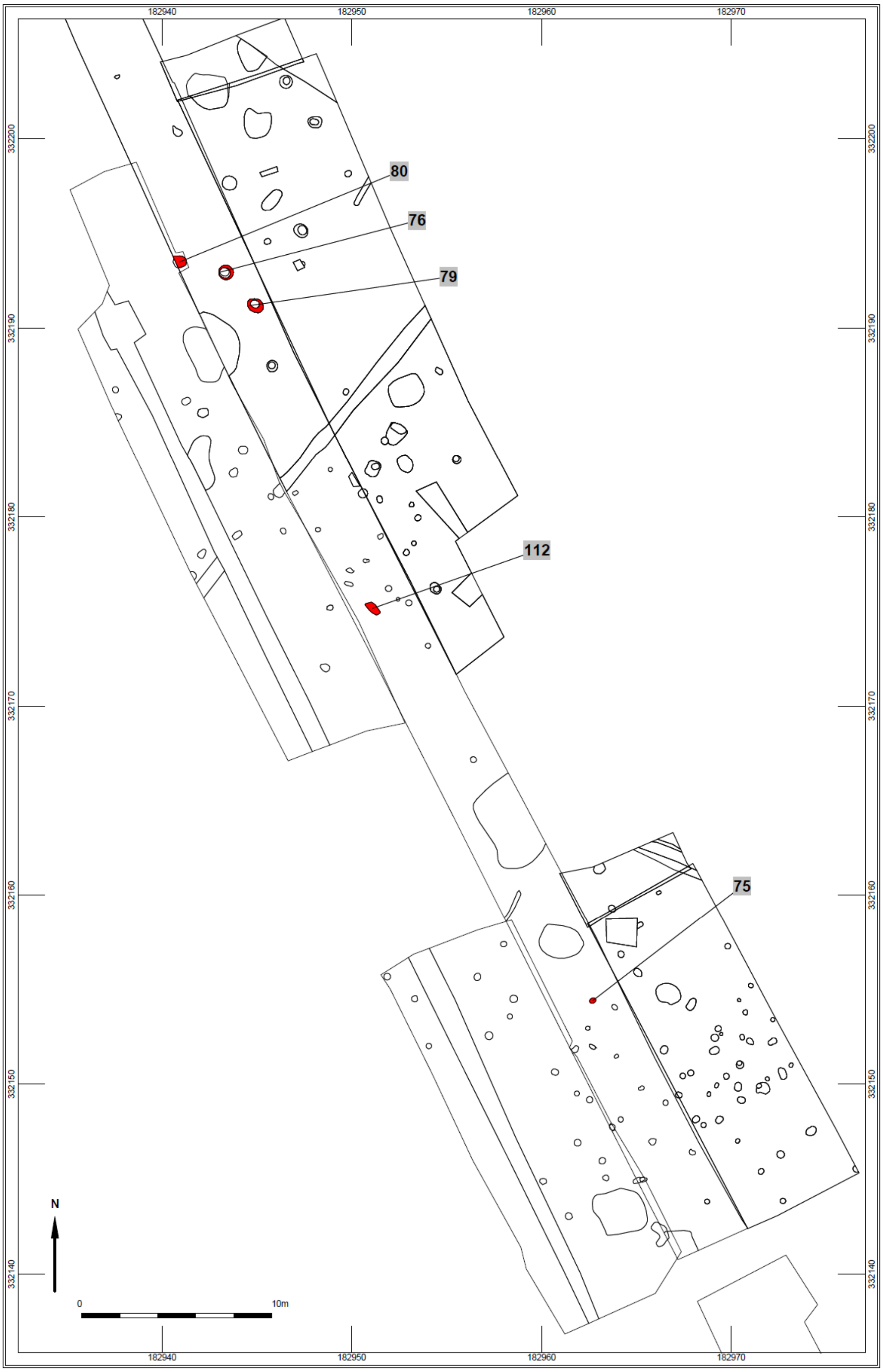


Figure 18. Overview of the botanical samples taken from the Iron Age features.

Table 5. Overview of the researched Iron Age botanical samples from Stein, each with their corresponding charred remains. Amounts are given per litre. Sample 80 did not contain (prehistoric) charred remains and was the only sample that was left out of the table. Latin names are consistent with Heukels' Flora (van der Meijden 2005).

Sample nrs	**75**	**76**	**79**	**112**	**278**
Taxa					
CEREALS AND CROPS					
Cerealia	1	3	3	2	
Daucus carota					1
Hordeum spec.			1		
Hordeum vulgare var. vulgare		1			
Panicum miliaceum					1
Triticum cf. dicoccum			2		1
Triticum dicoccum				2	1
Triticum spec.				2	3
Triticum spec. (chaff)			1	2	4
WEEDS					
Anagallis arvensis					2
Apera spica-venti					1
Aphanes arvensis					1
Atriplex spec.					1
Avena spec. chaff needles					2
Bromus secalinus-type		1			1
Bromus spec.					4
Carex spec.					1
Chenopodium album				1	2
Euphrasia spec./Odontites spec.					1
Galeopsis segetum/ladanum					1
Galium aparine/spurium			1		13
Juncus spec.					1
Lapsana communis					1
Mentha arvensis					6
Persicaria lapathifolia			1		5
Plantago lanceolata	1				1
Poaceae					5
Rumex acetosella ssp.tenuifolius	1		1		17
Rumex spec.					1
Sambucus ebulus	1				
Scleranthus annuus					1
Setaria cf. viridis	1				
Setaria spec.					1
Spergula arvensis					1
Stellaria cf. media					2
Trifolium spec.	1				4
Tripleurospermum maritimum					1
Veronica arvensis					1
Vicia cf. sativa					1
Vicia hirsuta					1
Vicia hirsuta/tetrasperma					8
Vicia tetrasperma					2
TOTAL	6	5	10	9	99

Barley and emmer are not identified for certain together in one sample and concentrations cannot be representative since they are very low, as was the case for most samples.
One exception is sample 278. This sample was taken from a feature which was found distinctly separate from the Iron Age cluster in the north-east. In this sample, in contrast with the other samples, very many weed species are found.
Strikingly, only one pulse remain was found: *Daucus carota* (carrot). This is unusual, because the number of pulse species actually normally increases during the Iron Age. Perhaps this low amount of pulses seen is due to the low amount of samples taken, but possibly there is another reason. In southern Limburg, there are little to no parallels found when it comes to late Iron Age botanical samples. The only area in which two late Iron Age features were botanically investigated was Maastricht-Aachen Airport in Beek (Van Beurden and Kubiak-Martens 2008; Table 6), not far from Stein. The composition of these samples turns out to be similar to that of Stein. *Vicia faba* and *Camelina sativa* are the only pulse and oil plants respectively that were found amongst some cereals and mostly wild plants/weeds. The abundance normally seen in the Iron Age is not reflected here either.
As another comparison, it is also interesting to look across the border into the southern Lower Rhine area in Germany, about 60 km east of Stein. Here, several sites from the La Tène period are found. In for instance Hambach (Table 6), in an early La Tène site (dating back to the Middle Iron Age) there are several cereals and pulses found not seen in Stein, such as *Triticum spelta* (spelt wheat), *Camelina sativa* (gold-of-pleasure), *Linum usitatissimum* (linseed), *Lens culinaris* (lentil), and *Pisum sativum* (pea) (Knörzer 1984, 293-295). When looking at a Hambach site in the late La Tène (dating back to the late Iron Age), it is an entirely different picture altogether. There, almost exclusively cereals were found, such as several *Triticum* species (emmer, spelt and bread wheats) and *Hordeum vulgare var. vulgare* (hulled barley). The other edible plants retrieved from the site are *Avena fatua* (common wild oat), gold-of-pleasure, hazelnut, and carrot (Knörzer 1984, 295-296; Table 6). Apart from carrot, the composition of this site in Hambach shows no pulses and mainly cereals, similar to Stein. Of course, the low number of samples taken in Stein makes it hard to say anything conclusive about the different types of pulses grown. However, the similarity of Stein to the late Iron Age sites in Beek and in

Hambach might possibly indicate a more general trend in the late Iron Age in the western loess area (Knörzer 1980, 456).

5.3 Statistics, soil and surroundings

5.3.1 Statistics

Similar to the LBK samples, statistical research into the composition of features with regard to cereals and cereal weeds was performed and a frequency table of the individual taxa was made, including the sites Beek and Hambach (Table 6). To make a decent comparison between the sites, frequencies in samples rather than actual amounts were used. NB. Since the amount of samples taken from the site was too limited, other types of statistics could not be performed for this research.

It can be seen in Table 6 that *Cerealia spec.* and the chaff of *Triticum spec.* dominate the upper parts of the table, which points towards agrarian waste. A second, more uncommon, however here relatively abundant seed is that of *Rumex acetosella ssp. tenuifolius*.

5.3.2 Soil quality

From the seeds found, *Rumex acetosella, Scleranthus annuus,* and *Setaria cf. viridis* stand out because of their soil preference. All like dry, acidic and nutrient poor soils. *Rumex* can grow amidst cereals and is found with remains of *Triticum*, *Hordeum*, and *Cerealia spec.*, so that it is considered part of the harvest. It appears that the soil conditions of the fields from which they arrived were sub-optimal. This would be in line with the idea of shifting cultivation in which fields are abandoned regularly most likely due to soil exhaustion after millennia of agricultural use.

Table 6. Frequencies of taxa of the Stein, Beek, and Hambach late IA samples.

Because there is a comparison between different sites and number of samples, the frequencies are given as a percentage. The number of samples is given on the top of each column. Taxa which are more common in the samples are thought to have played a more common role in daily life. Latin names are consistent with Heukels' Flora (van der Meijden, 2005)

Site	**Stein**		**Beek**		**Hambach**
Total sample number	**5**		**2**		**4**
Taxa	**Freq.**	**Taxa**	**Freq.**	**Taxa**	**Freq.**
Cerealia	80	*Cerealia*	100	*C. album*	75
Rumex acetosella ssp.tenuifolius	60	*C. album*	100	*T. dicoccum*	75
Triticum spec. (chaff)	60	*A. arvensis*	100	*Triticum spec.*	75
Bromus secalinus-type	40	*Avena spec. chaff needle*	100	*R. acetosella ssp.tenuifolius*	50
Chenopodium album	40	*Setaria spec.*	100	*B. secalinus-type*	50
Galium aparine/spurium	40	*Chenopodiaceae*	100	*P. lapathifolia*	50
Persicaria lapathifolia	40	*P. lapathifolia/maculosa*	100	*S. arvensis*	50
Plantago lanceolata	40	*R. acetosella ssp.tenuifolius*	50	*Avena spec.*	50
Trifolium spec.	40	*P. lapathifolia*	50	*T. spelta*	50
Triticum cf. dicoccum	40	*P. lanceolata*	50	*A arvensis*	25
Triticum dicoccum	40	*H. vulgare var. vulgare*	50	*Atriplex spec.*	25
Triticum spec.	40	*Poaceae*	50	*D. carota*	25
Anagallis arvensis	20	*S. ebulus*	50	*H. vulgare var. vulgare*	25
Apera spica-venti	20	*Vicia cf. sativa*	50	*S. annuus*	25
Aphanes arvensis	20	*V. hirsuta/tetrasperma*	50	*Setaria spec.*	25
Atriplex spec.	20	*Avena spec.*	50	*V. hirsuta/tetrasperma*	25
Avena spec. chaff needle	20	*C. sativa*	50	*A. fatua glume base*	25
Bromus spec. fragments	20	*Cerealia, chaff*	50	*C. sativa*	25
Carex spec.	20	*C. avellana*	50	*C. avellana*	25
Daucus carota	20	*D. ischaemum*	50	*D. ischaemum*	25
Euphrasia/Odontites spec.	20	*E. a crus-galli*	50	*F. convolvulus*	25
Galeopsis segetum/ladanum	20	*Fabaceae*	50	*F. rubra*	25
Hordeum spec.	20	*F. convolvulus*	50	*P. hydropiper*	25
Hordeum vulgare var. vulgare	20	*G. spurium*	50	*P. maculosa*	25
Juncus spec.	20	*P. hydropiper*	50	*Phleum spec*	25
Lapsana communis	20	*P. maculosa*	50	*P. aviculare*	25
Mentha arvensis	20	*P. aviculare*	50	*S. arvensis*	25
Panicum miliaceum	20	*T. aestivum*	50	*Thl. arvense*	25
Poaceae	20	*V. faba var. minor*	50	*Tri. arvense*	25
Rumex spec.	20	*Triticum spec. (chaff)*	0	*T. aestivum*	25
Sambucus ebulus	20	*B. secalinus-type*	0	*V. dentata*	25
Scleranthus annuus	20	*G. aparine/spurium*	0	*Cerealia*	0
Setaria cf. viridis	20	*Trifolium spec.*	0	*Triticum spec. (chaff)*	0
Setaria spec.	20	*T. cf. dicoccum*	0	*G. aparine/spurium*	0
Spergula arvensis	20	*T. dicoccum*	0	*P. lanceolata*	0

Table 6 (continued). Frequencies of taxa of the Stein, Beek, and Hambach late IA samples

Site	**Stein**		**Beek**		**Hambach**
Total sample number	**5**		**2**		**4**
Taxa	**Freq.**	**Taxa**	**Freq.**	**Taxa**	**Freq.**
Stellaria cf. media	20	*Triticum spec.*	0	*Trifolium spec.*	0
Tripleurospermum maritimum	20	*A. spica-venti*	0	*T. cf. dicoccum*	0
Veronica arvensis	20	*A. arvensis*	0	*A. spica-venti*	0
Vicia cf. sativa	20	*Atriplex spec.*	0	*A. arvensis*	0
Vicia hirsuta	20	*Bromus spec. fragments*	0	*Avena spec. chaff needle.*	0
Vicia hirsuta/tetrasperma	20	*Carex spec.*	0	*Bromus spec. fragments*	0
Vicia tetrasperma	20	*D. carota*	0	*Carex spec.*	0
Avena fatua glume base	0	*Euphrasia/Odontites spec.*	0	*Euphrasia/Odontites spec.*	0
Avena spec.	0	*G. segetum/ladanum*	0	*G. segetum/ladanum*	0
Camelina sativa	0	*Hordeum spec.*	0	*Hordeum spec.*	0
Cerealia, chaff	0	*Juncus spec.*	0	*Juncus spec.*	0
Chenopodiaceae	0	*L. communis*	0	*L. communis*	0
Corylus avellana	0	*M. arvensis*	0	*M. arvensis*	0
Digitaria ischaemum	0	*P. miliaceum*	0	*P. miliaceum*	0
Echinochloa crus-galli	0	*Rumex spec.*	0	*Poaceae*	0
Fabaceae	0	*S. annuus*	0	*Rumex spec.*	0
Fallopia convolvulus	0	*S. cf. viridis*	0	*S. ebulus*	0
Festuca rubra	0	*S. arvensis*	0	*S. cf. viridis*	0
Galium spurium	0	*S. cf. media*	0	*S. cf. media*	0
Persicaria hydropiper	0	*T. maritimum*	0	*T. maritimum*	0
Persicaria lapathifolia/maculosa	0	*V. arvensis*	0	*V. arvensis*	0
Persicaria maculosa	0	*V. hirsuta*	0	*V. cf. sativa*	0
Phleum spec.	0	*V. tetrasperma*	0	*V. hirsuta*	0
Polygonum aviculare	0	*A. fatua glume base*	0	*V. tetrasperma*	0
Sherardia arvensis	0	*F. rubra*	0	*Cerealia, chaff*	0
Thlaspi arvense	0	*Phleum spec*	0	*Chenopodiaceae*	0
Trifolium arvense	0	*S. arvensis*	0	*E. crus-galli*	0
Triticum aestivum	0	*Thl. arvense*	0	*Fabaceae*	0
Triticum spelta	0	*Tri. arvense*	0	*G. spurium*	0
Valerianella dentata	0	*T. spelta*	0	*P. lapathifolia/maculosa*	0
Vicia faba var. minor	0	*V. dentata*	0	*V. faba var. minor*	0

5.3.3 Crop husbandry

Harvest

All the Iron Age samples (except sample 80) consisted of cereals and weeds, and one pulse. Therefore, the weeds are considered to have arrived in the settlement as part of the harvest. During the Iron Age, both harvesting methods and cultivation strategies had changed significantly since the LBK. Metal utensils were now available and harvesting could take place on a larger scale. Additionally, cereals could now be reaped lower on the stalk, which is reflected by the amount and variety of charred seeds found from this period. In general, more and often lower growing weeds are now found because of the new harvesting technique applied. The LBK tradition of intensive garden cultivation had made room for a different type of land use: shifting cultivation. This means that both farms and fields would be moved to a new location every generation, most likely because of exhausted soil conditions of fields, and fields would be left to lie fallow to recuperate. In the Stein samples, it can be seen in Table A3 that many species indeed stand out with regard to their growth height, especially from sample 278: *Anagallis arvensis* (5-50cm), *Galeopsis segetum/ladanum* (7-30 cm), *Mentha arvensis* (5-45cm), *Plantago lanceolata* (5-45 cm), and *Tripleurospermum maritimum* (10-50 cm). The minimal heights of these plants are very low, even for Iron Age standards, but even more strikingly low plants are found such as *Aphanes arvensis* (2-20 cm), *Scleranthus annuus* (5-20 cm), and *Veronica arvensis* (2-30 cm). Why would such extra effort be put into such low harvesting? When we assume that fields were left to lie fallow for longer periods of time, it makes sense to harvest as much of the plant as possible before moving on to another field. It would be a waste to leave plant material behind that could have valuable uses for e.g. animal fodder and/or roofing. The optimal use of the plant in this way unavoidably will include many weeds, but this compromise will no doubt have been accepted easily. Conversely, it is even imaginable that harvest of cereal ears and straw would have taken place in two stages to minimize the weed contamination in human food as compared with animals.

Cultivation type

As stated in paragraph 4.2, the ratio of perennials:annuals should shed some light on the intensiveness of the land use in the late Iron Age in Stein. As can be seen in Figure 19, in the finds of Stein, the amount of annuals and perennials in the Iron Age is far from equal. Perennials are less abundant than annuals (both summer and winter varieties). I must be said however, that sample 278 (from the west of the excavation) and the other samples (from the northeast of the excavation) might represent two different groups. In sample 278, a high amount of weeds is found, whereas the other samples contain almost none. De Hingh (2000) has shown from results of studies in the Moselle area, that the frequency of perennials decreases in the second half of the Iron Age. In the study, this fact is linked to a more intensive use of the land in the last centuries BC. The frequency of perennials in the samples though, is still 50%, which leaves room for a broader interpretation. Bakels (2009) has suggested that both intensive cultivation and extensive cultivation could have taken place. In order to differentiate between these two options, several plant characteristics can be considered.

One interpretation of the results from the northeast of Stein could be that the charred remains derive from a field that was left to (seasonally) lie fallow or which was used extensively. After generations of field use, soils became exhausted and these fields would be left to regenerate. The presence of the perennials supports this argument, because they prefer undisturbed fields. Especially sample 75 is worth mentioning (Tab. 8), since all three species of perennials found in the Iron Age samples of Stein are present (i.e. *Plantago lanceolata*, *Rumex acetosella ssp. tenuifolius*, and *Sambucus ebulus*) with *Plantago lanceolata* in itself being a sign for fallow fields.

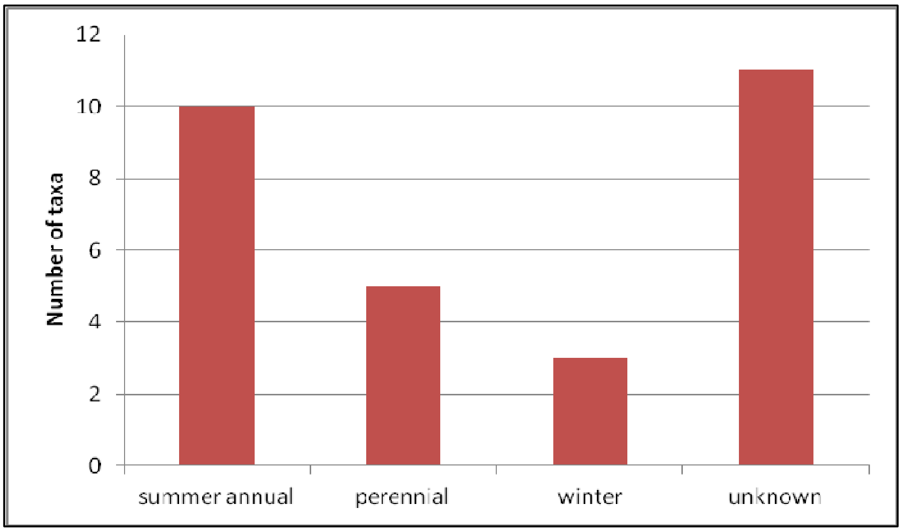


Figure 19. In this graph, the trend of summer annual versus perennial weeds found in the late IA period is shown. No winter annuals were found in either time period. In the LBK, almost all the weeds found are summer annuals, whereas towards the Iron Age, perennials are found more next to summer annuals

Conversely, sample 278 (from the west) has many weeds, but only 4 out of 33 are perennials. It could be that the field from which these derived was indeed used more intensively than the field(s) from the northeast group. Another indication for the intensive use of this field is the presence of *Daucus carota*, a pulse which needs more intensive care than cereals.

What also seems to be in agreement with the proposed theory is seen in Fig. 20. Iron Age plants that need direct or indirect human influence to settle are abundant in sample 278, whereas the northeast samples have relatively many self-settling plants, found in more than one sample (Tab 8).These plant types indicate a field which is cared for with less attention (i.e. extensive land use). Additionally, when looking at which ecological groups the plants belong to in the Iron Age (Fig. 21), it can be seen that the diversity is maximal for both groups. Mainly cereal weeds and undifferentiated ruderals/segetals are represented, which is considered normal for agricultural fields. However, weeds from grassland are now highly represented as well.

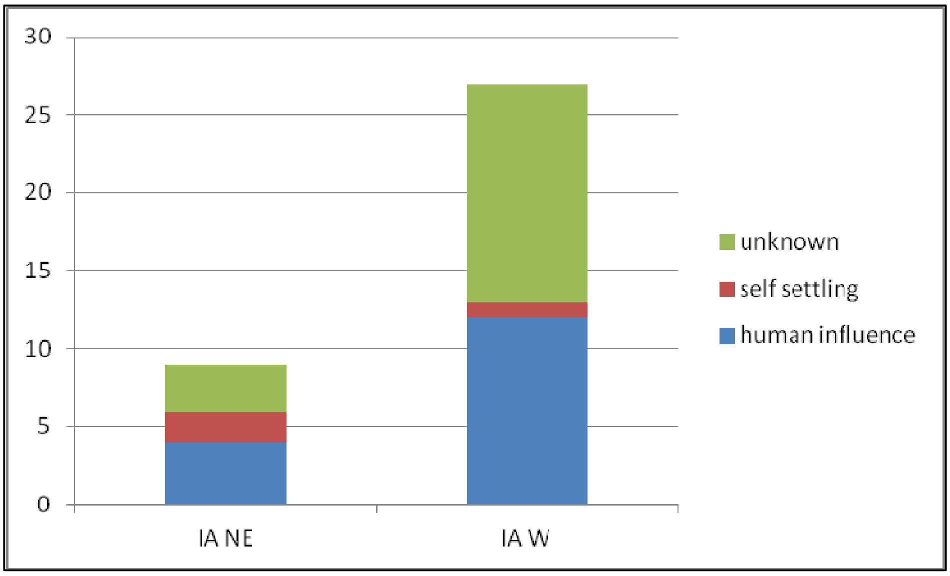


Figure 20. The plants found in the IA samples are divided into the groups in the northeast (IA NE), consisting of sample 278, and in the west (IA W), consisting of sample 75, 76, 79, and 112, to show differences. Each group is shown with respect to being either self-settling or needing human influence.

It must be mentioned that one weed, *Persicaria lapathifolia*, was categorized as a lake side weed (Ecological Group 1) in Kreuz' article (2011). The environment in which

Persicaria lapathifolia is normally found however, consists of ruderal settings and hoed fields (Schamineé 1998; 200-204, 254). This is the second time (also see paragraph 3.3.3) that Kreuz' description of a weed is inaccurate, which leads to a different interpretation of results.

Apart from this issue, a general diversification of ecological groups in the Iron Age can be seen. The presence of species from grassland and other ruderal areas gives another indication that different types of plants are given the opportunity to grow on the fields where they derived from. Conversely, it could be that fields were lain in different areas to make up for the land lost that was lying fallow.

Thus, based on the results of Stein, both the models proposed by De Hingh (2000) and Bakels (2009) are still plausible. The image arises of a shifting cultivation culture in which some fields were tended to more casually. But perhaps because fields were not in use for longer periods of time to begin with, other fields might have been used more intensively. Only one pulse species in one sample was found. Since pulses need more intensive care than for example cereals, the weeds from sample 278 could very well be from a field which was indeed cared for with greater attention.

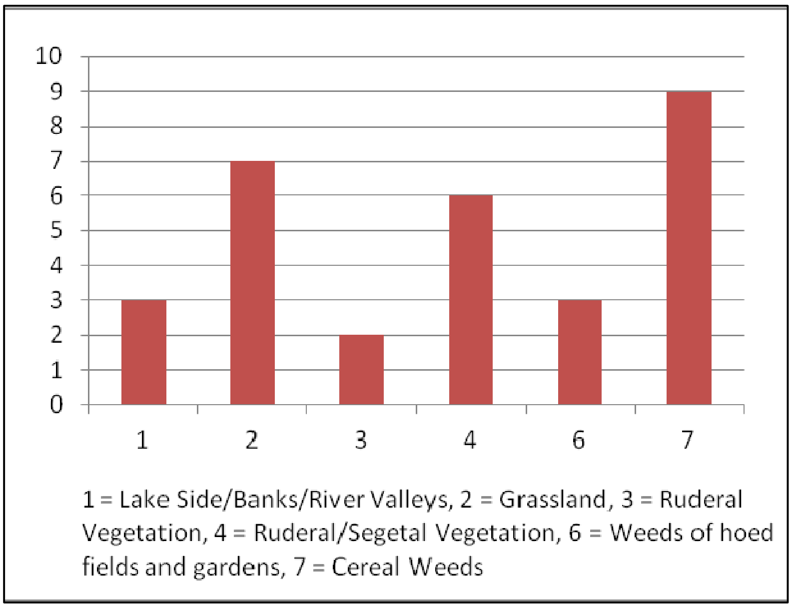


Figure 21. Here, the ecological groups to which the found weeds belong to are shown for the IA samples. In the late Iron Age, apparently all the ecological groups have representatives.

In addition, although not directly reflected in the results from Stein, the possibility of wheat:hulled barley maslin crop sowing could have been practiced rather than monocrop sowing, which at present is applied to reduce the risk of total crop failure (Jones 1995, 111), and could have been used as such in IA times as well. All these factors contribute to the idea that farming conditions and practices had notably changed in southern Limburg since the LBK. Soil quality had deteriorated, less pulses were being produced, and fields had to lie fallow to regenerate their soils. Farmers in the late Iron Age in southern Limburg were no doubt facing many trials with their agriculture. How they managed and in what ways they coped with e.g. environmental difficulties remain questions to be hopefully answered in further research.

6 Discussion

6.1 LBK farming

6.1.1 Summary of results

Finds

o Most of the seeds commonly found in the LBK were also found in Stein. The exceptions are poppy (*Papaver somniferum*), linseed (*Linum usitatissimum*), and lentil (*Lens culinaris*).

o In comparison, in Geleen-Janskamperveld, only 4 km away from Stein, many cereals, pulses, and even two fruit species were found, which shows a larger diversity in food plants.

o Special finds from Stein are:

- *Panicum miliaceum* (common millet), which was not found from the LBK in the Netherlands before, could possibly represent a backup plan for when harvests fail.
- *Corylus avellana* (common hazel), which was found in much higher amounts than is usually seen for the LBK in the Netherlands, could be a secondary form of food supply for farmers living on the borders of the loess and/or new families struggling to reach high harvest yields in the beginning of their settlement.
- *Solanum nigrum* (black nightshade), which is too short to have reached the settlement with the harvest, since harvesting in the LBK is mostly performed halfway up the stalk of cereals.

Statistics

o All samples show the characteristics of agrarian waste (cereal remains together with weeds)

o Most samples have a low density of remains, but one sample has a high density and is considered to have been discarded in bulk

o The bulk sample was analyzed and the grain from it was burnt whilst still in the chaff, which denotes an early step in the harvest processing.

- It was assessed in which harvest processing step the grain was most likely burnt, and the drying step preceding pounding and winnowing (for daily use) is the best candidate.

- The total amount of grains from the bulk sample was extrapolated and turned out to at maximum 83g, which is actually very low for consumption purposes.

o The soil quality in the LBK in Stein seems to have been (for at least parts) more acidic than is commonly assumed for LBK farming fields.

o The type of harvesting commonly assumed for the LBK, sickle harvesting, was assessed using the growth height of plants found and it was affirmed that plants generally reach to half or higher that the average height of cereals, with the exception of *Solanum nigrum*.

o The type of crop husbandry was assessed and it was affirmed that the intensive garden cultivation model is the most likely option here based on the remains from Stein.

o The main problem posed in this research, spring versus autumn sowing, was assessed, and autumn sowing stays the most plausible theory.

6.1.2 Discussion of results

Most results were discussed in the Results section, however some things remain a question.

A new theory was put forward for the LBK here, in which a new family and/or farmers living at the front of the expansion of the LBK culture need extra food supplies in the form of for example dried fruit and nuts in their first year of settlement until their own harvest is sufficient enough to get through the winter months. Although this theory seems to be in concurrence with the remains of several sites, it is of course not tested for large numbers and it is still important to check whether for example faunal remains from the sites can give insight into other secondary activities such as hunting, to support the view.

In the debate of spring- versus autumn sowing, the balance tips more towards the continuing of the Near Eastern tradition of autumn sowing defended by Amy Bogaard (2004). This is mainly based on the presence of winter annuals (such as *Lapsana communis*, *Vicia hirsute/tetrasperma*, and, if Kalis' argument holds true: *Bromus*

secalinus-type). In addition, the arguments of Angela Kreuz (2011) were questionable sometimes and could not be supported by the results of Stein.
It must also be said that results could have been more conclusive when the amount of samples taken was not so little. That way, it would have been able to perform more elaborate statistical analyses, as were done by Amy Bogaard (2004) and Angela Kreuz (2011).

6.1.3 The LBK farmers' year cycle

Neolithisation of the western and northern parts of the Netherlands was only deemed possible when the switch from winter wheat to summer wheat allowed farmers to move from the loess area to wetter and colder areas (Kalis, pers. comm.). In the LBK, hunting and gathering is assumed to be less important in farming life. We do however find evidence of gathering activities, which might have been done by new (colonizing) families. It seems that in Stein, which has old LBK houses in the excavation, and might therefore represent an early settlement, farmers needed their extra food from the forest (edge). Also, winter wheat was most likely the main cereal for this settlement, which means that the switch to summer wheat had not (visibly) taken place. The impact of the autumn sowing of winter wheat for a farmers year cycle is evident. The late summer/autumn would be needed for both harvesting and preparing the soil for the sowing of cereals in a limited time frame, resulting in a very busy period of the year. The winter would be a period where not a lot could be done for the wheat, so other activities (e.g. repair, gathering, hunting?) might be done in this period. Spring time would be another busy time where, amongst others, pulses would be sown, wheat fields would perhaps be weeded, and animals would be giving birth. The summer would be spent tending the livestock and the fields, awaiting harvest time. When eventually summer wheat could be grown, it would mean that the busy peak in the year cycle would shift to the spring time, leaving the autumn for other tasks. It seems a more flexible way to live and perhaps this was another reason that from this time on, the Neolithisation process could develop into the rest of the Netherlands.

6.2 Iron Age farming

6.2.1 Summary of results

Finds

- o Most of the finds are common to the late Iron Age, however almost no charred remains of pulses were found.
- o When comparing finds of Stein with Beek and the German site of Hambach, the same low amounts of pulses are seen, perhaps indicative of a more general trend.

Statistics

- o All samples show the characteristics of agrarian waste (cereal remains together with weeds)
- o The soil composition in the late Iron Age in Stein seems to have been (at least for parts) acidic, indicated by *R. Acetosella, Scleranthus annuus,* and *Setaria cf. viridis.*
- o Harvesting in the Iron Age is assumed to have been performed low on the stalk, which was affirmed by the presence of many low growing weeds.
    - Many low-growing plants were found, some of which were very low.
    - The importance of low reaping seems apparent. Whether this was for the clearing of fields before moving on to the next and/or because of the importance of straw remains unknown.
- o The shifting cultivation model, generally accepted for the (late) Iron Age, was also most probable when assessed using the Stein remains.
    - Two groups could be tentatively distinguished (northeast and west), each having a different composition indicating both extensive use (NE) and intensive use (W).

6.2.2 Discussion of results

Similar to the LBK results, the Iron Age results have been discussed elsewhere. However, some issues still remain.

The most limiting factor in the research towards the excavated Iron Age site in Stein was again the fact that very little samples had been taken from features. One of the (only 6) samples did not contain any remains, so that ultimately, only the remains of 5 features could be looked at. 4 samples, from the northeast of the excavation, seem to be part of one group. 1 sample, from the west, is different than the others. Because it is only one sample it is hard to call it a group, and the interpretations and comparison with the other group should be considered tentative.

The low amount of samples taken made the results limited, also since next to no elaborate statistics could be performed. In addition to this, possible comparisons with and interpretations of similar sites with Stein cannot be truly representative.

6.3 Comparison of LBK vs. Iron Age

Since two time periods, the LBK and the late Iron Age, are represented in the close proximity of the same excavation in Stein, it would be interesting to compare the results of both and see if and what changes occurred. It must be noted that because there is a very limited amount of samples from the Iron Age, it is hard to draw any conclusions, however, general trends could perhaps be given.

6.3.1 Changes in seeds and soil

Amount and species type of remains

Since amounts of seeds cannot be representatively compared (IA has little charred remains), only the species found and their frequency will be focused on.

Species which occur in both the LBK and IA samples are *Bromus secalinus-type, Cerealia spec., Chenopodium album, Triticum dicoccum,* and *Triticum* chaff. All of these remains are either a cereal or a known cereal weed and all are thus considered part of the harvest. This implies that both in the LBK as well as in the late Iron Age, the same surrounding of Stein were employed as an agricultural area, perhaps because it was rendered beneficial for farming.

A recurring aspect in both taxa lists is the presence of low growing plants, which are often not included in the harvest.

Soil quality

Another factor that is consistent in both time periods, although not always represented by the same species, is the occurrence of acidophilous plants. *Echinochloa crus-galli* (in the LBK), *Rumex acetosella ssp. tenuifolius, Scleranthus annuus*,,and *Setaria cf. viridis* (in the late IA) prefer acidic, nutrient poor soils. Although a sign of less fertile land, in the LBK it doesn't seem to influence the agriculture with respect to cereal and pulse diversity. Apart from the absence of linseed, lentil, and poppy, the other common food plants are accounted for. In the IA however, almost no pulses were found, perhaps due to prevailing exhausted fields which might have their origin in millennia long agriculture of the area. This might be a general trend, since in Beek and the German Rhineland, similar low amounts of pulses were found. In the IA in Stein, no evidence was present of the collecting of food.

Crop husbandry

Generally, it is assumed that LBK farmers performed intensive garden cultivation and late Iron Age farmers used the land with a combination of intensive and extensive cultivation.

A change towards a more intensive use of land is seen when we look at the types of plants from the features of both time periods, a trend also seen by Kreuz (2011). Summer annuals are the main constituents of the LBK finds, whereas in the Iron Age samples, more perennials are seen and even three winter annuals (Fig. 22). Also, an increase is noticeable of plants needing human influence to settle, a characteristic of intensive farming, from the LBK towards the late Iron Age (Fig. 23). Another change seen is that of more varied ecological types in the Iron Age as opposed to the LBK times (Fig. 24). This could be due to fields that were tended to (more or less intensively) at different locations each time, probably because of the shifting cultivation regime.

A final comparison lies in the fact that in the LBK, several kinds of dried staple food were found, implying additional food gathering by farmers, whereas in the IA, none of these were present in the samples. Whether it was not practiced or not visible in the archaeological record remains undecided.

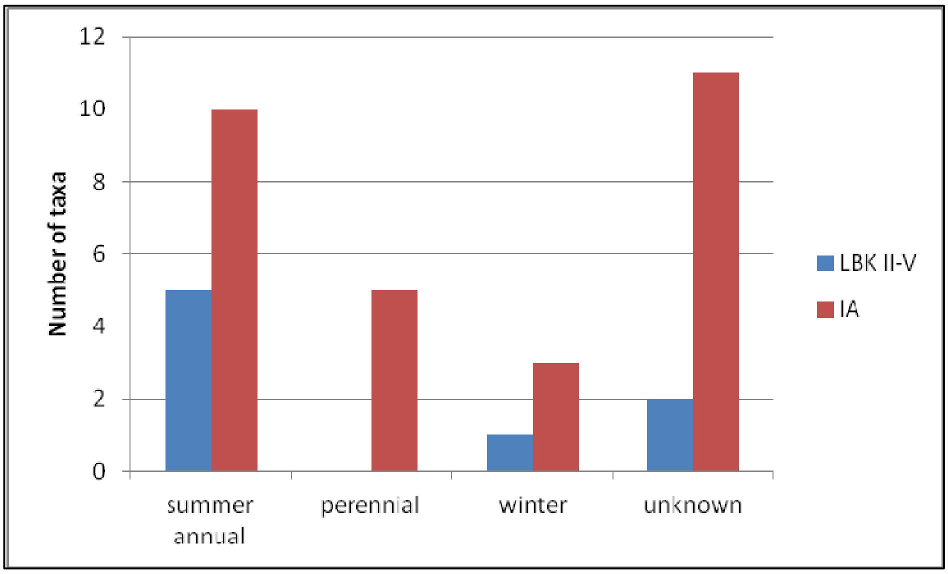


Figure 22. In this graph, the trend of summer annual versus perennial weeds found in both LBK and IA periods is shown. No winter annuals were found in either time period. In the LBK, almost all the weeds found are summer annuals, whereas towards the Iron Age, perennials are found more next to summer annuals

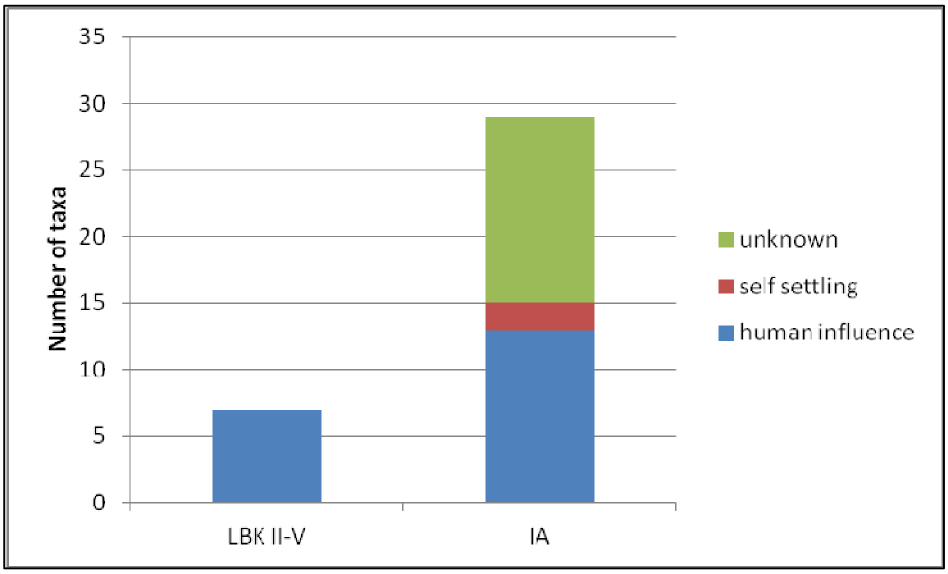


Figure 23. The found taxa of both LBK and IA times are shown with respect to being self-settling or needing human influence to survive are represented in this graph. In the LBK, all weeds belong to the group needing the influence of humans. In the Iron Age, more plants are found which are self-settling. Only weeds are included, since cereals and pulses are considered to always be under human influence.

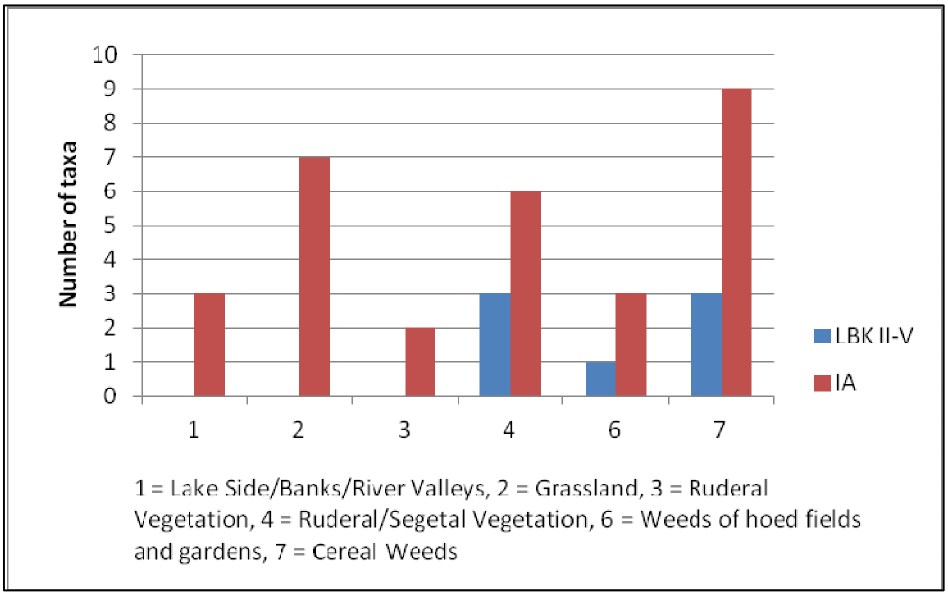


Figure 24. Here, the ecological groups to which the found weeds belong to are shown for both LBK and IA periods. In LBK times, only ruderal/segetal, weeds of hoed fields and gardens and cereal weeds are found. Towards the Iron Age, all the ecological groups have representatives.

7 Conclusion

In this research, an attempt was made to gain further insight into the farmers' year cycle and the possible methods used for cultivation in the LBK and late IA on the loess.
Most of the generally accepted characteristics of LBK farming such as intensive garden cultivation and harvesting height were affirmed for De Heidekampweg, Stein. An indication of lower soil quality than normally thought of for LBK agriculture however was seen through the presence of some acidophilous plants. It seems that some fields in this area might have had a less optimal composition.
The evidence for agriculture in Stein was mostly as expected. However, not all the plants that are common for the LBK were found in Stein. Cereals and major cereal weeds as well as one pulse were present, but also common millet, a plant not normally seen in the LBK in the Netherlands. Another remarkable find was the high amount of hazelnut, which in this thesis was explained as a way of secondary food supply for beginning farmers in an existing settlement or farmers settling in a new environment (on the front of the LBK expansion). This should be further investigated with the use of e.g. archaeozoological research (to gain possible evidence for hunting and other "secondary" activities). Based on the results obtained from Stein, the theory of autumn sowing of cereals remains the most plausible, also supported by the ongoing research of dr. A.J. Kalis towards a winter annual previously thought of as a weed, but now denoted as a probable winter cereal as well.
For the Iron Age, it was established that shifting cultivation was the most likely way of land use in Stein. Although many cereals were retrieved from the site, almost no pulses were found, which might be a general trend in the late Iron Age in this area. In addition, many (very) low growing weeds were found in one sample, indicating the apparent need for full retrieval of the plant. This could be because people wanted to clear their field completely before leaving it to lie fallow for a while. Another explanation could be that this was always done to ensure that there was enough roofing and/or fodder to use. Which is the most likely remains unsure.

Within the samples, two tentative groups could be made on the basis of location and composition. The remains form these groups would indicate that that both intensive and extensive cultivation may have been practiced.
The soil quality in Stein in the IA again was relatively poor, indicated by several plants. Also, no collected food was found, which could be due to the low sampling frequency, or due to the general absence of this type of extra nutrients in the environment in IA times or in the archaeological record at present. Similar to the LBK finds, it would be interesting to see if e.g. archaeozoological research can provide insight into possible additional ways of obtaining food in a sub-optimal agricultural environment, perhaps with the use of hunting.
Although many aspects of the farmer's existence in both LBK and IA remain unknown, this thesis has provided extra insight and some new ideas that can help towards solving the difficult problem that is prehistoric agriculture.

8 Abstract

At De Heidekampweg In Stein, Limburg, The Netherlands, an excavation was performed which yielded remains from both the Neolithic and the late Iron Age. Both periods were researched with regard to their botanical macro remains. Since Stein is located on the border of the loess, it was interesting to look at whether any differences were seen in comparison with the general ideas on crop cultivation of either period. For the Neolithic Bandkeramik (LBK) culture, some special finds were present, such as *Panicum miliaceum* (common millet), a species never before found in the LBK in The Netherlands, and substantial amounts of *Corylus avellana* (hazelnut) shells, which led to a new theory for people living on the borders of the loess. Perhaps these people exploited forest edges more in general and/or made use of them when starting up their fields for agriculture when harvest yields were not (yet) sufficient. Based on the result of this thesis and current other research, the idea on the present debate whether LBK farmers sowed their cereals in spring or autumn was that autumn sowing was more likely to have happened, which means that the Neolithisation process could not spread further into The Netherlands until summer wheat was available.

The remains of the late Iron Age showed a large range of low-growing weed species. These are found when crops are reaped very low on the stalk, which led to the idea that apparently people wanted the entire length of the stalk of the plant preserved. This in turn could be an indication for the importance of straw, although we have found no direct evidence for this. Also, almost no pulses were found, which seemed to have been a more general trend in late Iron Age in the surroundings as well.

In both periods, it is clear from the weed species found that the soil quality of the fields that were harvested was less than optimal. This was seen because of the presence of acidophilous plants.

Because the amount of samples taken in the excavation was (too) little, certain statistical methods such as Correspondence Analysis (CA) and Principal Component Analysis (PCA) could not be employed and therefore strong conclusions could not be made. For future research, it would be interesting to look at the zoological remains of the site as well to see whether the results agree with this research.

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10 Lists of figures, tables and appendix

MAIN TEXT:

APPENDIX

11 Appendix

TABLES

Table A1. Overview of the charred seed and chaff remains found in the individual samples of the LBK. The number of fragments is given, as well as the minimal amount of seeds that could have derived from them. The maximum amount of seeds is equal to the number of fragments. However, the truth will lie somewhere in between. The sieved volume of the samples sometimes differs, but for the results section, the concentrations were calculated per litre. Latin names are consistent with Heukels' Flora (van der Meijden, 2005).

Sample nr	**99 (pit next to long pit of structure 1)**	
Volume sieved	**1 litre**	
Taxa	Minimal amount	Number of fragments
Bromus secalinus-type	3	3
Cerealia spec.	18	56
Chenopodium album	39	55
Corylus avellana	4	183
Echinochloa crus-galli	9	9
Fallopia convolvulus	1	1
Setaria verticillata/viridis	2	2
Solanum cf. nigrum	1	1
Triticum dicoccum	28	28
Triticum spec. (chaff)	87	87

Sample nr	**129 (small pit next to structure 3)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia spec.	1	1
Chenopodium album	2	2
Triticum spec. (chaff)	7	7

Sample nr	**132 (long pit next to structure 1)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia spec.	2	2
Chenopodium album	1	1
Corylus avellana	3	3
Triticum spec.	1	1

Table A1(continued). Overview of the charred seed and chaff remains found in the individual samples of the LBK.

Sample nr	**141 (pit next to structure 2)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	1	1
Bromus spec.	2	2
Cerealia spec.	2	2
Chenopodium album	2	2
Triticum cf. dicoccum	1	1
Triticum spec.	1	1

Sample nr	**145 (long pit of structure 2)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	1	2
Cerealia spec.	8	38
Chenopodium album	2	2
Corylus avellana	1	16
cf. Echinochloa/Panicum	1	1
Panicum miliaceum	1	1
Triticum dicoccum	5	5
Triticum monococcum	1	1
Triticum spec. (chaff)	1	2

Sample nr	**148 (pit next to structure 3)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	1	1
Bromus spec.	1	1
Cerealia spec.	1	1
Chenopodium album	6	6
Chenopodium/Atriplex spec.	1	1
Fallopia convolvulus	2	2
Pisum sativum	3	3
Triticum spec. (chaff)	8	8
Vicia hirsuta/tetrasperma	1	1
	24	24

Sample nr	**149 (small pit next to structure 2)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Triticum spec. (chaff)	3	3

Table A1(continued). Overview of the charred seed and chaff remains found in the individual samples of the LBK.

Sample nr	**271 (pit next to structure 9)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus spec.	3	3
Cerealia spec.	5	5
Chenopodium album	3	3
Fallopia convolvulus	1	1
Triticum dicoccum	1	1
Triticum spec. (chaff)	7	7
Sample nr	**273 (pit between structure 6 and 9)**	
Volume sieved	**2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	5	5
Cerealia spec.	1	1
Fallopia convolvulus	1	1
Triticum spec. (chaff)	11	11
Sample nr	**286 (long pit of structure 11)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus spec.	1	1
Cerealia spec.	3	8
Chenopodium album	4	5
Corylus avellana	1	2
Fallopia convolvulus	1	2
Triticum spec. (chaff)	3	3
oolithic hematite	1	
Sample nr	**299 (long pit of structure 13)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia spec.	2	9
Triticum dicoccum	1	1
Triticum spec. (chaff)	2	2
oolithic hematite	1	

Table A1(continued). Overview of the charred seed and chaff remains found in the individual samples of the LBK.

Sample nr	**319 (large pit of structure 6)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia spec.	2	7
Chenopodium album	1	3
Triticum dicoccum	1	1

Sample nr	**323 (burnt red loam concentration in sample nr 319)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia spec.	1	3
Triticum spec. (chaff)	4	4
Rumex spec. (recent)	1	

Sample nr	**325 (split tree trunk feature of structure 6)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	2	4
Cerealia spec.	5	30
Chenopodium album	2	3
Fallopia convolvulus	1	1
Triticum spec. (chaff)	2	2

Sample nr	**326 (split tree trunk feature of structure 6)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Bromus secalinus-type	4	8
Cerealia spec.	5	12
Chenopodium album	3	8
Fallopia convolvulus	1	1
Triticum spec. (chaff)	1	1

Sample nr	**327 (small long pit of structure 6)**	
Volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Fallopia/Polygonum spec.	1	1

Table A2. Overview of the charred seed and chaff remains found in the individual samples of the IA. The number of fragments is given, as well as the minimal amount of seeds that could have derived from them. The maximum amount of seeds is equal to the number of fragments. However, the truth will lie somewhere in between. Latin names are consistent with Heukels' Flora (van der Meijden, 2005).

Sample nr	**75**	
volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia	1	4
Plantago lanceolata	1	1
Rumex acetosella ssp.tenuifolius	1	1
Sambucus ebulus	1	1
Setaria cf. viridis	1	1
Trifolium spec.	1	1
Sample nr	**76**	
volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia	3	8
Bromus secalinus-type	1	1
Hordeum vulgare var. vulgare	1	2
Sample nr	**79**	
volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia	3	4
Galium aparine	1	1
Hordeum spec.	1	1
Persicaria lapathifolia	1	1
Rumex acetosella ssp. tenuifolius	1	1
Triticum cf. dicoccum	2	2
Triticum spec. (chaff)	1	1
Sample nr	**80**	
volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Urtica dioica (recent)	1	
Sample nr	**112**	
volume sieved	**1 litre**	
Taxa	**Minimal amount**	**Number of fragments**
Cerealia	2	2
Chenopodium album	1	1
Triticum dicoccum	2	2
Triticum spec.	2	2
*Triticum spec. (chaff)**	2	2

Table A2 (continued). Overview of the charred seed and chaff remains found in the individual samples of the IA

Sample nr **volume sieved**	**278** **2 litres**	
Taxa	**Minimal amount**	**Number of fragments**
Panicum miliaceum	1	1
Triticum dicoccum	1	1
Triticum dicoccum/spelta	1	1
Triticum dicoccum/spelta spikelet fork	1	1
Triticum dicoccum/spelta glume base	6	6
Triticum spec.	5	5
Anagallis arvensis	3	3
Apera spica-venti	1	1
Aphanes arvensis	1	1
Atriplex spec.	1	1
Avena spec. chaff needle	4	4
Bromus spec. fragments	7	7
Bromus type secalinus	2	2
Carex spec.	1	1
Chenopodium album	3	3
Daucus carota	2	2
Euphrasia spec./Odontites spec.	2	2
Fabaceae type Trifolium	8	8
Galeopsis segetum/ladanum	1	1
Galium spurium	25	25
Juncus spec.	2	2
Lapsana communis	1	1
Mentha arvensis	12	12
Persicaria lapathifolia	10	10
Plantago lanceolata	2	2
Poaceae small	9	9
Rumex acetosella	33	33
Rumex spec.	2	2
Scleranthus annuus	2	2
Setaria spec.	1	1
Spergula arvensis	1	1
Stellaria cf. media	4	4
Tripleurospermum maritimum	2	2
Veronica arvensis	1	1
Vicia cf. sativa	2	2
Vicia hirsuta	2	2
Vicia hirsuta/tetrasperma	16	16
Vicia tetrasperma	3	3

Table A3. Height range of all the plants retrieved from both LBK and IA samples of De Heidekampweg, Stein. Taxa names that include more than one species are not appointed a height. The height of plants are taken from Bakels (2009) and Heukels' Flora (van der Meijden, 2005).

Taxa	Height in m
Anagallis arvensis	5-50
Apera spica-venti	40-100
Aphanes arvensis	2-20
Atriplex spec.	-
Avena spec. chaff needles	-
Bromus secalinus-type	30-100
Bromus spec.	-
Bromus spec.	-
Carex spec.	-
Cerealia	-
cf. Echinochloa/Panicum	-
Chenopodium album	15-120
Chenopodium/Atriplex spec.	-
Corylus avellana	-600
Daucus carota	30-90
Echinochloa crus-galli	10-120
Euphrasia spec./Odontites spec.	-
Fabaceae Trifolium-type	-
Fallopia convolvulus	-100
Fallopia/Polygonum spec.	-
Galeopsis segetum/ladanum	7-30
Galium aparine	60-120
Galium spurium	100-150
Hordeum spec.	-
Hordeum vulgare var. vulgare	50-130
Juncus spec.	-
Lapsana communis	30-120
Mentha arvensis	15-45
Panicum miliaceum	20-120
Persicaria lapathifolia	30-120
Pisum sativum	30-90
Plantago lanceolata	5-45
Poaceae	-
Rumex acetosella ssp.tenuifolius	10-60
Rumex spec.	-
Sambucus ebulus	60-150
Scleranthus annuus	5-20
Setaria cf. viridis	3-100
Setaria spec.	-
Setaria verticillata/viridis	3-100

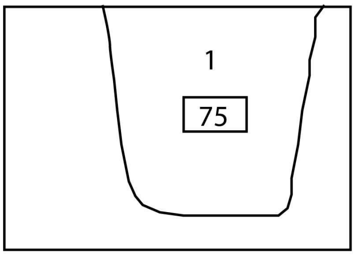
Table A3 (continued). Height range of all the plants retrieved from both LBK and IA samples of De Heidekampweg, Stein.

Solanum cf. nigrum	7-30
Spergula arvensis	15-40
Stellaria cf .media	10-40
Tr. dicoccum/spelta glume base	-
Tr. dicoccum/spelta spikelet fork	-
Trifolium spec.	-
Tripleurospermum maritimum	10-50
Triticum cf. dicoccum	75-120
Triticum dicoccum	75-120
Triticum dicoccum/spelta	-
Triticum monococcum	75-120
Triticum spec.	-
Triticum spec. (chaff)	-
Triticum spec. fragments	-
Veronica arvensis	2-30
Vicia cf .sativa	10-100
Vicia hirsuta	15-60
Vicia hirsuta/tetrasperma	15-50
Vicia tetrasperma	15-70

DRAWINGS OF SECTIONS: IRON AGE

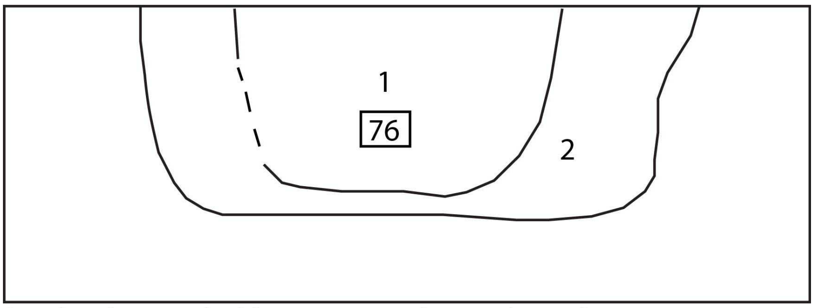
The scale of the IA sections is 1:10.

Feature 47



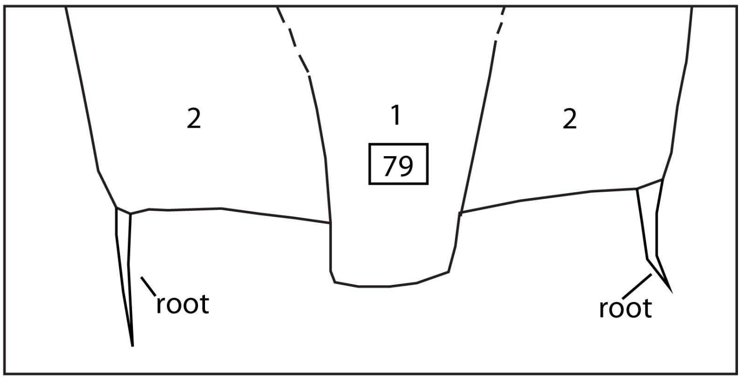
1. gr/br hetr. loess, many roots

Feature 18



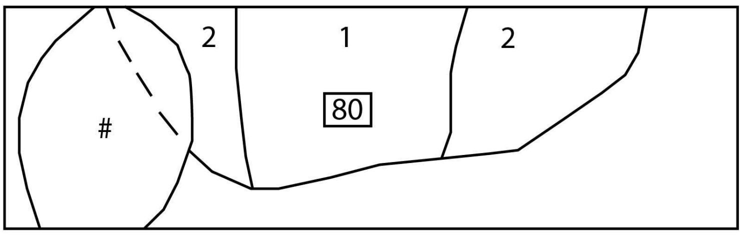
1. grbr , br mottled loess, some charcoal specks
2. br/lbr lightly mottled loess

Feature 19



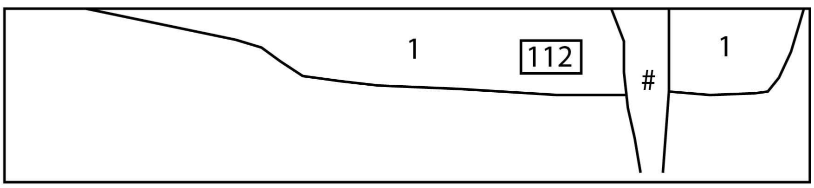
1. black/greybrown hetr., charcoal specks
2. br/lbr hetr.

Feature 17



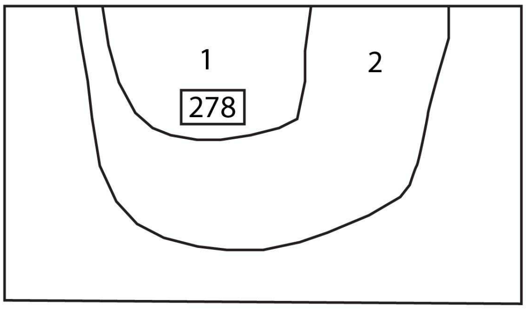
1. lgrbr, gr mottled
2. lgr, lgrbr mottled

Feature 29



1. lgr, br, hetr. loess, small amounts of charcoal

Feature 32

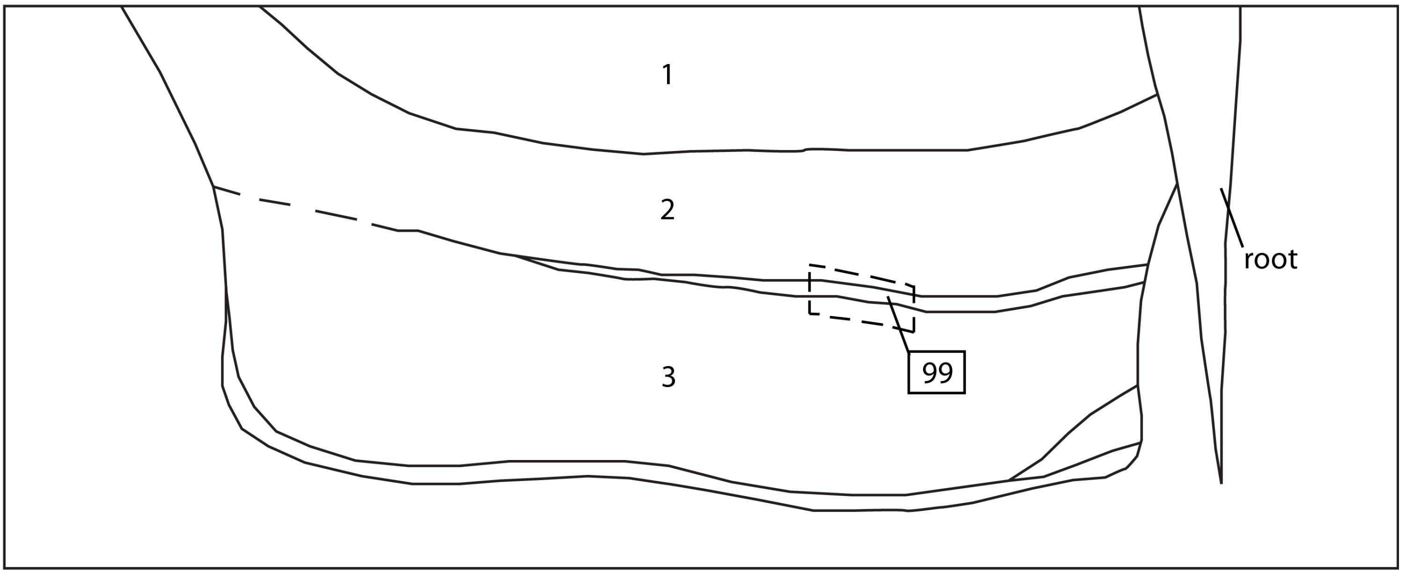


1. grbr/dblgr mottled loess, charcoal chunks
2. lgrbr/lgr mottled loess

DRAWINGS OF SECTIONS: LINEARBANDKERAMIK

The scale of the LBK sections is given in each drawing respectively.

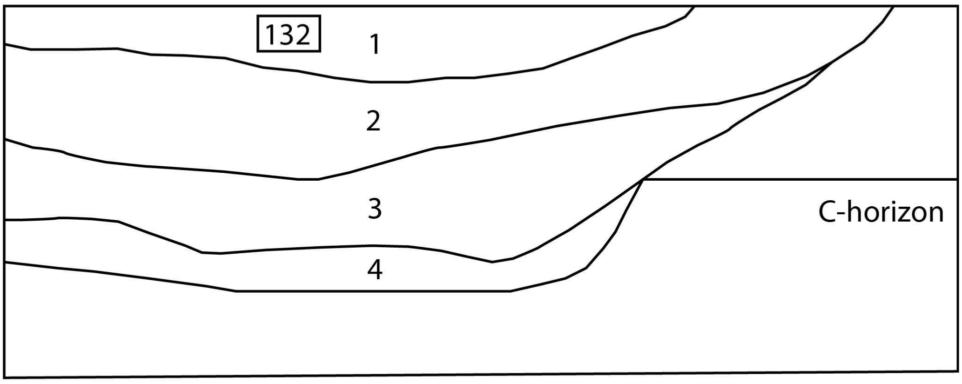
Feature 32



1. dgr, loam and charcoal specks
2. purple gr, white parts
3. purple gr, homogenous

Scale 1:10

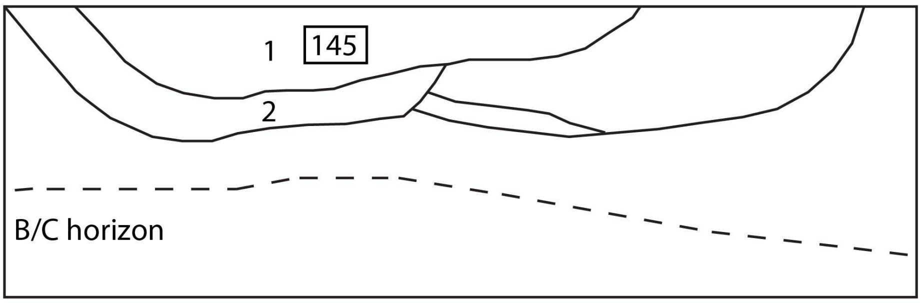
Feature 31



1. grbr, homogenous, charcoal chunks
2. brgr, heterogenous, charcoal, burnt loam
3. br/dgr, heterogenous, lightly speckled with charcoal
4. lbr/br heterogenous

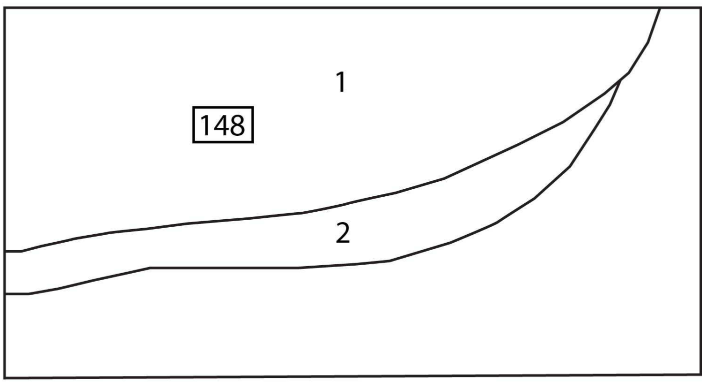
Scale 1:20

Feature 1



Scale 1:20

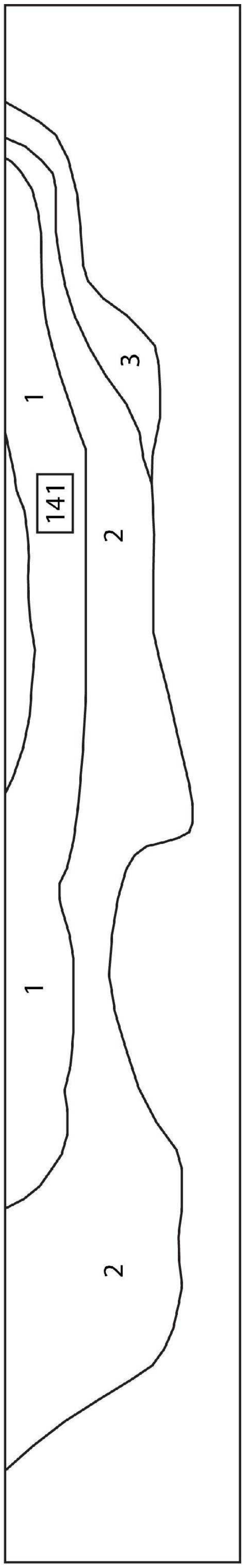
Feature 44



1. br/dgr, homogenous loess, charcoal specks, loam
2. lbrgr mottled loess

Scale 1:10

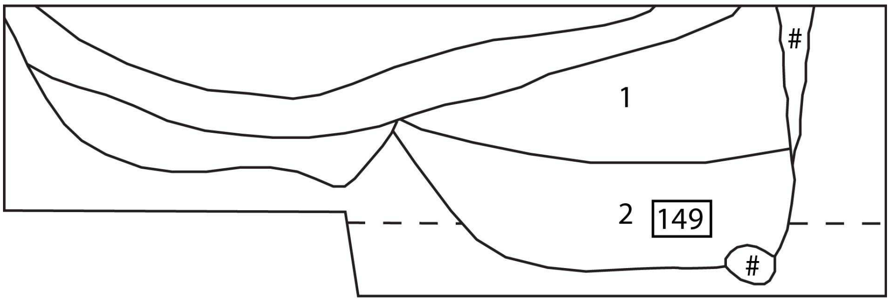
Feature 26



1. black, dgr, hetr loess with charcoal specks and loam
2. gr/lbr hetr loess

Scale 1:20

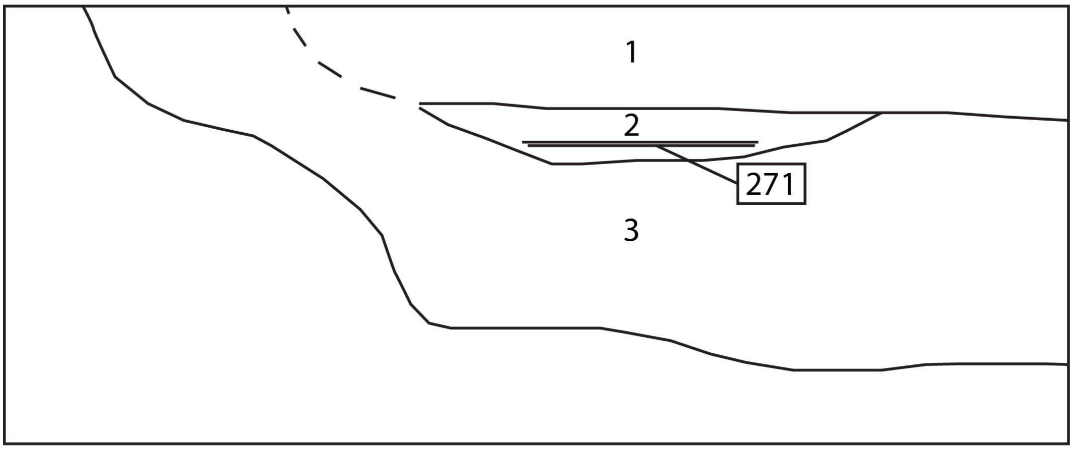
Feature 31



1. dbr, brlbr mottled hetr loess
2. dbr hom loess

Scale 1:20

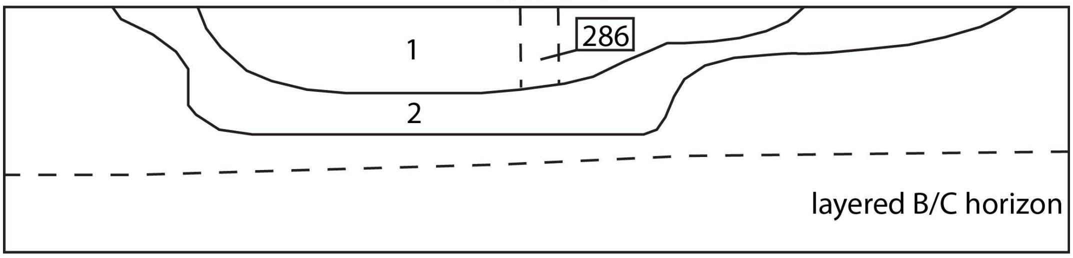
Feature 20



1. gr/dgr loess, burnt clay
2. brgr loess, charcoal band
3. brgr/br-y mottled, charcoal specks

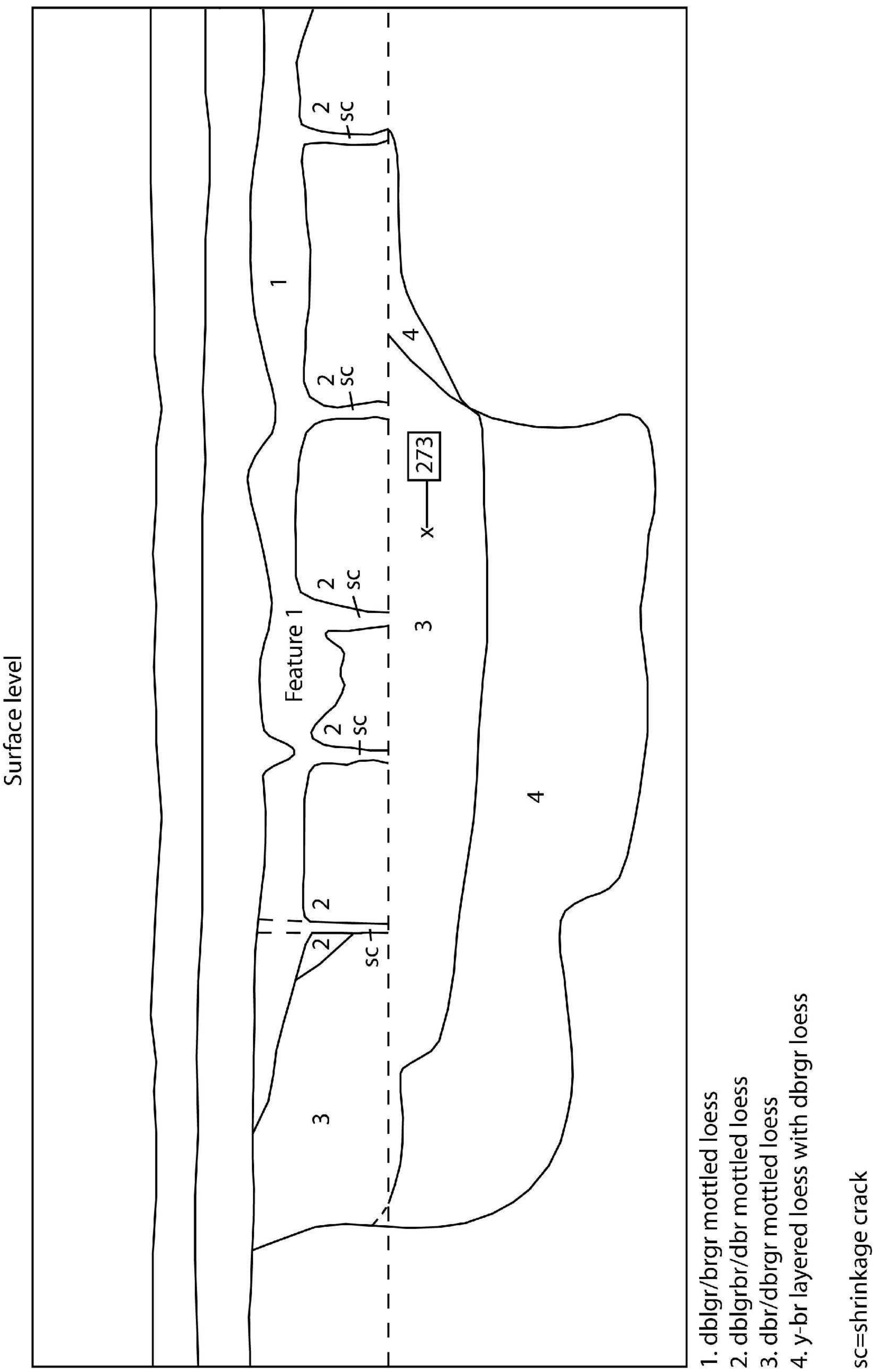
Scale 1:20

Feature 18



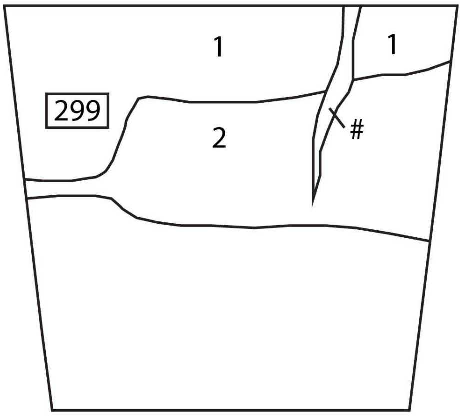
1. dgr/black, charcoal, loam chunks
2. gr, grbr mottled

Scale 1:20



Scale 1:20. The dashed line indicates where the section was placed 1m to the back.

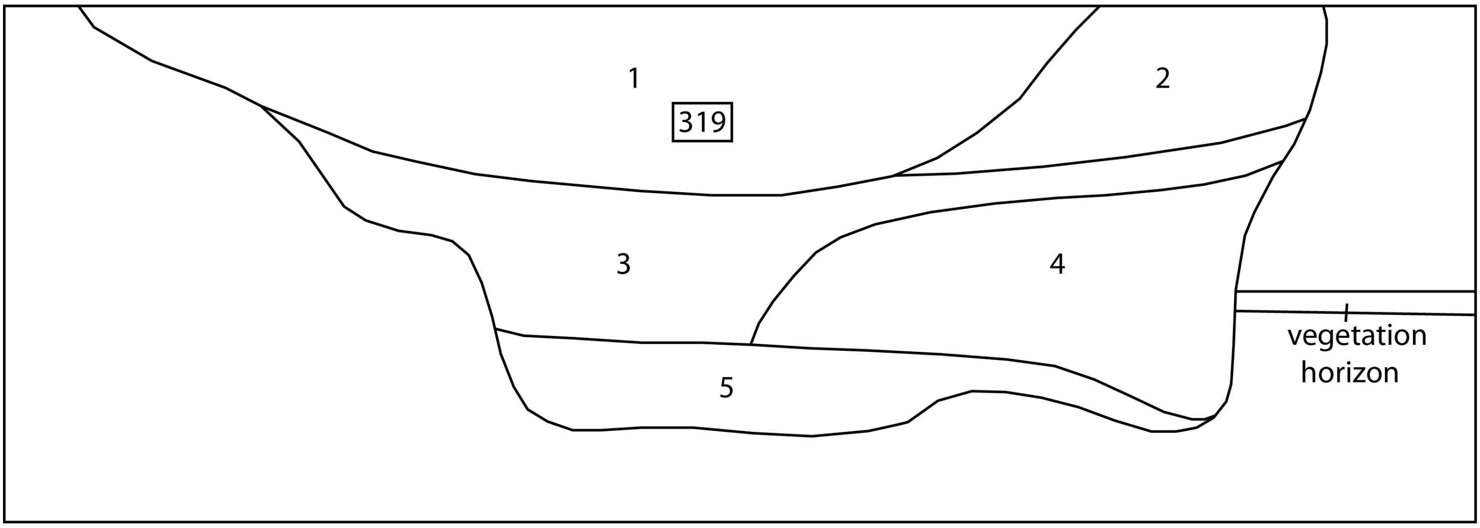
Feature 52



1. dgrbr loess, charcoal, burnt loam
2. grbr loess, ybr loess chunks, charcoal

Scale 1:20

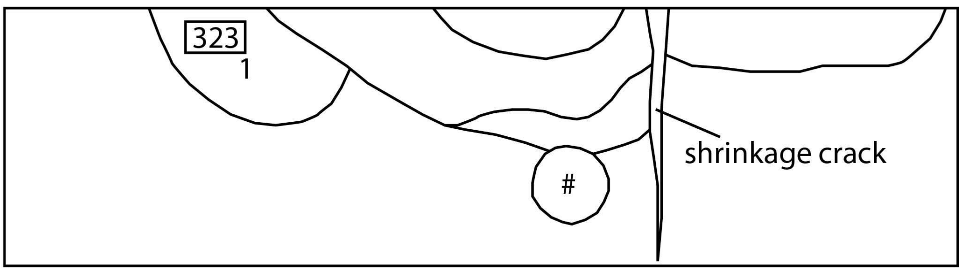
Feature 2



1. br/dbr, burnt clay, charcoal chunks
2. dbr, possibly part of 1
3. gr, lbr mottled, heterogenous
4. br, lbr, slightly disturbed
5. brgr, disturbed

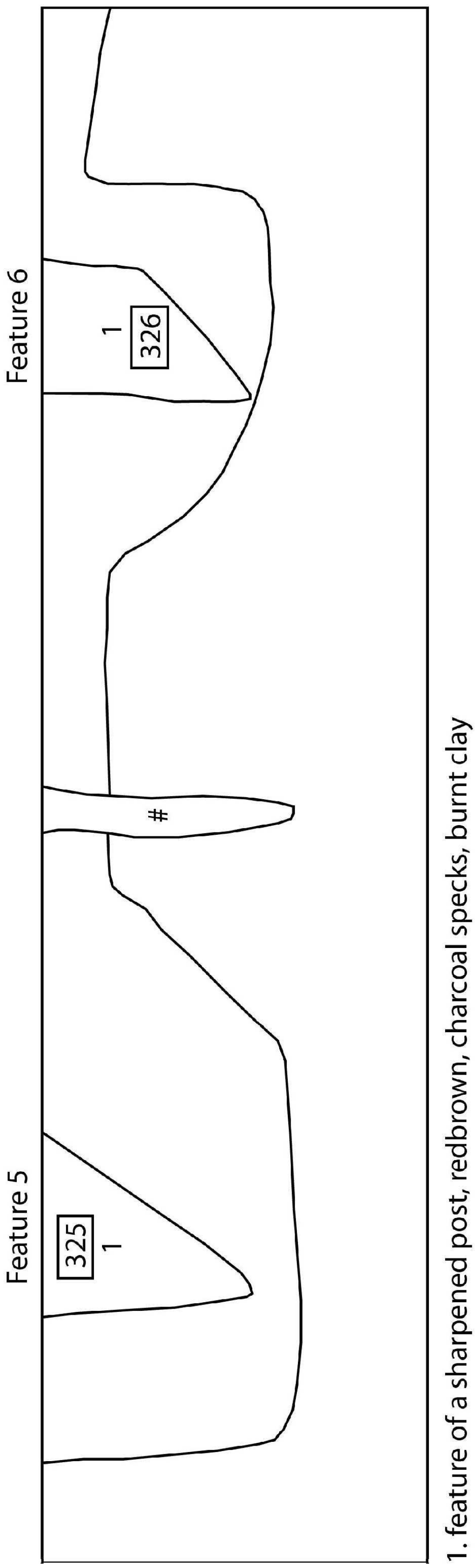
Scale 1:20

Feature 27 Feature 2

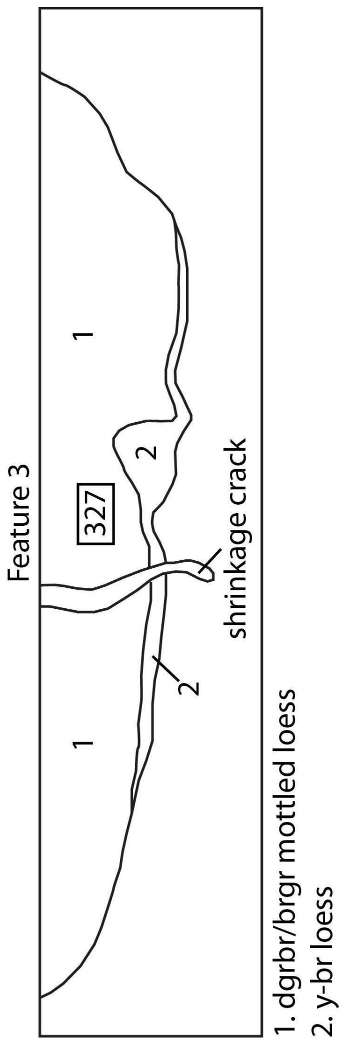


1. grbr, y-br loess

Scale 1:20



Scale 1:20



Scale 1:20

PHOTOGRAPHS: IRON AGE

Fig. A1. This is the section of the feature of which botanical sample 75 was taken.

Fig. A2. This is the section of the feature of which botanical sample 76 was taken.

Fig. A3. This is the section of the feature of which botanical sample 79 was taken.

Fig. A4. This is the section of the feature of which botanical sample 80 was taken.

Fig. A5. This is the section of the feature of which botanical sample 112 was taken.

Fig. A6. This is the section of the feature of which botanical sample 278 was taken.

PHOTOGRAPHS: LINEARBANDKERAMIK

Fig. A7. This is the section of the feature of which botanical sample 99 was taken. As can be seen, a charcoal layer is located at two-thirds from the top.

Fig. A8. This is the section of the feature of which botanical sample 129 was taken.

Fig. A9. This is the section of the feature of which botanical sample 132 was taken.

Fig. A10. This is the section of the feature of which botanical sample 141 was taken (part 1).

Fig. A11. This is the section of the feature of which botanical sample 141 was taken. (part 2).

Fig. A12. This is the section of the feature of which botanical sample 145 was taken.

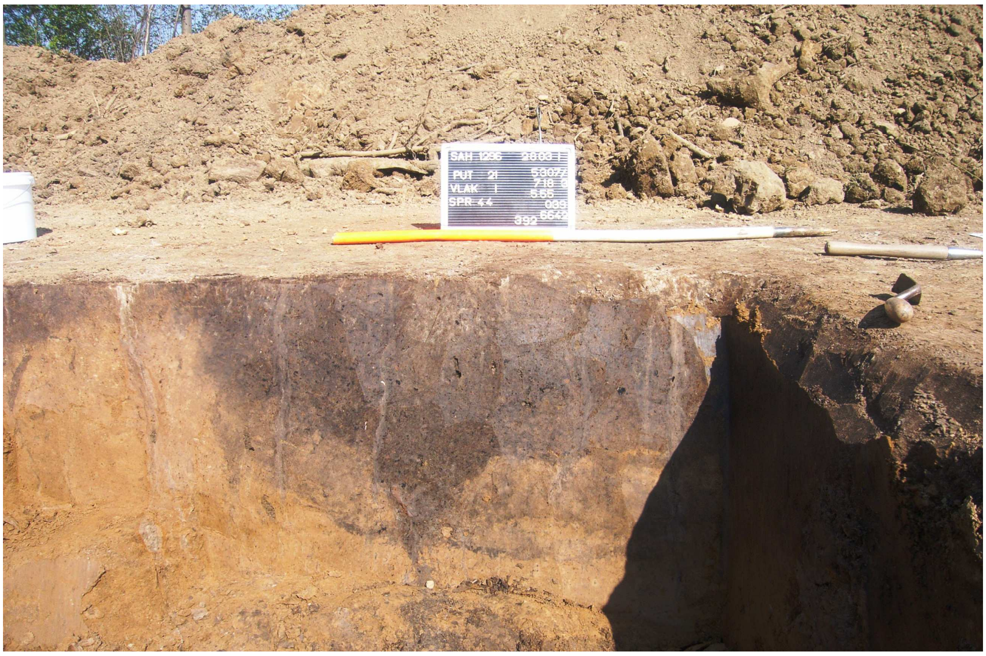


Fig. A13 This is the section of the feature of which botanical sample 148 was taken.

Fig. A14. This is the section of the feature of which botanical sample 149 was taken.

Fig. A15. This is the section of the feature of which botanical sample 271 was taken.

Fig. A16. This is the section of the feature of which botanical sample 273 was taken.

Fig. A17. This is the section of the feature of which botanical sample 286 was taken.

Fig. A18. This is the section of the feature of which botanical sample 299 was taken.

Fig. A19. This is the section of the feature of which botanical sample 319 was taken.

Fig. A20. This is the section of the feature of which botanical sample 323 was taken.

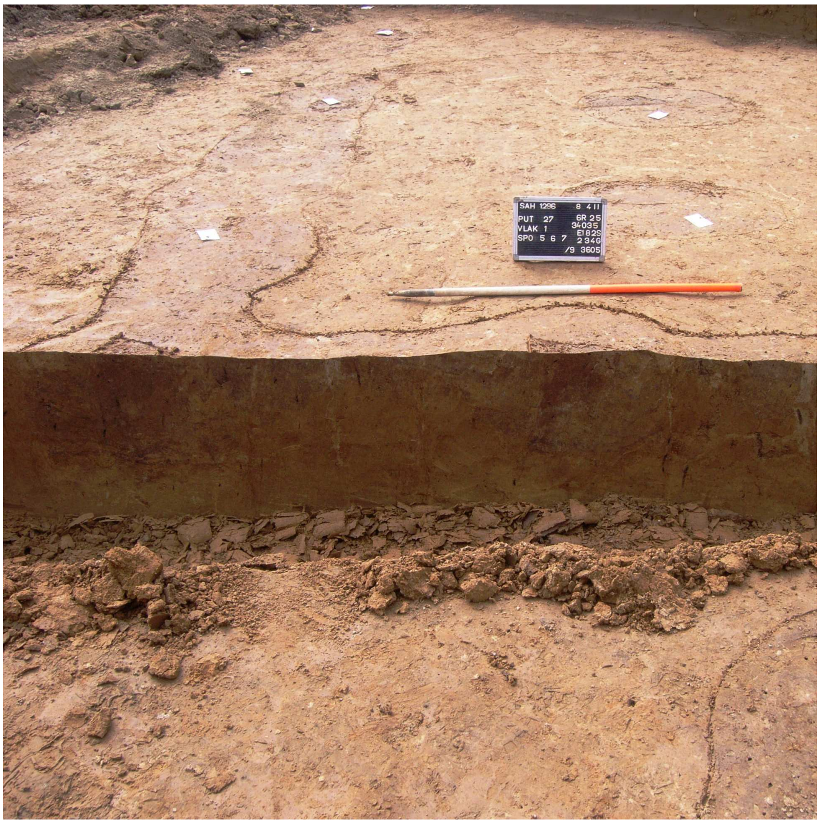


Fig. A21. This is the section of the feature of which botanical samples 325 and 326 were taken.

Fig. A22. This is the section of the feature of which botanical sample 327 was taken.