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Wild West Frisia : the role of domestic and wild resource exploitation in Bronze Age subsistence

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Citation

Amerongen, Y. F. van. (2016, November 10). *Wild West Frisia : the role of domestic and wild resource exploitation in Bronze Age subsistence*. Archaeological Studies Leiden University. Leiden University Press. Retrieved from <https://hdl.handle.net/1887/44180>

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Title: Wild West Frisia : the role of domestic and wild resource exploitation in Bronze Age subsistence

Issue Date: 2016-11-10

8. Bronze Age farming in West Frisia

8.1 INTRODUCTION

The four subsistence strategies related to West Frisian farming have been investigated separately in the previous four chapters, including the analysis of hunting, animal husbandry, crop husbandry, and wild plant gathering. Through these investigations, the potential role and praxis of each separate component has become clear in a more detailed manner, merited by the application of multiple disciplines. However, as introduced in Chapter 1, it is not the analysis of the separate aspects that provide insight into the complex system of farming. The different parts which constitute a farming system can in reality not be viewed as separate entities due to their balanced interconnectedness with other parts of the system. Therefore, the four analysed subsistence strategies need to be integrated to create a better understanding of farming as a whole.

In order to understand subsistence farming in a larger context, in this chapter, these four strategies are synthesized into three main themes. These themes were chosen based on the analysis results of the previous Chapters 2-7, which were rooted in the approach that basic subsistence includes the basic needs food, fire, shelter, and water (Chapter 3, section 3.1). The analyses in Chapter 2 were mainly focused on the reconstruction of the environment in which activities related to the fulfilment of the basic needs occurred. This chapter was therefore concerned with the composition and distribution of flora and fauna in West Frisia. Chapters 4-7 were mainly focused on the analysis of the role and praxis of each subsistence strategy in the procurement of food, as well as shelter (housing and clothing). These four chapters thus investigated how the different subsistence strategies contributed to the overall diet, range of clothing, and shelter options in West Frisia. In addition, these chapters have enabled the identification of the different activities required to accomplish the fulfilment of the basic needs. The three overarching themes of the previous chapters can be summarized as (1) The

reconstruction of the landscape (section 8.2); (2) Reconstruction of subsistence (section 8.3); and (3) Reconstruction of activities related to subsistence (section 8.4).

These themes will form the foundation of the integration of data, focusing on the most basic and universal aspects related to farming. In each theme, the aim is to arrive at a still more detailed understanding of the balanced manner in which each subsistence strategy is part of the larger system of Bronze Age farming. The combined analysis of all available data from one settlement (Bovenkarspel Het Valkje; section 8.5) is the culminating analysis which shows the added value of a holistic approach, which even revealed differences in subsistence on a household-level scale. It is only through this horizontal comparison between the different strategies that the relative contribution of each subsistence strategy to small-scale mixed farming systems can truly be evaluated. Concluding this chapter therefore, is a reconstruction of Bronze Age farming in West Frisia, in which the relative role of crop and animal husbandry, and hunting and gathering is discussed. Following this reconstruction, a new model for Bronze Age farming in West Frisia is presented, as well as an assessment of the role of West Frisia as a case-study for coastal communities in the Bronze Age.

Finally, based on the new model, several main subjects are chosen which will be used for comparative purposes with other areas in the Netherlands and north-western Europe in Chapter 9.

8.2 RECONSTRUCTION OF THE LANDSCAPE

In this section, the landscape is reconstructed on a detailed level by integrating the data of the composition and distribution of the flora and fauna in West Frisia (Chapter 2) with the data on farming practice (Chapter 5 and 6). By taking into account the potential impact of the animals and humans living in

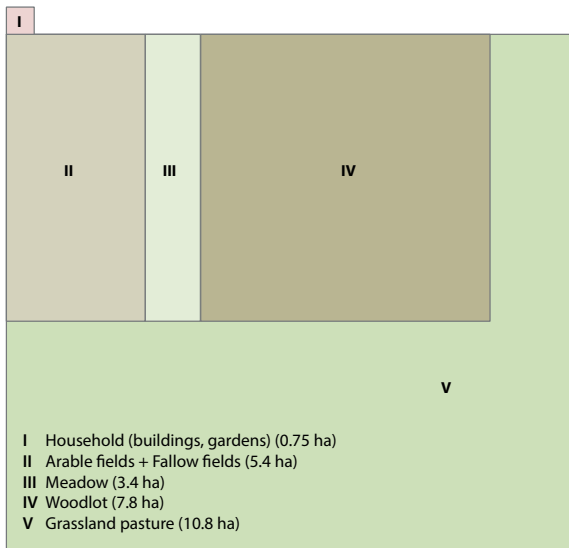


Figure 8.1. Hypothesized maximum total area required per household (0.28 km²), grassland pasture only.

West Frisia in the Bronze Age, this integration allows for an assessment of the possibilities of types and extent of vegetation present around the settlements. To accomplish this, both the areas required by households and their livestock and crops, as well as the area required by the wild animals living in Middle Bronze Age West Frisia were investigated. Both types of required area are first discussed individually, followed by a map showing the total impact on the maximum possible vegetation of West Frisia in the Middle Bronze Age. This final map includes the relative distribution of vegetation, animals, and humans present in the environment, as well as the potential impact on it. For the Late Bronze Age, such a detailed reconstruction was not made, but a general discussion is provided instead.

8.2.1 Area required by households and their livestock and crops

Area per household

The total area required by households and their livestock was calculated by combining area sizes required for the settlement, the arable and fallow fields, the meadow, the pasture, and the woodlot (*i.e.* required area of the forest that serves as a source of wood for the settlement). The information on the areas required for animal and crop husbandry were obtained

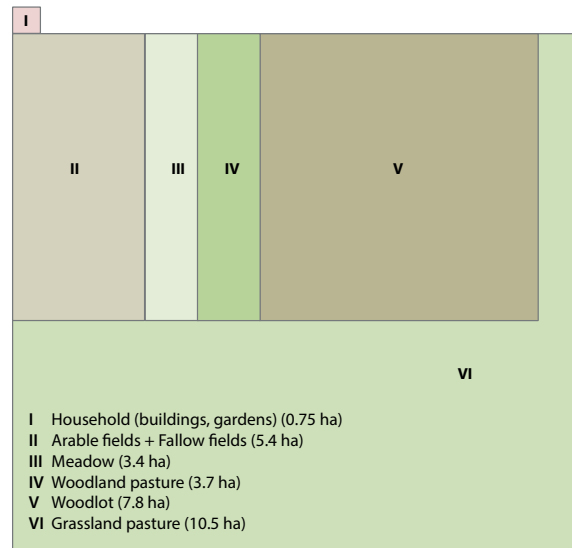


Figure 8.2. Hypothesized maximum total area required per household (0.31 km²), grassland pasture for all animals, and additional woodland pasture for goat.

from Chapter 5 and 6, respectively. The other areas, including the area of the settlement, the meadow, and the woodlot were obtained from the archaeological study of requirements for prehistoric farmers by Gregg (1988; see section 8.3.1.2). Two total impact areas were constructed (Figure 8.1 and Figure 8.2), which only differ in their pasture types. The first considers only grassland pasture usage, whereas the second considers both grassland and woodland pasture for the species goat and cattle (*cf.* Chapter 6). Furthermore, the values for required pasture as well as arable and fallow fields in general reflect maximum values, meaning that a maximum of 2 years fallow is included (*i.e.* three times the hypothesized value of 1.8 ha of arable fields per household), as well as the maximum herd sizes hypothesized in Chapter 5. The values employed from the work of Gregg have been divided by six to arrive at values per household, since she reconstructs an average of six contemporaneous households at a settlement (see section 8.3.1.2). The resulting total maximum area of the household in Figure 8.1 is 0.28 km², and that of the household in Figure 8.2 0.31 km² (Appendix A1.13).

Estimated possible number of contemporary houses in West Frisia

The total impact of humans in West Frisia was calculated as follows for both the grassland pasture only and mixed grassland/woodland pasture situations.

Table 8.1. Average number of contemporary houses and inhabitants (both humans and domestic animals) during the Middle and Late Bronze Age based on the available exploitable land in West Frisia (from: van Zijverden forthcoming).

	Middle Bronze Age			Late Bronze Age		
	total nr. houses	total nr. humans	total nr. domestic animals	total nr. houses	total nr. humans	total nr. domestic animals
Pasture type						
Grassland only	1,003	7,018	6,516 cattle 7,519 sheep 2,506 goats 1,003 horses	370	2,589	2,404 cattle 2,774 sheep 925 goats 370 horses
Grassland mainly, with additional woodland pasture for goat	929	6,501	6,036 cattle 6,965 sheep 2,322 goat 929 horses	343	2,398	2,227 cattle 2,569 sheep 856 goats 343 horses

Table 8.2. Average number of contemporary houses and inhabitants (both humans and domestic animals) during the Middle and Late Bronze Age based on uncovered concentrations of Bronze Age remains during field surveys in West Frisia (from: van Zijverden forthcoming).

Middle Bronze Age			Late Bronze Age		
total nr. houses	total nr. humans	total nr. domestic animals	total nr. houses	total nr. humans	total nr. domestic animals
832	5,824	5,408 cattle 6,240 sheep 2,080 goats 832 horses	175	1,222	1,135 cattle 1,310 sheep 437 goats 175 horses

The total area which was exploitable in both the Middle and Late Bronze Age was employed based on the research of Van Zijverden (forthcoming). These values were divided by the total average area required by one household (see previous section) to arrive at the average number of contemporary houses which could be sustained by the exploitable land in West Frisia, as well as the inhabitants of these houses in terms of humans and domestic animals. This situation was reconstructed for both the Middle and Late Bronze Age (cf. van Zijverden forthcoming) and the results are shown in Table 8.1.

The results of the calculations presented in Table 8.1 indicate that West Frisia could have been very densely populated throughout the Bronze Age, and that people and their livestock will no doubt have had a large impact on their surroundings in both periods. In the Late Bronze Age, fewer numbers of houses, people and domestic animals could be sustained, due to a decrease in the total size of exploitable land (van Zijverden forthcoming; Chapter 2).

Besides the calculations made above on the average possible number of households based on the available exploitable land in each of the Bronze Age periods, estimations on the households actually present in West Frisia were also made (van Zijverden forthcoming). These estimations are made based on the retrieved remains during field surveys of West Frisia. When it is assumed that each concentration of retrieved Bronze Age remains represents a household, the average total numbers of actually present households could be estimated (Table 8.2).

From the comparison of Table 8.1 with Table 8.2, it is clear that in the Middle Bronze Age, the estimated number of households in West Frisia is approaching the total potential area exploitable by humans during this time. The Middle Bronze Age in West Frisia can therefore be regarded as densely populated. In the Late Bronze Age however, the estimated number of households covers less than half of the potentially exploitable area. Apparently, during this time, there was a severe reduction in the total populations of humans and their livestock in West Frisia.

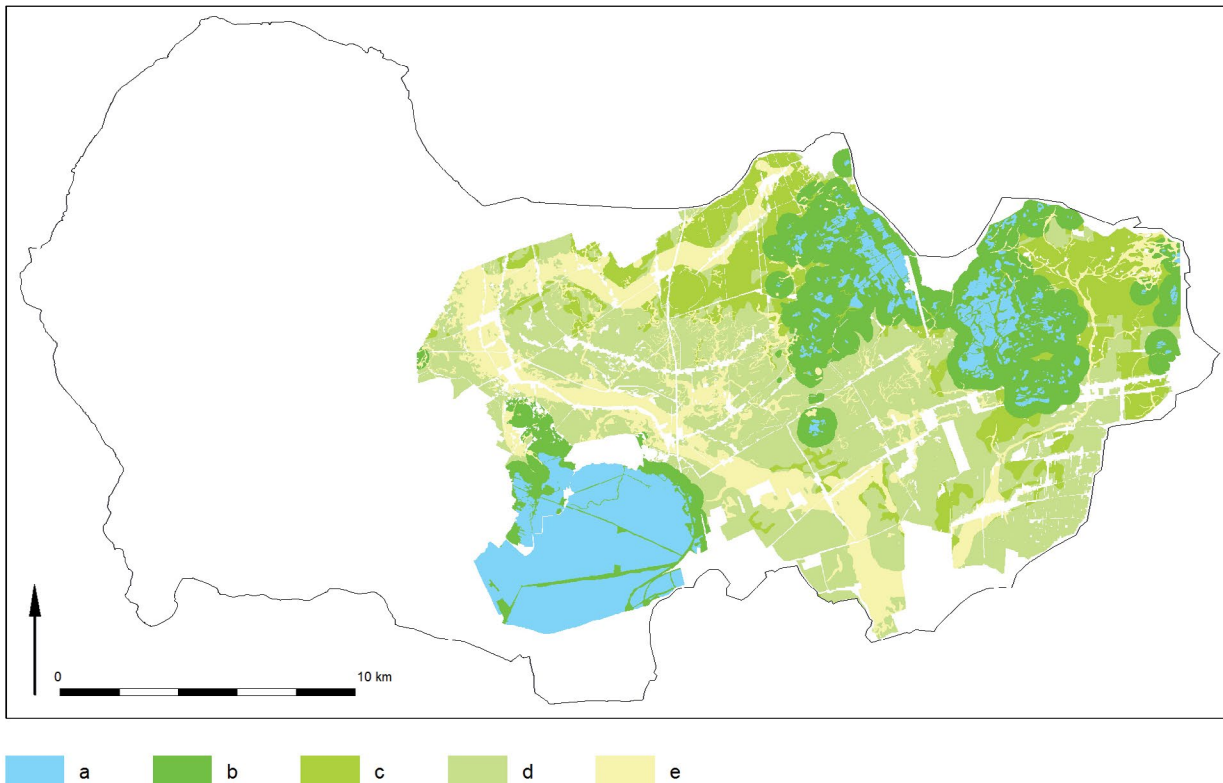


Figure 8.3. The forested situation map of eastern West Frisia; a: water; b: *Alnetea-Glutinosa* and *Artemisia-Salicetum albae* carr forests; c: *Fraxino-Ulmetum* forest; d: *Viola odorata-Ulmetum* forest; e: *Quercus-Fagetum* forest (from: Cronau 2016).

8.2.2 Area required by wild animals

The impact of wild animals on the environment, or the area required for their survival, was researched based on the uncovered large wild mammal species in eastern West Frisia (including red deer, roe deer, moose, wild boar, and beaver; Cronau 2016). In this research, the presence of the same large mammals throughout the Bronze Age is interpreted as evidence that healthy populations of these species existed in West Frisia during both the Middle and Late Bronze Age. Only large mammal species are researched, since it is expected that their impact on the environment will have been greatest. Two extreme situations were considered for eastern West Frisia: a maximum vegetation cover, or forested situation (Figure 8.3), and a minimum vegetation cover, or deforested situation (Figure 8.4).

In order to study the impact of large mammals on these two types of vegetation cover, several

aspects of their behaviour were researched (Cronau 2016). First, the approximate density of each large mammal species in the vegetation was researched, except beaver, since this species only affects some trees around water bodies (Cronau 2016; Table 8.3; Figure 8.5 e). However, since density alone is not an adequate measure of impact on vegetation, the animal densities were subsequently translated into total weights of the populations of each animal species, to account for differences in volume of matter consumed. In turn, this total weight was converted to the total consumption of vegetative matter of each species (Cronau 2016; Table 8.3). Other types of animal behaviour which were researched include food preference, interaction with individuals of the same and other species, habitat preference, home range, and migration (Cronau 2016). The resulting information from all these behavioural aspects combined was used to predict the total impact of wild animals on the vegetation.

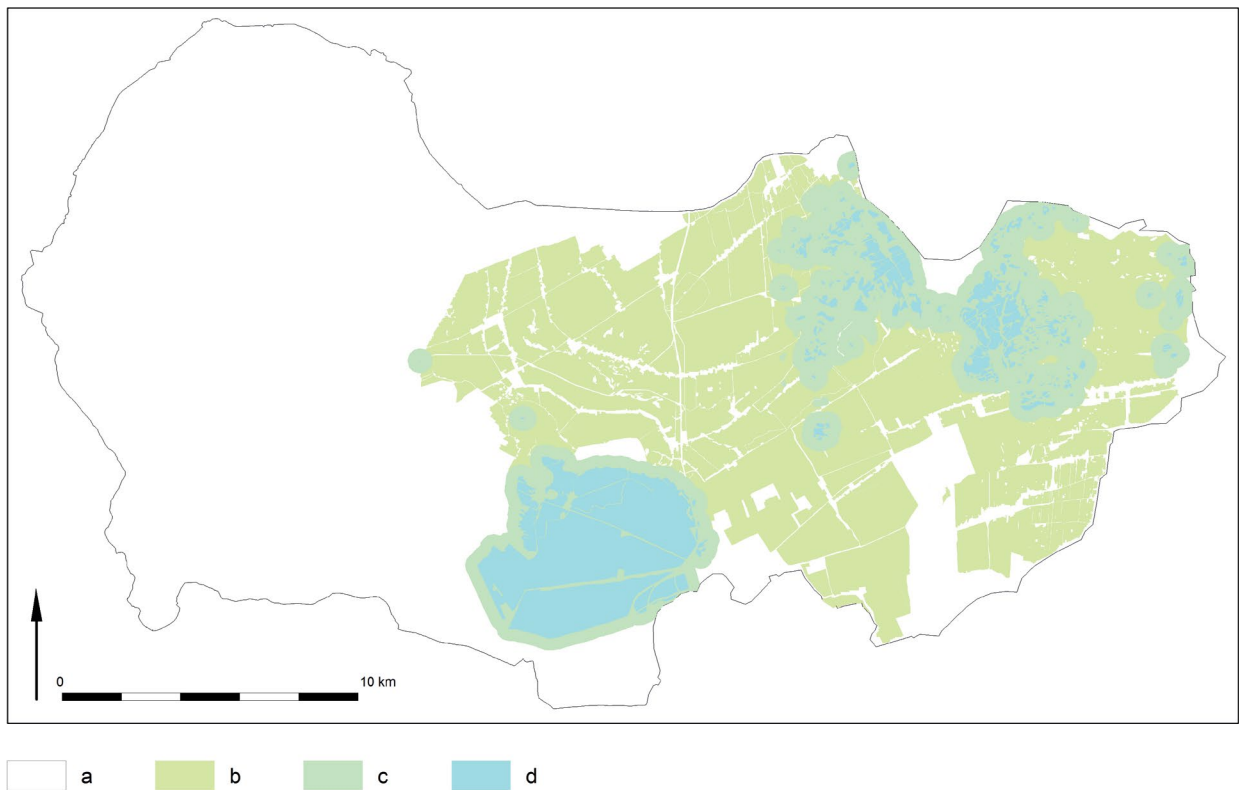


Figure 8.4. The deforested situation map of eastern West Frisia. a: *Arrhenatheretum elatoris* grassland; b: *Phragmiton australis* reed swamp; c: water (from Cronau 2016).

8.2.3 Distribution of plants, animals, and humans in the West Frisian landscape

Middle Bronze Age

The impact based on humans and their livestock, wild animals, and the interaction between them was combined to assess the composition of the landscape of eastern West Frisia in the Middle Bronze Age (Cronau 2016). In Figure 8.5, the resulting map is shown. From this figure, it becomes clear that the impact of humans and livestock in the Middle Bronze Age was indeed extensive (Figure 8.5 e, f and g; cf. section 8.2.1), amounting to around 16 km² of the landscape being treeless because of direct human impact. It must be noted that the impact radii of humans (Figure 8.5 g) are an idealized situation, representing a circle around the settlement. In reality, these areas will have been more distributed over the surroundings, according to for example each of the pasture categories observed in Figure 8.1 and 8.2, although the total impact of

humans on the environment will remain the same, regardless of location.

The further surroundings of the settlements must, however, still have been covered by a variety of vegetation types, since the pressure here is lower (Figure 8.5 a-d). Water and different vegetation types which may thus still be expected to be part of the landscape are, grassland, shrub land, and large areas of forest of different types. These types form a combination of Figure 8.3 and Figure 8.4 depending on the pressure from Figure 8.5: the lowest pressure is observed for the wetter vegetation types (Figure 8.3 b; Figure 8.4 a), which may also be related to their ability for fast regeneration. The drier forest types surrounding the wetter vegetation (Figure 8.3 c and d) will have had an open canopy, due to the combined distributed and concentrated pressure of wild animals, and would have alternated with open grassland (Figure 8.4 b). Around the water bodies (Figure 8.3 a; Figure 8.4 c), the impact was medium high, mostly because of

Table 8.3. Density of animal species and their total consumption per km² (Cronau 2016).

Ungulate species	1) Forested situation of West Frisia		2) Deforested situation of West Frisia	
	Density (individuals/km ²)	Total consumption (average kg dry matter/km ² /yr)	Density (individuals/km ²)	Total consumption (average kg dry matter/km ² /yr)
Moose	1.42	3,834	0.26	702
Roe deer	18.15	2,015	0.15	17
Wild boar	5.75	5,313	2.29	2,116
Red deer	10.34	9,208	6.42	5,717
Total	35.66	20,370	9.12	8,552

beavers, creating a treeless boundary. The highest pressure will have been exerted on the driest forest type (Figure 8.3 e), where both livestock and wild animals grazed, restricting the growth of these already slow regenerating forests to a climax vegetation (Cronau 2016).

Livestock will most likely have grazed wherever adequate grassland was available (Figure 8.5 c, d, and f). Sheep in particular will have grazed the driest parts of the grassland (Figure 8.5 c, d, and f) in both summer and winter, and was probably restricted to the driest grassland in winter (Figure 8.5 f), due to wet conditions being present in the other vegetation types during this time of the year. To reach these dry areas, people from some of the settlements would have had to travel somewhat further from the settlement, but every settlement lies within a 5 km range from these locations. Therefore, the action radius of farmers postulated in Chapter 3 remains valid for animal husbandry practices as well. The different activities related to the movement of livestock across the land are further explored in section 8.4.

The overall resulting habitat types are in concurrence with those observed in Chapter 2, but this analysis has enabled a more detailed understanding of the location of the different landscape elements around the West Frisian settlements and the impact on them by people and livestock.

A final result from this impact analysis is that the reconstruction of the Middle Bronze Age landscape of eastern West Frisia has provided an extra indication that Bronze Age subsistence must have indeed consisted of small-scale farms: farms of larger size than those observed in Figure 8.5 would never have been able to be supported by the available suitable land for habitation.

A science-based artist impression of the Middle Bronze Age West Frisian landscape can be found in Appendix A1.14.

Late Bronze Age

The pressure of humans and (wild) animals on the Late Bronze Age environment, although not reconstructed here in detail, would have been largely comparable to the pressure reconstructed for the Middle Bronze Age. This is considering the lower amount of available suitable land for habitation during this time (Chapter 2, section 2.5.3), but also the lower number of people inhabiting this land (section 8.2.1). However, local pressure on certain vegetation types will probably have been higher due to the different suitable vegetation types suitable for grazing being condensed into smaller areas (Chapter 2, section 2.5.3).

8.3 RECONSTRUCTION OF SUBSISTENCE

This section researches in detail how basic needs may have been met in West Frisia. The potential for dietary addition in each of the different subsistence

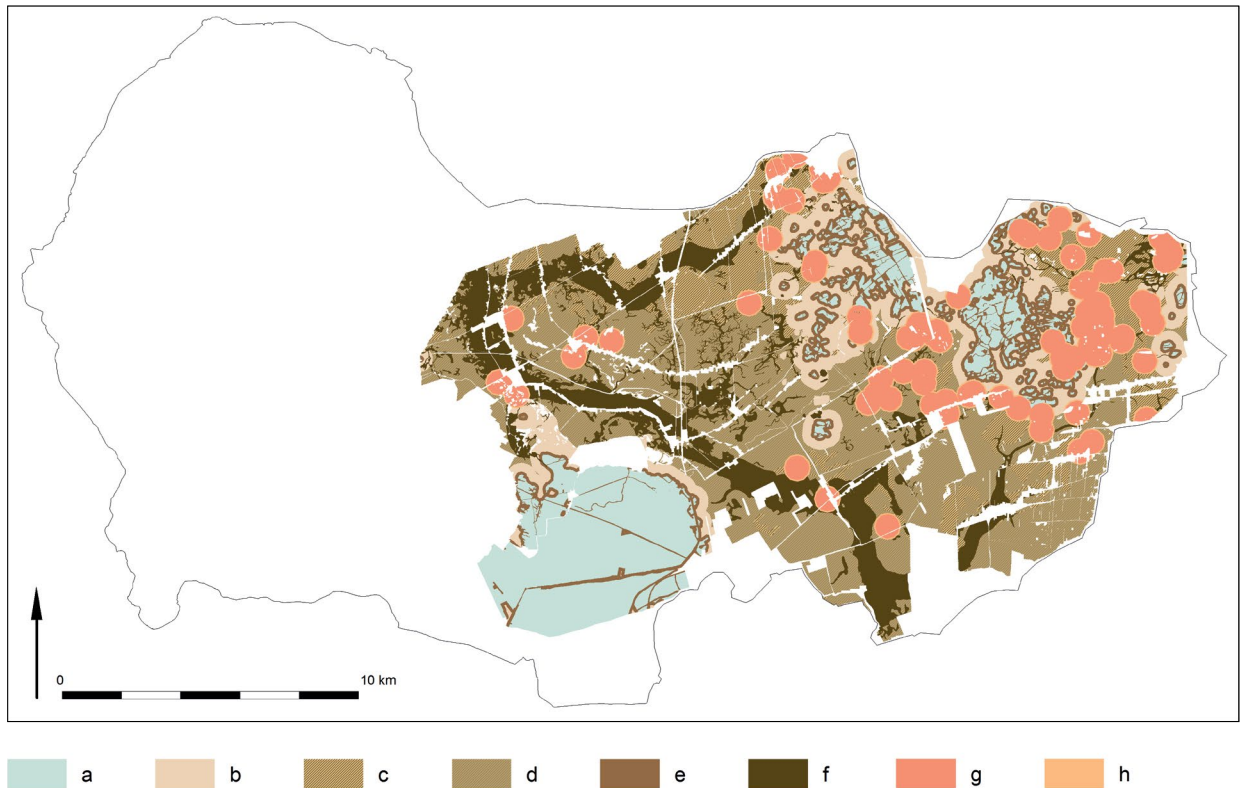


Figure 8.5. Reconstruction of the Middle Bronze Age vegetation in eastern West Frisia, including the impact of humans, livestock, and wild animals. Pressure is exerted on the landscape by the settlement and its domestic and wild resource exploitation, or by grazing of wild and domestic animals, which can be distributed or concentrated for different vegetation types. a: water/reed swamp; b: low pressure; c: low to medium distributed pressure, and medium concentrated pressure; d: medium distributed pressure, and low to medium concentrated pressure; e: high overall pressure; f: very high overall pressure; g: human settlement and livestock impact area (two houses are considered here as a settlement); h: transitional zone from cultural to natural landscape (from: Cronau 2016).

strategies has become clear from Chapter 4-7, but their actual role and interconnectedness in the farming system is not apparent based on these separate analyses. Also, the ability of each of these strategies to provide for the other basic needs of housing and clothing has not been synthesized yet. Therefore, in this part of the chapter, diet, clothing and the house form three sub-themes which are explored based on the results from Chapter 4-7. The analyses in each of these sub-themes will reveal the need for all four strategies in each part of subsistence, and especially the continuing and even vital importance of wild resources in Bronze Age farming.

8.3.1 Diet

Indications for the diet of small-scale mixed farming communities have been obtained from different sources,

namely ethnography, archaeology, nutritional studies, and physical anthropology. Each of these approaches is discussed separately below.

8.3.1.1 Ethnography

Indications for the role of different subsistence strategies in small-scale mixed farming communities were already discussed separately in Chapters 4-7, based on selections on the work by Murdock (1981). Figure 8.6 shows the average values of the different food strategies observed in the selected cultures (Appendix A1.4).

What becomes clear from Figure 8.6 is that, in communities practicing mixed farming, people always depend more on agriculture (cf. crop husbandry) for their diet than on any other food strategy, including

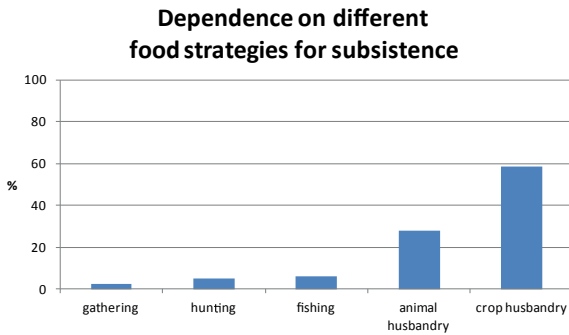


Figure 8.6. Average values of the different food strategies in small-scale farming communities based on the selected cultures of the ethnographical work by Murdock (1981).

animal husbandry, since cereals form the staple food of the selected communities. In addition, Figure 8.6 shows that the use of wild resources comprises 13% of subsistence, divided between gathering of plants, hunting (incl. trapping and fowling), and fishing). Also interesting to note is that the exploitation of wild resources seems to occur regardless of the size of the community (*i.e.* neighbourhoods, hamlets, villages; Appendix A1.4), although the relative dependence on each of the wild resources is different. For example, in villages, people depend significantly less on hunting than in neighbourhoods or hamlets (Appendix A1.4).

These results show the dependence of present-day mixed farming communities on the different food strategies for their subsistence. However, since Murdock is so vague about their specific contribution to the diet, and his research does not necessarily apply directly to prehistoric societies, more detailed research is needed, which is discussed next.

8.3.1.2 Archaeology

One of the major studies on prehistoric diet, and the role of each of the food strategies in the total diet, is the work of Gregg (1988). She has researched the addition of each of the food strategies to the diet of a (Neolithic) farmer, as well as the monthly fluctuations in the availability of each available food resource. Her work is based on existing optimal foraging models (Jochim 1976; Keene 1981). By

including farming practices, Gregg adapted these models into an optimal farming model (Gregg 1988, 16). Through calculations based on several assumptions, she sought to acquire knowledge about the amount of wild and domestic resources in the diet of Neolithic farmers, and the extent of land required to support a settlement. Although this model is out-dated in some respects, and farming can by no means be regarded as optimal, her study does allow for an insight into annual and monthly resource availability and requirement in a farming context.

Below, Gregg's main assumptions are presented and it is clarified why her study can form an example and a basis of comparison for West Frisia.

Gregg: assumptions and model input

The research area chosen by Gregg is southern Germany in the sixth millennium B.C. She states that most Neolithic settlements in the research area were small, dispersed settlements of 4-10 contemporaneous houses spaced approx. 100 meters apart (Gregg 1988, 4 and references therein). Some of the settlements were occupied continuously for up to 400 years, with a 25 year cycle of house construction, occupation, and abandonment. The main assumptions of this model are summarized in Table 8.4. The table indicates that most assumptions agree very well with the results from the analysis of West Frisian crops and livestock (Chapters 5 and 6). Crop husbandry results are comparable to Gregg's model except for minor differences including the fact that cultivated crops in West Frisia include both wheat and barley, although in the Late Bronze Age, mostly wheat is present; the average field size of arable fields per individual is 0.3 ha (1.8 ha/6 persons); and postulated crop yields are higher at 2000-2700 kg/yr after deduction of harvest losses. Animal husbandry results are also in concurrence: all aspects are similar, with only slightly higher reconstructed numbers of sheep/goat kept per household. Due to the large overlap of assumptions made by Gregg with the results for West Frisia, her model is employed and adapted to create an understanding of the Bronze Age subsistence in West Frisia.

Table 8.4. Overview of the main assumption of the model of Gregg for the south-west German Neolithic, compared with the results for West Frisia from Chapter 5 and 6.

	Neolithic southwest Germany	West Frisia
Settlement characteristics		
Settlement type	permanent	permanent
Settlement pattern	small, dispersed settlements	small, dispersed settlements
Nr. of contemporaneous houses	4-10 (av. 6)	at least 4 (Bovenkarspel Het Valkje; Roessingh in prep.)
Crop husbandry		
Crops	wheat	wheat and barley
Fields	ley fallow*	no fallow-short fallow
Average field size per individual	0.35-0.45 ha	0.3 ha (1.8 ha/6 persons)
Sowing time	spring or autumn-spring	spring
Soil fertility	high	high
Harvest yield wheat	1000 kg/yr	2000-2400 kg/yr
Animal husbandry		
Animals	cattle, sheep, goat, pig	cattle, sheep, goat, pig, dog, horse
Housing	yes, four months (winter)	possible
Feed	forest browse, pasture, fodder, crop stubble, fallow plots	forest browse, pasture, fodder, crop stubble, fallow plots
Average herd size per house	5-8 cattle, 2-5 sheep, 2-4 goats, 0-2 pigs	5-8 cattle, 5-15 sheep/goats, 0-3 pigs
Herd dynamics	stable/no growth	stable/minor growth
Birth season	spring	spring
Milk consumption	yes	yes (cf. Chapter 5, section 5.4.3)

*Ley fallow is a special type of fallow in which livestock is grazed on the emerging grass and shrub land after a fallow period. The length of such fallow can be short-, medium-, or long-term (after: Ruthenberg 1980, 14-5).

With the abovementioned assumptions, Gregg has developed a hypothetical settlement for her modelling (Gregg 1988, 128). The settlement consisted of six houses, with, randomly generated, four to eight household members (Gregg 1988, Table 32), and owned livestock (Gregg 1988,

Table 40). Using these variables as the input for her model, she calculates that this settlement would require around 13 ha for arable fields, 4.5 ha for houses, outbuildings, and garden plots, 53 ha for the woodlot (for fuel and wood for construction), 18 ha for pastureland, 20 ha for natural meadows, and 2.6

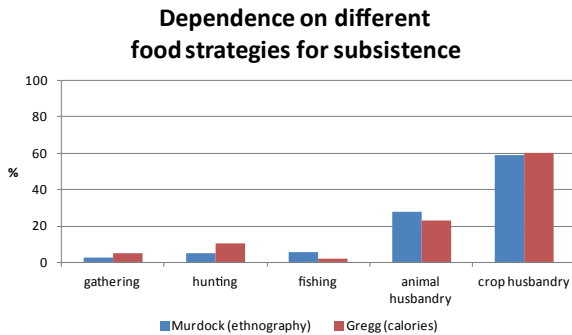


Figure 8.7. Average values of the different food strategies in small-scale farming communities based on the selected cultures of the ethnographical work by Murdock (1981) and the archaeological work by Gregg (1988).

ha for forest browse. Her reference settlement would thus require a minimum of 6 km² for their domestic resources (including 40 cattle, and 40 sheep/goat), which is around 1 km² per household (Gregg 1988, 165-7). The total amount of land required by farmers in West Frisia amounts to around 0.3 km² per household (cf. section 8.2.1). This difference is most likely related to the amount of woodland required by Gregg's model in comparison with the West Frisian situation. Woodland browse contains much less nutrients than pasture, and so, a much larger area is needed to meet domestic animal demands.

Gregg: implementation and adaptation

Gregg's model is based on the work of Jochim (1976), who examined the structure of wild resource exploitation of the Mesolithic. His model investigates the monthly use of each wild resource as part of the total annual diet based on caloric intake. Additional (domestic) resources were added by Gregg to mimic Neolithic farming subsistence. Her model allows for a month-by-month comparison of resource use and changes resulting from different relative proportions of domestic and wild resources in the diet throughout the year can therefore be identified. Four main large wild animals were included in the model (*i.e.* red deer, roe deer, boar, and beaver) since they occurred most often at the Neolithic sites. Furthermore, fish, birds, small game, and wild plant foods were grouped by Gregg into collective classes. She also researched their seasonal availability and density near the settlement. In the case of farmers practicing animal husbandry, Gregg argues that the density of red deer will be low, since red deer and

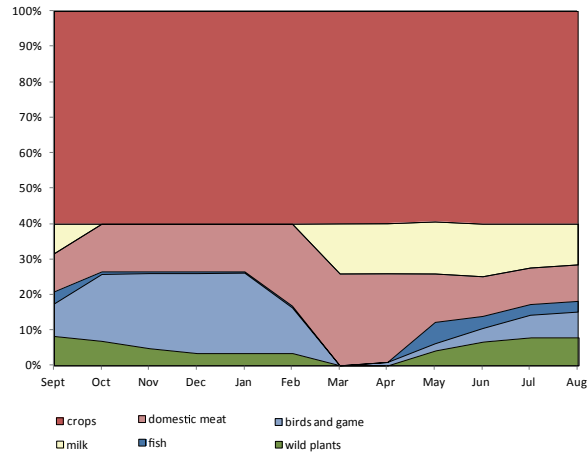


Figure 8.8. Monthly fluctuations in the available food groups in the Bronze Age diet based on calories (adapted from: Gregg 1988).

cattle compete for the same resources. Therefore, for this study, the low density of red deer indicated by Gregg is used.

As discussed above, many of the assumptions made by Gregg are considered comparable to the Bronze Age West Frisian situation (cf. Table 8.4). However, an adaptation was made to her model (Appendix A1.15): Gregg assumes a contribution of pulses/legumes to the diet of the Neolithic farmer. However, very few to no remains of this food group have been identified in Bronze Age West Frisia, and the North Sea coast/southern Scandinavia in general (Chapter 6, Table 6.4 and Table 6.5). Therefore, the calories allotted by Gregg to this food group were placed under the wild plant category, since these would have formed a substitute for the nutrients otherwise obtained from domestic pulses/legumes (cf. Chapter 7, section 7.4.2.1). With this new information included, the monthly diet values of table E (Gregg 1988, 240) by Gregg were recalculated and used for the West Frisian situation (Appendix A1.15). The results from the recalculations are summarized in Figure 8.7 and Figure 8.8, and are subsequently divided into the main food categories used by Murdock (1981). The figures show the average annual addition of each resource group to the diet (based on calories), and the monthly fluctuations in availability of each resource, respectively.

As it is unsure what Murdock meant by the relative dependence on the different food categories, it is hard to compare differences directly, but it can be seen in Figure 8.7 that the general trend of Murdock's observations is matched by the calculations made by Gregg. The latter does however seem to imply a stronger dependence on the consumption of wild animals at the expense of domestic animals, which may reflect a difference between more recent and prehistoric farming communities.

In Figure 8.8, the monthly contribution of each food category to the diet based on calories is shown. From this figure, it is apparent that the combination of crop and animal husbandry contributes most calories to the diet throughout most of the year. Similar values have been proposed by Buurman for West Frisia (Buurman 1996, 31). In winter months, the reduced amount of calories from domestic animals (both meat and milk) are buffered by small and large game meat. Some additional calories are obtained from fish and wild plants, especially in summer months, although their overall contribution to the caloric diet is low. According to Gregg (1988, 186), wild resources are not required at all for additional calories in March and April, because domestic food sources are highly abundant during this time. They are therefore (mostly) absent in Figure 8.8 during those months.

The above graphs provide an interesting insight into the fluctuations of food resource use by prehistoric farmers throughout the year. The variety of food resources employed by these farmers indicates the importance of nature in their lives, not only for crop and animal husbandry practices, but also for wild resource exploitation. Various available resources will have been used to complete the diet, differing in relative composition on a monthly basis. Gregg's calculations furthermore provide insight into the quantitative contribution of each of the food categories based on calories. An aspect missing from her elaborate work however, is the qualitative contribution of each of the food categories for obtaining a healthy diet. A diet solely based on obtaining the required amount of daily caloric intake might not necessarily be sufficient in providing a person with essential macro- and micronutrients required to maintain a good health. Therefore,

the importance and possible implications of these (missing) nutrients is discussed next.

8.3.1.3 *Nutritional studies*

Quantitative data required for establishing a healthy diet rather than a calorie-sufficient diet was obtained from a report on human vitamin and mineral requirements released by the World Health Organisation (WHO) and the Food and Agriculture Organisation of the United Nations (FAO) (WHO & FAO 2002). In this report, it is outlined that dietary guidelines should ensure that 97% of the population meets their daily nutrient requirements. The dietary prerequisites are expressed as the Recommended Nutrient Intake (RNI). However, instead of listing individual RNI values, the report provides food-based dietary guidelines (FBDGs), which provide a list of food combinations which ensure adequate nutrient intake. These FBDGs mainly aim at the acquisition of critical micronutrients. The critical micronutrients, which are most difficult to obtain for people consuming a staple diet of cereal grains or tubers, are vitamin A, vitamin C, folate, iron, and zinc (WHO & FAO 2002, 7-8). Deficiencies of these micronutrients can result in (fatal) ailments such as blindness, scurvy, anaemia, disrupted brain and muscle development, and stunted growth and higher susceptibility to infectious diseases, respectively (WHO & FAO 2002, 9-10). In order to counter or prevent these effects, it is essential that micronutrient uptake is increased by broadening and diversifying the diet.

The consumption of a combination of additional food sources has been established for people consuming, amongst others, white rice or refined couscous-based diets. These diets however, consist of cereals that have been modified from their original nutrient composition, mostly by removing the germ and bran from the grain. Since in prehistory intact (whole) grains were consumed, the diets proposed by the WHO and FAO are not directly comparable to the prehistoric situation. In order to reflect the Bronze Age situation in West Frisia more closely, information on whole grains of emmer wheat and hulled barley was applied to the dietary suggestions of the WHO/FAO report. In this manner, it could be assessed whether Bronze Age farmers consumed a

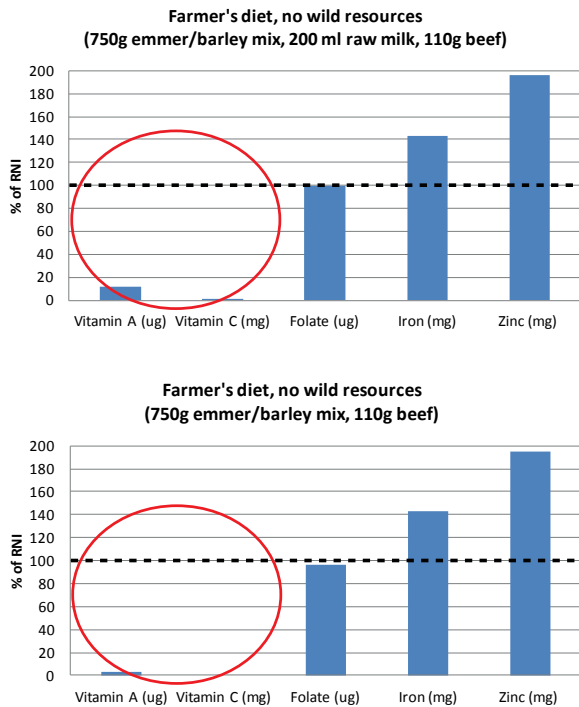


Figure 8.9. Overview of the diet of Bronze Age farmers based on cereals, red beef meat, and including milk (left) or excluding milk (right), without addition of wild resources. The dashed line indicates the recommended nutrient intake (RNI) per day of the most important micronutrients. The red circle indicates the obvious lack of essential vitamins in this type of diet.

diet with sufficient critical micronutrients, or whether there was a shortage of these importance elements.

Bronze Age West Frisia

First, an overview of the micronutrients available in a Bronze Age farmer's diet was constructed based on domestic resources (*i.e.* without addition of wild resources) and with the aid of the calculations from WHO & FAO (2002, 21-4). Two types of diet were constructed, which both include a mix of emmer and barley (because they were usually present in a 50/50 frequency ratio in Bronze Age contexts in West Frisia), and beef meat (*i.e.* the most frequently encountered domestic animal in the zoological remains). In the second diet, also raw milk was included, since this domestic resource will also have been available to farmers during several months of the year, and indications for its use are found in

Bronze Age Enkhuizen Kadijken, England, and Scotland (Chapter 5, section 5.4.3; Copley *et al.* 2005; Craig *et al.* 2005; Roessingh & Lohof 2011). Micronutrient information has been compiled from several sources (WHO & FAO 2002; Piironen *et al.* 2008; Chatzav 2009; Raw milk 2016; USDA 2016), and calculations were made to assess the nutritional contents of the diet (Appendix A1.15). Nutritional content is, in this case, defined as the amount of (micro)nutrients in a given diet composition, in which each of the most difficult to obtain micronutrients should reach 100% or more. When all critical micronutrients reach over 100% in a diet, nutrient demands are met.

What can be seen from Figure 8.9 is that in both Bronze Age “domestic” diets the micronutrient content of the critical vitamins A and C is far below the recommended daily levels. Figure 8.9 thus shows that farmers could not solely rely on their produced crops and animals to ensure their health. Such low levels of vitamins would ultimately result in scurvy (lethal) or blindness, and it is not assumed that entire settlements would succumb to these ailments: habitation lasted for several centuries. Therefore, is important to identify possible sources of these vitamins in other food groups, which Bronze Age West Frisians could have consumed to ensure adequate vitamin intake.

Domestic animal vitamin A and C sources

Liver meat can form a potential source of vitamin C, since many animals (excluding humans) can produce their own vitamin C and store it in this organ. The concentration of this vitamin in liver meat is not very high however (Bender 1992; USDA 2016) so that considerable amounts of liver would need to be consumed by each person on a daily basis (*i.e.* 200g on average) in order to assure adequate levels of vitamin C in the diet. Vitamin A is available at reasonable levels in organ meat as well, especially liver, and can thus have aided vitamin A intake when a slaughtered animal was consumed.

A problem with organ meat is, however, that levels of vitamins decrease during heating (Bender 1992), so unless organ meat was consumed raw, processing the meat would have decreased the levels of vitamin A and C considerably. Furthermore, the availability

of vitamins from organ meats fluctuates throughout the year, since these organs logically only become available after slaughter. Furthermore, when a liver becomes available after slaughter, it must be consumed within a short period of time, since organ meat spoils easily and preservation is difficult (*e.g.* Mays 2004, 85). Therefore, a more consistent source of these vitamins is required to complete the diet on a daily basis.

Plant vitamin A and C sources

Wild plants can be valuable sources of micronutrients. Plants especially, such as pulses or legumes, (leafy green) vegetables, and fruits, have a high micronutrient density and are the preferred way of obtaining critical micronutrients (WHO & FAO 2002, 8).

Where possible, the nutrient profile of the edible wild plants from house contexts (Chapter 7, Table 7.7) has been identified in order to assess the vitamin A and C potential of wild plants in West Frisia. These wild plants were postulated to have been collected for their seeds and/or vegetative parts based on their prevailing preservation state and relative frequency in houses contexts (Chapter 7, section 7.3.3 and section 7.4.2.1).

The information on the critical micronutrients of these plants was obtained from research on the edible wild plant use by Canadian indigenous people (Kuhnlein & Turner 1991, Chapter 6). It may be argued that Canada is not comparable to north-western Europe with respect to plant nutrient composition. However, although general micronutrient content may vary depending on the environmental conditions in which a plant grows, this mainly affects the mineral content, since these are absorbed from the surroundings. Vitamins on the other hand, are produced by the plant itself and are only influenced by available sunlight, location, and seasonality (Bernstein 1945, 570; United States 1948,9). Since Canada has a relatively similar latitude to north-western Europe, and therefore has mostly comparable sunlight hours and seasons, conditions which might affect vitamin content of wild plants are deemed largely comparable to West Frisia. In addition, many wild plant species are present in both areas.

The vitamin content of the West Frisian edible wild plant species on which data was available is summarized in Table 8.5. In this table, the energy is shown which can be obtained from each species, as well as the actual vitamin content of the plant species, its nutrient density, the daily intake value based on 100 g of raw material, and the amount of grams required to be consumed of each species in order to obtain the required levels of vitamin A and C.

As can be seen, many of the wild plants are naturally rich in vitamin content, especially when it is considered that modern-day apples or carrots contain around 5 mg/100g vitamin C and 3-800 µg/100 g vitamin A (USDA 2016). Most of the wild plants from Table 8.5 exceed these values.

Vitamin A and C content is highest in greens and leaves, although roots of wild carrot (*Daucus carota*) also contain levels of vitamin C. Limited data is available on the vitamin content of these plant seeds, however they generally contain much less vitamins than young green parts of the plant. This would be an explanation for the fact that many present-day cultures collect plants mainly for their vegetative parts. The seeds of wild plants probably have comparable characteristics to the crops produced by farmers. From the plants of which greens and leaves are consumed, only 35-150g of raw material needs to be eaten daily to meet vitamin C requirements. Especially greens of turnip (*Brassica rapa*), fat hen (*Chenopodium album*), stinging nettle (*Urtica dioica*), and curly dock (*Rumex crispus*) are highly nutritious. Both turnip and stinging nettle have probably been collected in West Frisia solely for their green parts (Chapter 7, Table 7.7). These species also grow on locations which are easily accessible to the farmers, such as on the settlement or on nearby arable fields. Common plantain (*Plantago major*) leaves on the other hand, have relatively low vitamin C levels, so that more than 600g needs to be consumed to meet demands.

As stated, vitamin C can also be obtained from roots of wild carrot, of which 200g provide daily required vitamin C levels. This plant could provide vitamin C during winter. People would have to travel somewhat further from the settlement to obtain it, as it grows on

Table 8.5. Nutrient composition per 100 g of the wild plants uncovered from house ditches in West Frisia.

Taxa	Part Used	Energy (kcal)	Vitamin C			Vitamin A		
			mg	% ND	100% DV (g)	RE (µg)	% ND	100% DV (g)
<i>Brassica rapa</i>	greens	22	130	433	42	990	198	86
<i>Capsella bursa pastoris</i>	greens	33	64	212	87	327	65	260
<i>Chenopodium album</i> (cooked)	greens	32	37	123	149	970	194	88
<i>Chenopodium album</i> (raw)	greens	34	98	328	56	1,277	256	67
<i>Montia fontana</i>	young greens	31	34	115	160	-	-	-
<i>Plantago major</i>	greens	-	33	111	165	-	-	-
<i>Polygonum aviculare</i>	greens	-	78	260	71	-	-	-
<i>Rumex acetosella</i>	greens	43	34	112	164	560	112	152
<i>Rumex crispus</i>	greens	24	88	294	62	1,014	203	84
<i>Sonchus asper</i>	greens	26	63	209	88	-	-	-
<i>Urtica dioica</i>	greens	-	90	299	61	-	-	-
<i>Mentha spec.</i>	leaves	39	64	213	86	1,334	267	64
<i>Plantago major</i>	leaves	61	8	27	688	252	51	337
<i>Stellaria media</i>	leaves	-	35	116	158	613	123	139
<i>Urtica dioica</i>	leaves	38	75	250	73	2,248	450	38
<i>Daucus carota</i>	roots	-	24	80	229	-		
<i>Chenopodium album</i>	seeds	414	-	-	-	-	-	-
<i>Echinochloa crus-galli</i>	seeds	417	-	-	-	-	-	-
<i>Polygonum lapathifolium</i>	seeds	425	-	-	-	-	-	-

All information is derived from Kuhnlein and Turner 2009, except for *Sonchus asper* (Guil-Gerrero et al. 1998), and *Montia fontana* (Tardio et al. 2011). ND: nutrient density; DV: daily intake value; RE: retinol equivalent.

nitrogen-rich grasslands. Alternatively, people may have cultivated these plants in a vegetable garden, but the presence of such gardens in West Frisia is unclear. Vitamin A is supplied by less species in Table 8.5, but still, consumption of 50-150g (average 100g) of

plant material is usually sufficient to reach demands (Figure 8.10). However, roots of wild carrot, which are available during winter, do not contain vitamin A, and this absence may form a problem during that time. Another interesting fact of wild greens/leaves, which

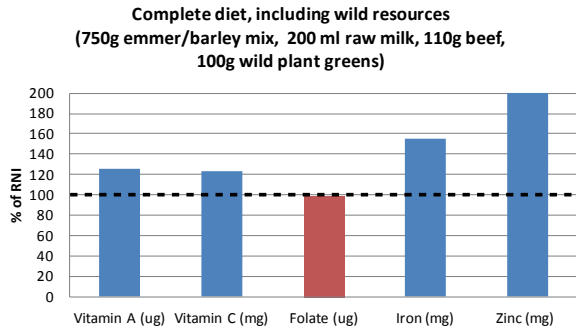


Figure 8.10. Overview of the diet of Bronze Age farmers based on cereals, red beef meat, and milk, including 100g of wild plant greens (average values of greens and leaves from Table 8.5). The dashed line indicates the recommended nutrient intake (RNI) per day of the most important micronutrients. Folate is indicated in red, because the exact folate content measurements were not available for the researched wild plants, even though this micro-nutrient is present in wild plants. The actual amount of folate will thus be even higher than shown here.

can be seen in Table 8.5, is that they contain very few calories/100g. This means that calorie-wise, wild plants indeed are not a considerable addition to the diet, which is in concurrence with Gregg's model (Figure 8.7 and Figure 8.8). Gregg also implies that in March-April there is an absence of wild plants in the diet because domestic resources are abundant. During this same period of the year however, most plants provide young shoots and leaves with high levels of vitamin A and C, which would be required to form a healthy diet. It is therefore clear from the above results that calories alone are not an appropriate measure to assess diets: critical micronutrients also need to be present in sufficient quantities to maintain health. These could be obtained from wild plants throughout the year, also during times of domestic resource abundance.

Wild animal vitamin A and C sources

Another wild resource which is rich in vitamins, besides wild plants, is fish. Especially eel meat contains high levels of vitamin A, and less than 150 g of eel (raw or processed) provides enough of this vitamin for daily requirements (Nutritiondata 2014a). Fish can therefore form a valuable addition to the diet, especially when wild plants rich in vitamin A are less available, such as during winter months.

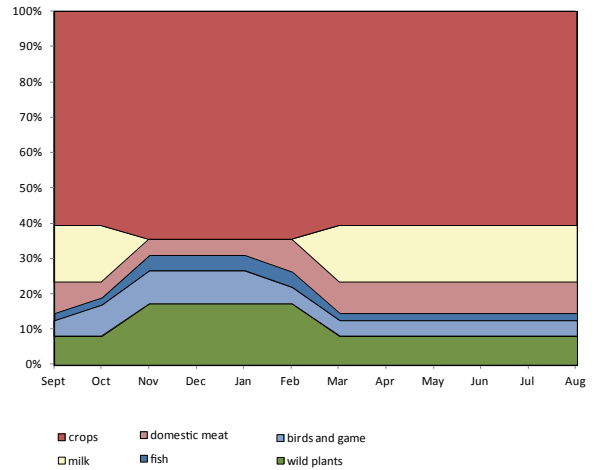


Figure 8.11. Monthly fluctuations in the available food groups in the Bronze Age diet based on a healthy, balanced dietary composition.

Vitamin C levels in freshwater fish vary widely, and only pike provides reasonable levels. Still, 200 g of raw pike can only provide around 13% of the recommended daily vitamin C intake (Nutritiondata 2014b), and is on its own not enough to acquire daily demands. Therefore, additional sources of vitamin C are still required to complete the diet.

Gregg's model revisited

As it is now clear that a diet based solely on calories does not necessarily reflect a healthy diet, the results of the adapted model presented by Gregg from Figure 8.8 were adjusted to incorporate the importance of each of her major available food groups to the diet based on health/well-being (Figure 8.11; Appendix A1.15).

In Figure 8.11, it is clear that wild plants, in combination with crops, meat, and sometimes milk, can be the main constant nutrient sources throughout the year. Important to note is that the collection of only nuts and fruits in autumn will not have been sufficient to provide people with their daily requirement of vitamin A and C. In periods of the year in which wild plant greens or fruits are lacking, roots can be consumed (although more grams are required) in combination with (smoked) fish, to meet vitamin demands.

Summarizing, the use of wild plants and animals (especially fish) will have been essential to the diet and well-being of Bronze Age farmers. Relying solely on what can be produced by the settlement will have resulted in severe deficiencies, ultimately leading to death. Of course, people will not have been aware of micronutrient levels in their diets in the manner that is possible today. However, through a combination of cause-and-effect reasoning and thousands of years of knowledge of wild plant use in their ancestry, they will have realised the importance of a varied diet, which included wild resources.

Ultimately, rather than using the term “optimal farming” for the farming practices described by Gregg, the Bronze Age subsistence should be seen as adaptable farming, with people adapting to the availability and abundance of necessary resources, both domestic and wild.

8.3.1.4 Physical anthropology

Bronze Age West Frisian farmers had access to a wide variety of food resources which could have ensured their health based on both calories and micro-nutrients. However, it is still unknown whether people were actually capable of doing so during this time. Therefore, with the aid of physical anthropology, the general health level of Bronze Age people was researched, including possible evidence for nutritional deficiencies.

Prehistoric nutrition: deficiencies

One of the assumptions made in the FAO/WHO report is that people are able to meet their nutritional demand, if, and when they have access to sufficient quantity and variety of resources. If this is not possible, for whatever reason, deficiencies might still arise and leave marks on bones of people. Examples of micronutrient deficiencies in the north-west European Bronze Age were sought in the literature, to assess the probability of a deficient diet during this time period. In addition, several West Frisian skeletons were analysed to assess the local situation.

General health in Bronze Age north-western Europe

General health of past people can be identified by several types of marks on the skeleton. These include porous bone in the top of the eye sockets (*i.e. cribra*

orbitalia), growth arrest lines in femur or tibia (*i.e. Harris lines*), enamel formation arrest lines (*i.e. enamel hypoplasia*), dental caries, and stature (*i.e. length of an individual*) (Tornberg 2013, 9 and references therein). Only a few studies on general health of late prehistoric people exist for the area of north-western Europe. A study in Sweden (Tornberg 2013) includes remains from the Nordic Late Neolithic/Early Bronze Age (2300-1100 BC), and one other study was performed in Denmark (Bennike 1985), encompassing only the Nordic Late Neolithic (2300-1700 BC). Finally, in Northern Germany, Bronze Age/pre-Roman Iron Age cremation burials (500 BC-100 BC) have been analysed for indications for general health as well (Hermanussen & Kühl 2006). Although the cultural time periods researched in Sweden and Denmark differ from the Dutch periods, these times in prehistory are roughly comparable to the Early Bronze Age and Middle Bronze Age in the northern Netherlands (cf. Chapter 9, section 9.4.1). The German study falls outside the Dutch Bronze Age, but will give indications for general health in the following period. Therefore, the data from these investigations into past health is used as an expectation for general health conditions during the Bronze Age in West Frisia.

In Sweden, the skeletal remains of 18 individuals could be analysed for direct and indirect indications for general health. Four different methods for examining general health were included in the study: dental health, nutritional deficiency, stature, and trauma (Tornberg 2013, 9). The results of the study seem to indicate a good general health pattern. Prevalence of dental caries indicate a high consumption of cereal, which can be seen as evidence for a stable diet. Furthermore, the prevalence of bone deformations which can be linked to nutritional deficiencies is low, both in adults and children (Tornberg 2013, 13). The adult values of nutritional deficiency in Sweden are comparable to the values found in Danish skeletal remains from the Late Neolithic (Bennike 1985). Deficiencies in the child skeletal material are represented less in the Swedish material, however, indicating either lower prevalence of such conditions, or death before recognisable aberrant bone deformation can occur. The reconstructed stature of both Swedish and Danish skeletal material yielded heights comparable to present day populations, which

are abnormally high for prehistory (Tornberg 2013: 14, Table III, and references therein). Especially the stature of the Swedish material (1.77 m for males and 1.66 m for females) seems to indicate very good living conditions and general health during the Late Neolithic (which is during the same time horizon as the West Frisian Early Bronze Age). Finally, there were few traumas recorded in the Swedish material, and they generally showed signs of healing, meaning that general health, in combination with care by others, must have been sufficient enough to survive the trauma for a considerable period of time. So, the general health of people living in these farming communities was good enough to limit the chance at deficiencies, and to heal adequately after suffering trauma.

Another research into general health was, as said performed by Hermanussen and Kühl (2006). In this study, 11 adolescent individuals from a Bronze Age and pre-Roman Iron Age cremation site from Northern Germany were examined for growth characteristics. Evenly spaced growth arrest lines (*i.e.* Harris lines) indicate a probability of an annual growth stop in these individuals, possibly linked to environmental conditions (Hermanussen & Kühl 2006, 22), which may include diet (Gunnell *et al.* 1998). It is interesting to postulate whether this growth arrest may have been the result of nutrient or calorie deficiency during winter months.

General health in Bronze Age the Netherlands

A few Dutch examples of general health in the Bronze Age also exist. In Wassenaar, a mass grave was uncovered (Smits & Maat 1993), which provided some information on health in the Early-Middle Bronze Age in the Netherlands. The average adult male stature was 1.75 m, with one 18 year old person even measuring 1.82 m (Smits & Maat 1993, 23). At Meteren-De Bogen, one person's stature was also reconstructed to 1.74 m (Robb 2002, 680). These statures are very high and indicate good general health (Smits & Maat 1993, 24). Female dental information showed that their teeth had a higher attrition rate than those of males, possibly linked to female activity involving the teeth, or grittier food consumed (Smits & Maat 1993, 24).

Specific evidence for nutrient deficiencies

Not all micronutrient deficiencies common in cereal

based staple diets are reflected in skeletal material. Of the critical micronutrients, only vitamin C and iron deficiency can be recognized. Vitamin C deficiency can cause internal lesions which can provoke a response in bone tissue when haemorrhaging occurs close to the skeleton. Iron deficiency causes anaemia, which in turn causes porous lesions in the upper part of the eye-sockets. However, it must be kept in mind that anaemia can also be the result of the body's defence against pathogens, so that it can also signify infection rather than iron deficiency. Evidence for both conditions are found in the Early Bronze Age.

Vitamin C deficiency (scurvy)

In Britain, an Early Bronze Age round barrow (2200-1970 cal BC) yielded, amongst others, a child which portrayed likely signs of vitamin C deficiency, or scurvy (Mays 2008). The combination of pathological indications present in this child led to the postulation that scurvy was the most likely cause, making this the earliest example from Britain. Overall however, scurvy seems to be a rare condition in prehistoric in north-western Europe, based on a survey of 123 skeletons of sub-adults from early Britain (Mays 2008, 185). This means that generally, people were able to obtain enough vitamin C in their diet during this time period.

Iron deficiency

Evidence of wide-spread iron deficiency exists in Ireland in the Early Bronze Age (Mount 2012). Here, skeletal material of all age categories from a dozen Early Bronze Age cemeteries all seem to reflect either poor adaptation to the environment or nutritional stress. However, Mount states that these possible explanations are unlikely in this area, since archaeological evidence indicates well-adapted societies that did not over-exploit their surroundings. Instead, he postulates that people were suffering *en masse* from infection. During infection, iron is stored in the liver, which can also result in anaemia. Mount suggests that a disease such as malaria may have been the cause of the wide-spread anaemia, forming the main threat to the Irish population during this time. Both the location (near water) and climate (1-2°C warmer than today) in Ireland in the Early Bronze Age were very accommodating to malaria mosquitoes, which were also still recorded in Ireland up until the 19th century.

What has become apparent from the above examples is that Bronze Age people will surely have experienced times of nutrient scarcity in their diet, possibly annually. However, overall, they seem to have possessed a good enough general health standard without major deficiencies in vitamin C and iron in their diet. It can therefore be assumed that people were usually able to obtain enough critical micronutrients, which is most easily achieved by consuming wild plants.

General health in Bronze Age West Frisia

Zwaagdijk

The site Zwaagdijk yielded three Bronze Age skeletons (Modderman 1964) from which general health information could be obtained (Veselka 2015). The stature of West Frisian people could be calculated based on two of these skeletons (skeleton 1 and 2) from Zwaagdijk: the female adult size was 1.60 m and the adult male size was 1.68 m, which in general indicates healthy growth unhindered by malnourishment or disease, both of which may have occurred periodically (Veselka 2015, 26-7).

Both skeleton 1 and 2 also showed conditions, including amongst others several dental pathologies, and indications for hard labour based on pronounced muscle attachments on bones.

The pronounced muscle attachments of the arms of the female skeleton (skeleton 1) indicate repetitive heavy labour with the arms such as sewing, weaving, washing (Veselka 2015, 26). Although an exact activity could not be linked to this pathology, it can be expected that perhaps grinding grain may be a possible cause as well, since this is a very laborious task consisting of similar arm movements (pers. comm. B. Veselka).

The skeleton belonging to a male (skeleton 2) showed healed double fractures of both of the underarms, indicating that general health and care was good (Veselka 2015). The muscle attachments in this individual were also very pronounced, but at different locations than in the female skeleton 1. The combination of his muscle attachment pathologies indicates heavy and powerful labour with the arms and legs probably in the form of frequently moving or lifting heavy objects. In addition, multiple joints

showed signs of osteoarthritis, indicating that they were worn by performance of heavy labour as well (Veselka 2015, 26).

The difference in bones and muscle attachment pathologies between these two individuals of opposite sex could, even though the sample is very small, possibly be linked to different activities being performed by men and women at the settlement (Veselka 2015, 36).

The third skeleton, skeleton 5, belonged to a child, which suffered from several conditions. This child experienced periods of malnutrition which resulted in growth retardation; maxillary sinusitis possibly due to bad ventilation indoors, exposure to smoke, or pneumonia; and rickets, due to vitamin D deficiency (Veselka 2015, 26). All these pathologies may have been interrelated or reinforced by each other.

Two of the three skeletons finally (skeleton 1 and 3), showed healed porotic lesions of the eye-socket or skull: *cribra orbitalia* and *cribra cranii*, respectively. In northern European mixed farming populations, these pathologies can be related to general absence of certain nutrients or to chronic infection (Walker *et al.* 2009, 120). The fact that the lesions healed does however show that periods of nutrient deficiencies or infection were overcome, again indicating good general health.

Drechterland N23

In Drechterland, recent rescue excavations prior to the construction of new road, (N23), several Bronze Age skeletons were uncovered. First, a skeleton belonging to a female was found, which was researched on general health characteristics (Pijpelink 2015a). The reconstructed stature of this individual was 1.61 m, indicating a good health standard. The only pathological indication found in this individual was *cribra orbitalia*, again indicating periods of insufficient nutrient intake, or exposure to chronic infection.

A further four skeletons were uncovered in the remains of a barrow mound, which had been disturbed in the past by building activities. These

four individuals (an adult man, two adult women, and a child) were also investigated on general health characteristics (Pijpelink 2015b). The height of the adult individuals ranged from 1.65 m-1.76 m, with the former height belonging to the two women, and the latter to the man. These heights, especially that of the male individual, indicate good general health. However, all individuals exhibited signs of osteoarthritis in the neck and back, related to the loss of cartilage between joints due to hard labour. Further pathological indications are the loss of dental elements, and severe wear on the teeth. Only the child exhibited *cribra orbitalia*, which may be related to specific nutrient deficiency or prolonged exposure to infection.

Markerwaardweg N23

Another Bronze Age skeleton was found at a different location during the rescue excavations related to the construction of the N23 road (see above). This skeleton was found face-down in a pit, and belonged to a male (van Spelde 2015). The individual had a height of around 1.70 m and possessed healed fractures, both again indicating that the general health standard was good. The bones did, however, show several signs of disease and trauma. The teeth were worn, and *dental hypoplasia* was established, which indicates periodic exposure to disease or malnutrition during early childhood. Osteoarthritis was also present, indicating worn joints due to hard labour. Mild signs of *cribra orbitalia* finally, indicate that this individual suffered from either nutrient deficiency or chronic infection in his life.

Overall, (specific) elaborate dietary deficiencies were not observed in West Frisian skeletons, and the general health of people was good. The child from Zwaagdijk had vitamin D deficiency, but this vitamin is best obtained through exposure to direct sunlight, and only to a lesser degree by consuming fatty fish such as eel or salmon. The fact that this child had multiple health conditions may have resulted in the child being kept inside, resulting in the vitamin D deficiency from lack of sunlight, not necessarily from lack of an appropriate diet.

The presence of *cribra orbitalia* or *cribra cranii* in many skeletons indicates that either nutritional deficiencies of vitamin C in the diet or chronic infection may have formed a serious problem during the Bronze Age. However, because the overall health of people was good based on stature and ability to heal from trauma, and no clear consistent malnourishment could be established, severe vitamin C deficiency is unlikely. Therefore, chronic infection may very well have been the main cause of the observed lesions. Similar to the EBA in Ireland, malaria may have formed a major threat to Bronze Age West Frisians, since the environment in West Frisia was equally suitable for the prevalence of this disease as in Ireland during this time. Further research is required to confirm this possibility, for example by identification of either the parasite (*Plasmodium*) or the host (*Anopheles* mosquitoes) causing malaria (Morgan-Forster 2010).

8.3.2 Clothing

Clothing is another basic necessity, and indications for potential sources of raw material for clothing have already been briefly discussed in Chapter 4-7. These results are summarized here to provide an overview of the clothing possibilities of Bronze Age West Frisians.

Sources of raw material for clothing in West Frisia

Several types of raw material would have been available to Bronze Age people in West Frisia, of both plant and animal origin. In Chapter 4, it became clear that a range of wild mammals was hunted, among which were many fur-bearing animals, or animals providing good hides (Chapter 4, Table 4.6). Observations of skinning marks on bones (Chapter 4, section 4.4.5.4) indicate that skins of animals were, at least in some cases, carefully removed to process them further, possibly also into clothing.

Chapter 5 showed that domestic animal species were exploited for multiple purposes (Chapter 5, sections 5.4.3 and 5.4.4). Domestic animal remains were frequently uncovered with slaughter marks,

indicating that the animals were fully processed after death. After slaughter, the hide of the cattle and pig would be available to process into sturdy leather, whereas sheep and goat skin would turn into a more supple form. Sheep could also have been exploited for their wool in West Frisia, even though no specific preference for this use could be observed (Chapter 5, section 5.4.4). The type of sheep kept in West Frisia (Appendix A1.5) does, however, have the potential to produce very fine wool, an example of which was observed in the province of Drenthe, in north-eastern the Netherlands, where these sheep possibly originate from. Here, balls of yarn and woollen garments were found, with high fibre quality (Appendix A1.5).

Examples for both domestic and wild animal skin use, as well as woollen garments in the Bronze Age, some of which are presented here, derive from several locations in Europe, and even from the Netherlands. For instance, in Hallstatt, Austria, several Bronze Age skins of domestic and wild animal species including cattle, goat and sheep, chamois (*i.e.* wild goat-antelope), ibex, dog or other small fur-bearing animals were uncovered in the salt mines (Ryder 1993: 107), as well as many intricate Bronze Age woven woollen textiles (Grömer *et al.* 2013); in Denmark, cattle skins have been uncovered as wrappings of the dead in grave contexts, as well as woollen garments, such as in the case of the Egtved girl (Hvass 2000); and in the province of Drenthe, in the north-east of the Netherlands, the Emmer-Erfscheiden bog body wore clothing consisting of a combination of domestic sheep and cattle hides, but also deerskin, and a woven woollen garment (Vons-Comis 1990). Apparently, a combination of wild and domestic animal skins as well as wool formed the major animal sources of raw material for the construction of clothing in the Bronze Age (Nyegaard 1983, 102).

Chapter 6 provided a possible source of raw material for creating clothing, which may have been cultivated specifically for this reason. The seeds of flax (*Linum usitatissimum*) uncovered at Bovenkarspel, Enkhuizen, Westwoud, and Hoogkarspel Watertoren, although few in number due to being possibly highly affected by

taphonomical processes (Chapter 6, section 6.4.8.2) suggest that this plant may have been cultivated, possibly also for the production of fibres for the construction of linen clothing.

Finally, Chapter 7 yielded indirect information on the wild plants which may have been used as raw material for clothing (Chapter 7, section 7.4.6.4), including stinging nettle and ribwort plantain (*Plantago lanceolata*). Furthermore, tannin-containing trees and plants were found and this substance would have been used to process animal skins into leather.

Examples of Bronze Age textile finds constructed from plant fibres are scarce, because preservation and recognition of these remains are rare and difficult. However, the Bronze Age nettle textile uncovered in Denmark exemplifies the use of plant fibres for textile production during this time (Bergfjord *et al.* 2012).

To summarize, a wide variety of skins and fibres were available during the Bronze Age for the production of clothing, and many different types of hides and textiles appear to have been used alongside each other to complete sets of garments. Unfortunately, the differential preservation conditions of garments constructed from either animal or plant origin (*i.e.* plant remains under alkaline conditions, animal remains under slightly acidic conditions: Good 2001, 211), means that combinations of garments constructed from these two types of fibre are rarely uncovered together.

Indications for clothing manufacture in West Frisia

Direct finds related to the processing of fibres, presumably for the production of textile, were found at several sites in West Frisia, including spindle whorls (*e.g.* Roessingh & Lohof 2011, 182). Loom weights however, have not been uncovered. Other direct finds, which can be related to the processing of animal skins include scrapers, awls, and needles (*e.g.* IJzereef 1981: 132, 140; Groot 2010a, 96; Veldhuis 2010, 76; Roessingh & Lohof 2011, 235; Zeiler & Brinkhuizen 2011, 212-4).



Figure 8.12. Clothing types in the Bronze Age of north-western Europe; Emmer-Erforscheiden bog body (left; from: van der Sanden 1996, 148, Fig. 205, ©Kevin Wilson); Egtved girl (right; adapted from: Anthropark 2009).

Clothing in West Frisia

Although no direct finds of textiles have (yet) been uncovered in West Frisia, the above examples of raw material types for clothing available here shows that a range of clothing types must have been present. Contemporary Bronze Age garments from the north-eastern part of the Netherlands and Denmark are shown in Figure 8.11 to give an impression of the possible range of clothing types present in West Frisia. However, since clothing is one of the most direct manners to convey identity (Valentijn in prep.), the actual West Frisian clothes will most likely have not been identical to those shown in Figure 8.12.

In order to attempt to identify the possible local appearance of clothing in West Frisia, the available colour palette for dyeing was summarized in Figure 8.13 based on the wild plant species known to have been used to dye textiles uncovered in West Frisian house contexts.

It becomes apparent from Figure 8.13 that many different colours were available for dyeing textiles in the Bronze Age. In turn, many colours could be obtained from multiple plant species, and no doubt a range of different hues could be created of each colour. Whether all colours were actually lightfast (*i.e.* resistant to change in colour when exposed to

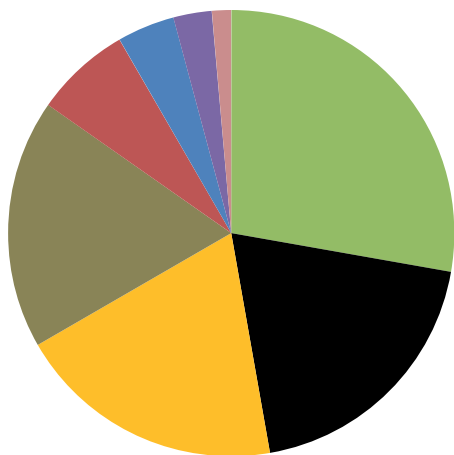


Figure 8.13. Colour palette available to Bronze Age West Frisians based on the frequency of uncovered wild dye plant species from house contexts.

light) and/or colourfast (*i.e.* resistant to change in colour when washed or exposed to weather conditions) is unknown, but repeated dyeing would have ensured coloured fabrics nonetheless. Dyed textiles are known from contemporary areas including the north-eastern Netherlands (Geimer in prep.; Joosten & van Bommel 2015) and Hallstatt (Joosten *et al.* 2006), reinforcing the idea that dyeing of textiles may very well have occurred in West Frisia as well.

8.3.3 Shelter

The third basic necessity of life which is discussed here is shelter. In the Bronze Age in general, shelter is of course provided by the house, which is no different for Bronze Age West Frisia. Scale models and actual reconstructions of West Frisian Middle Bronze Age houses have been made (*e.g.* Figure 8.14 and Figure 8.15), which provide an idea of the (relative) dimensions and possible appearance of such buildings. What is lacking from these reconstructions, and of countless many more prehistoric dwellings, however, is that the inside of the house is always portrayed as being empty. It is unclear why this is the case, since numerous finds of furniture, household supplies, tools, and equipment have been discovered which provide an insight into prehistoric life. Perhaps not every individual site has directly yielded all the objects related to daily life, but information on what must at least have been present in and around the house can be reconstructed nonetheless.

This reconstruction can be based on several lines of evidence, including creating an expectation of required objects based on known activities taking place around the house and the settlement, and by researching finds from other sites to prove that the knowledge for their construction existed during this time. By extrapolating finds from other, contemporary sites to the site discussed, the inside of the house can be tentatively decorated. Of course, many aspects of the house will still remain unknown, but by at least attempting to investigate the objects which may have been present, new ideas about daily life in prehistory can be generated, simultaneously alleviating the negative or degenerative thinking about prehistoric people. When these people were able to construct everything required for their subsistence out of raw material, why would furniture and decoration be an obstacle? Surely, people will not have sat on the floor in an open-plan house with nothing but a few pots and beams to hold and secure their belongings?

In the following few sections, an attempt is made to find evidence for what the inside of a Middle Bronze Age West Frisian house may have looked like, based on expected objects, objects from other Bronze Age sites, and finds from West Frisia. These three sources of information are employed and combined to ultimately show a science-based artist impression of the inside of the West Frisian Bronze Age house.

Expectation of required objects for daily life

The expectation of required objects was created by first summarizing the basic activities occurring in and around the settlement. For each of these activities, it was established which tools would be required to accomplish the task. Although the resulting list may be far from complete, it shows many tools which could be expected on the settlement, and in and around the house (Table 8.6).

Finds known from other Bronze Age sites

Many objects which were expected to be necessary for daily life were also uncovered at many Bronze Age sites throughout the Netherlands and north-western Europe. Some examples of these finds were indicated in Table 8.6 in bold and are presented here. For each aspect related to subsistence, pictures are shown of the finds, as well as where they were uncovered.



Figure 8.14. Scale model of a West Frisian Bronze Age house.



Figure 8.15. Life-size reconstruction of a West Frisian Bronze Age house (from: Bronstijdboerderij 2013).

Table 8.6. List of required basic tools for daily life in prehistory

	Tools	Equipment	Furniture
1. Diet			
1.1 Hunting	knife stick	net, weir, trap , spear, sling, bow and arrow , hook, etc.	
1.2 Animal husbandry	knife cheese strainer shearing tool?	rope halter bit and bridle milking container (bucket?)	
1.3 Crop husbandry	sickle digging stick, hoe pestle/mortar pounding tool sieves, winnows, baskets quern	plough/ard yoke	
1.4 Wild plant gathering	basket digging stick knife		
1.5 Consumption	pot whisk plate, cup, ladle, bowl		hearth
2. Clothing	carding/combining tool spindle whorl needle awl scraper	loom and related objects	loom stool
3. Shelter	axe chisel hammer		benches/ chairs beds (and bedding) stools shelves hearth hooks
4. General	rope containers (wood, ceramic, baskets) fire making tools shovel boat cart sweep/besom ladder		

Objects in bold were found during the excavation of various Bronze Age settlements throughout the Netherlands and Europe and are discussed below. Other objects, not indicated in bold, may also have been found, but are not further included in the discussion.

1. DIET

1.1 Hunting



Figure 8.16. Fish weir from Must Farm, Peterborough, England (from: Must Farm n.d.).

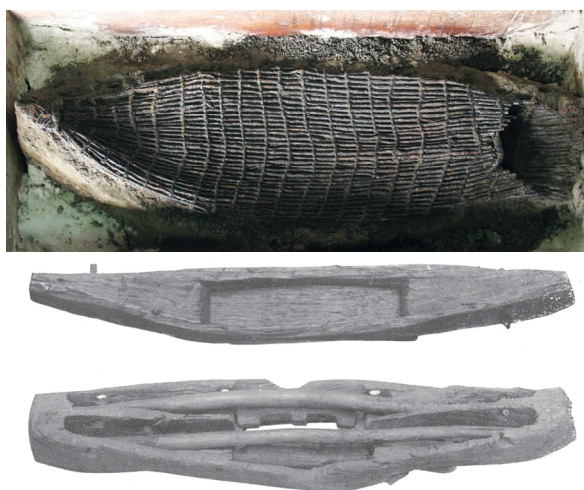


Figure 8.17. Traps. Above: fish fyke from Enkhuizen Kadijken, West Frisia, the Netherlands (from: Roessingh & Lohof 2011); below: tread traps from Hinge and Nisset Nørremose, Jutland, Denmark (from: Clark 1966, plate I).

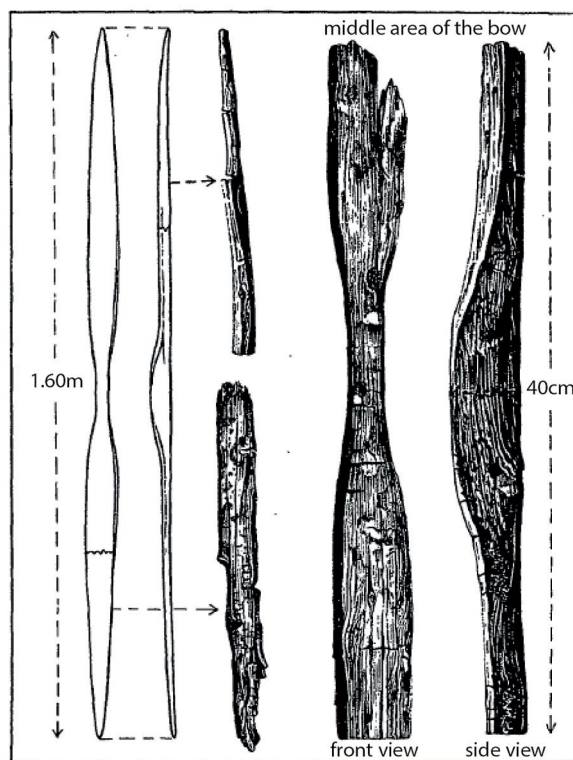


Figure 8.18. Bow from Noordwijkerhout - De Zilk, Noordwijk, the Netherlands (adapted from: van der Wal 1952) and arrowheads from West Frisia.

1.2 Animal husbandry



Figure 8.19. Cheese strainer from Zwaagdijk-Oost, West Frisia, the Netherlands.



Figure 8.21. Horse bridle-bit from Sigmaringen, Baden-Württemberg, Germany (from: British Museum 2016a).

1.3 and 1.4 Crop husbandry and wild plant gathering



Figure 8.20. Halter made from rope to restrain cattle from Siggård, Jutland, Denmark (from: Kveiborg 2009).



Figure 8.22. Bronze and flint sickles from Heiloo, the Netherlands; sickle handle made from wood from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007).



Figure 8.23. Ard found in Donneruplund, Velje, Denmark (from: Denmark's history 2014).



Figure 8.24. Simple yoke found at Flag Fen, Peterborough, England (from: British Museum 2016c).

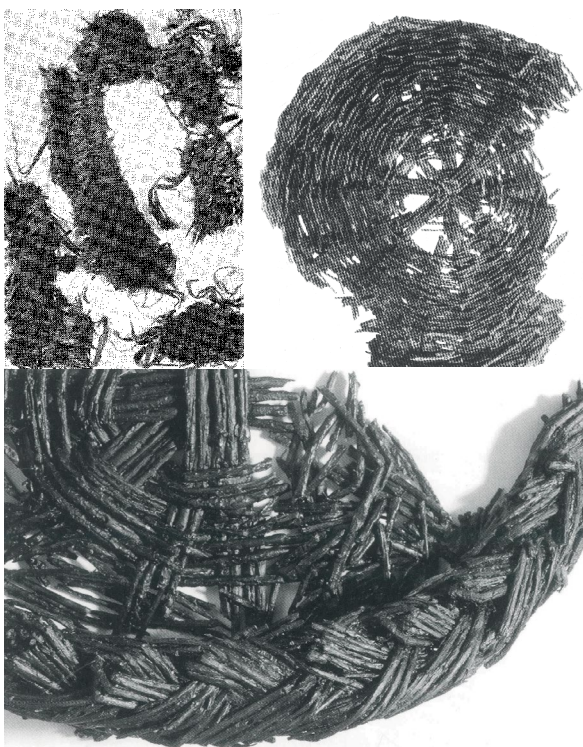


Figure 8.26. Hoe from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007).

To the left: Figure 8.25. Remains of basketry from Hoogkarspel, West Frisia, the Netherlands (top left; from: van Iterson Scholten 1977) and Hauterive Champréveyres, Switzerland (top right and below; adapted from: Pillonel 2007).

1.5 Consumption

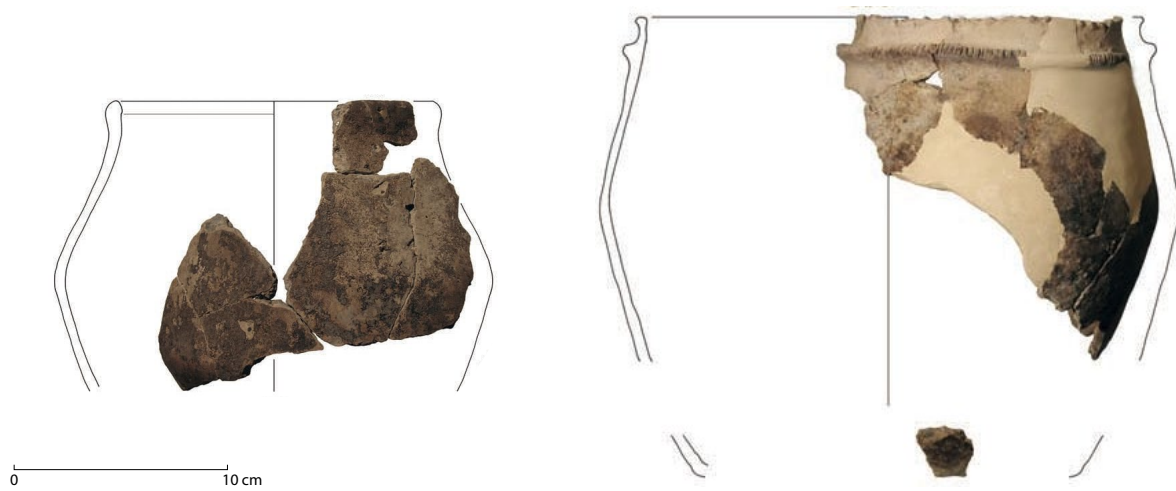


Figure 8.27. Examples of Bronze Age pots from Enkhuizen Kadijken, West Frisia, the Netherlands (adapted from: Roessingh & Lohof 2011: 164, 167).

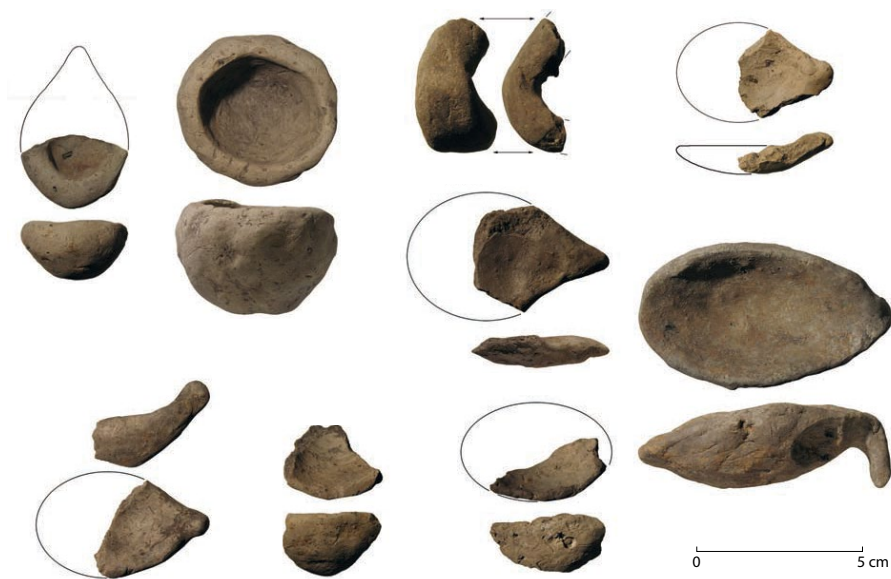


Figure 8.28. Small bowls and spoons from Enkhuizen Kadijken, West Frisia, the Netherlands (adapted from: Roessingh & Lohof 2011, 166).



Figure 8.29. Bowls from Enkhuizen Kadijken (adapted from: Roessingh & Lohof 2011: 165, 185).

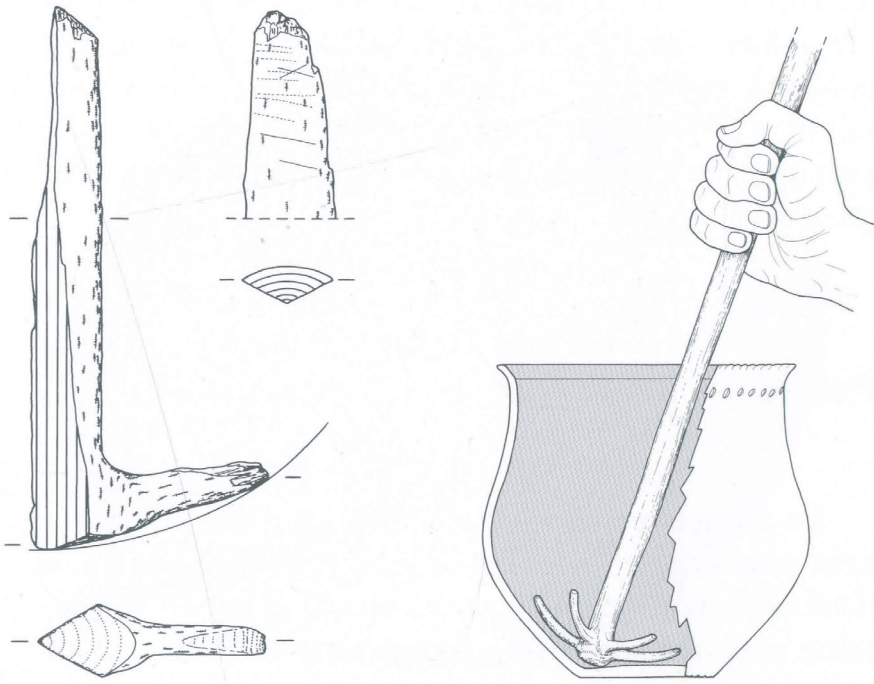


Figure 8.30. Remains of a whisk from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007).



Figure 8.31. Plate from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007).

2. CLOTHING

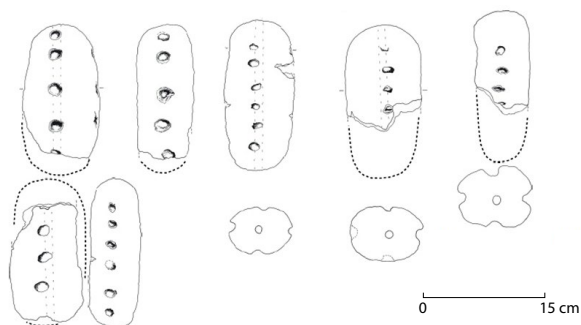


Figure 8.32. Loom weights made from loam from Zutphen Loërenk, the Netherlands (from: Fermin 2008, 232-33).



Figure 8.33. Awl and needle from Enkhuizen Kadijken (from: Roessingh & Lohof 2011, 213).



Figure 8.34. Spindle from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007) and spindle whorls from Enkhuizen Kadijken, West Frisia, the Netherlands (from: Roessingh & Lohof 2011, 163).

3. SHELTER



Figure 8.35. Wooden axe handle from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007) and bronze chisel from Westwoud, West Frisia, the Netherlands.



Figure 8.36. Wooden folding chairs. Left: folding chair from Guldhøj barrow, southern Jutland, Denmark (adapted from: Bullenwächter 2008); right: folding chair from northern Germany (from: Klapphocker 1950).

4. GENERAL



Figure 8.37. Pieces of rope found at Hoogkarspel (from: van Iterson Scholten 1977, 136).



Figure 8.38. Wooden container, lid, decorated rim of a container, and decorated containers from antler with wooden base from Hauterive-Champréveyres, Switzerland (from: Pillonel 2007).



Figure 8.39. Boat from Must Farm, England, United Kingdom (from: History blog 2012). Paddle probably used for maritime travel from Westwoud, West Frisia, the Netherlands (from: Ons West-Friesland 2015).



Figure 8.40. Shovel head made from moose antlers from Hoogkarspel Tolhuis, West Frisia, the Netherlands.

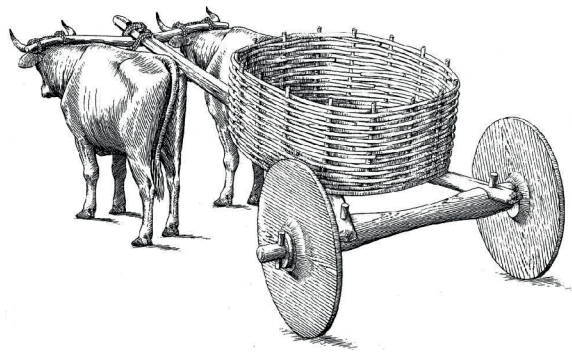


Figure 8.41. Two-wheeled cart from Bølling Sø, central Jutland, Denmark (Schovsbo 1987, 131).



Figure 8.42. Ladders. Left: ladder from Tiel-Medel, the Netherlands (van Hoof & Jongste 2005, 67); right: possible ladder from Enkhuizen Kadijken, West Frisia, the Netherlands (Roessingh & Lohof 2011, 252).



Figure 8.43. Decorated bone comb from Bovenkarspel Het Valkje, West Frisia, the Netherlands. Top left: photo of the actual uncovered part of the comb; bottom left: photo of the actual uncovered part of the comb with scratches highlighted by author; right: reconstruction of the complete comb (adapted from: IJzereef 1981, 139, fig. 86).

Science based artist impression of the inside of the West Frisian Middle Bronze Age house

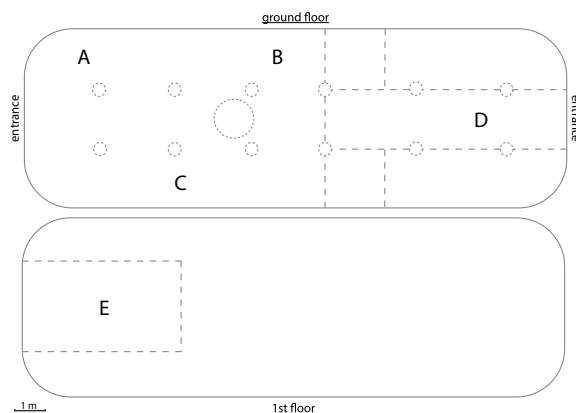


Figure 8.44. Top view of the inside of a West Frisian Middle Bronze Age house with first floor (above) and second floor, consisting of an attic (below). A: textile production area, due to favourable light conditions; B: cheese making area and storage of consumption related material due to cool conditions for cheese production in the northern part of the house; C: tool storage area and beds; D: barn, due to differences in house lay-out (Roessingh in prep.); E: attic with food storage, only in western side due to incompatibility with barn.

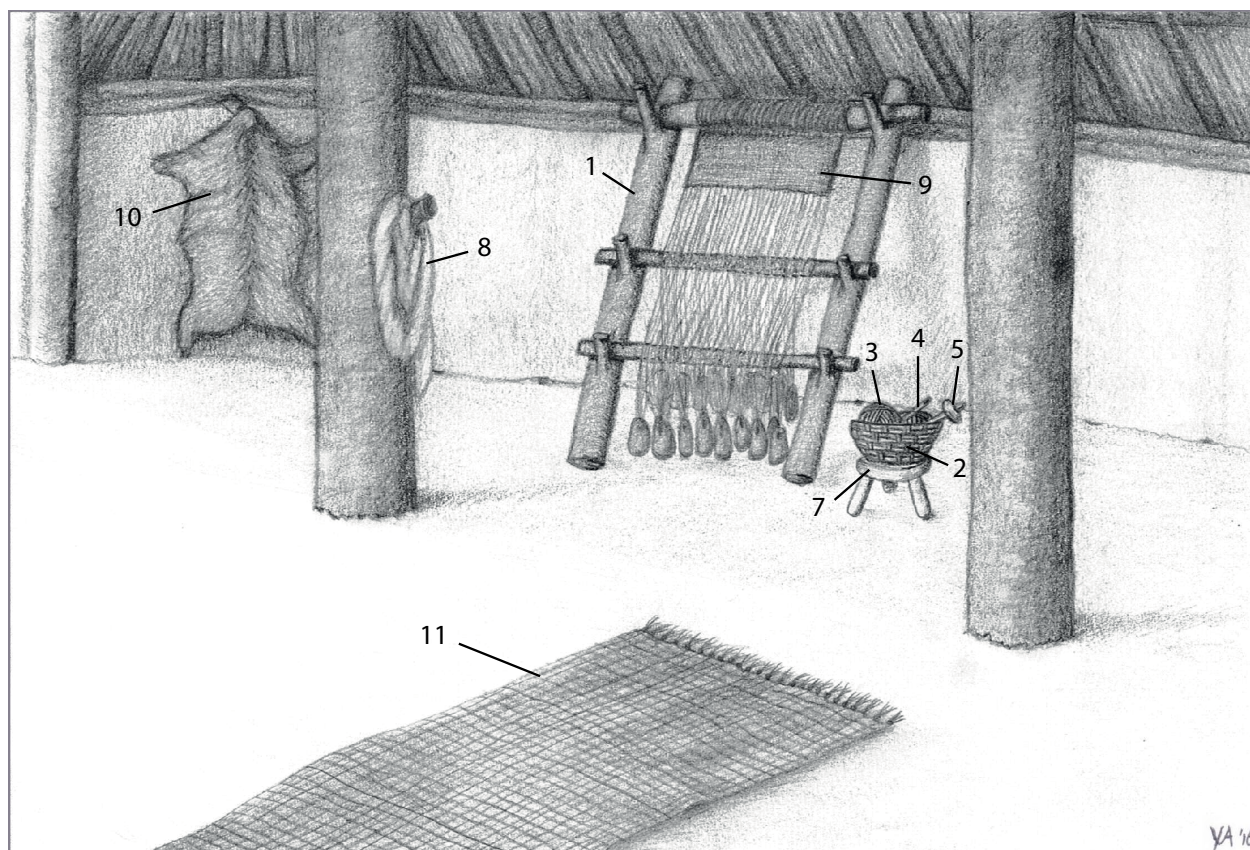


Figure 8.45. Textile production area. 1: warp-weighted loom; 2: basket; 3: ball of yarn; 4: needle; 5: spindle whorl; 6: loom weight; 7: stool; 8: carded wool; 9: linen; 10: hide; 11: mat.

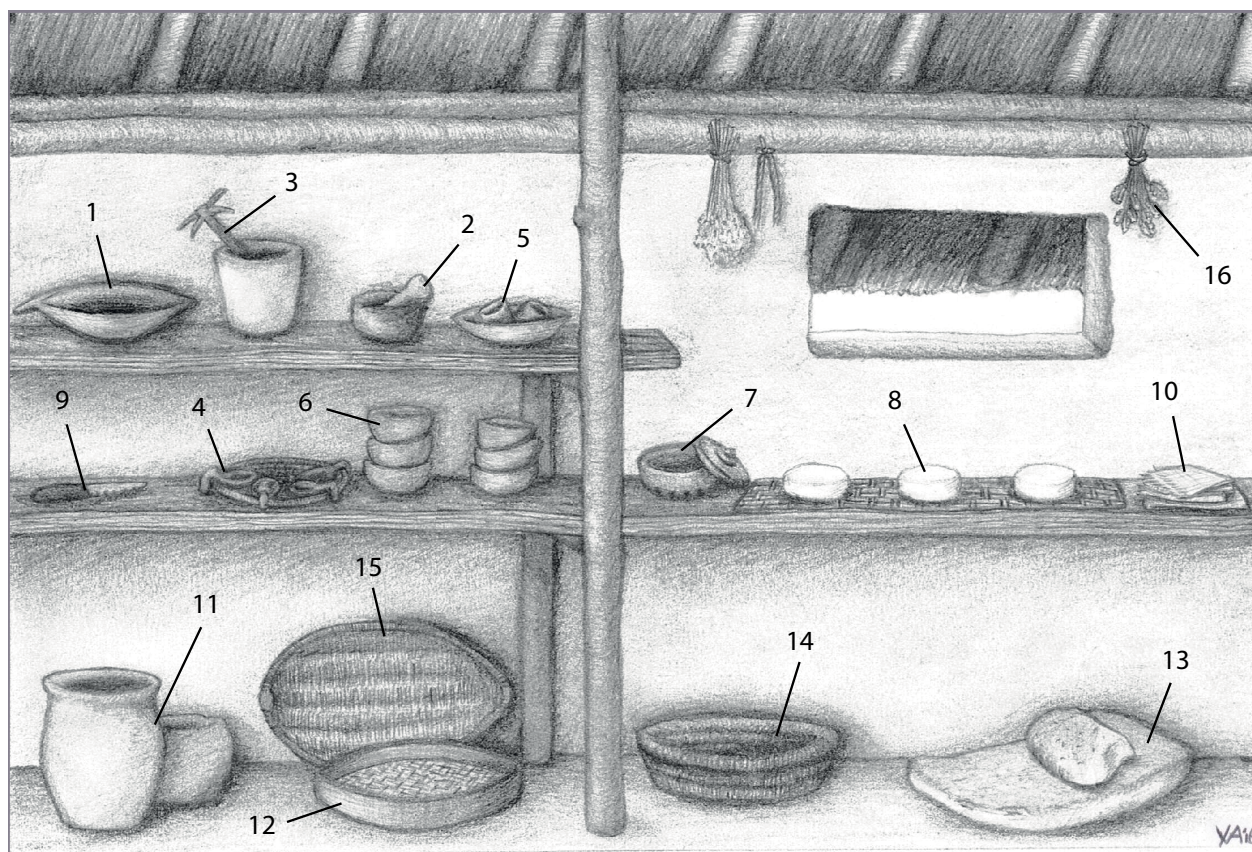


Figure 8.46. Cheese making area and storage of consumption related material. 1: bowl; 2: bone pestle; 3: whisk; 4: spoon; 5: miniature bowl; 6: ceramic container; 7: cheese strainer with lid; 8: cheese; 9: knife; 10: cheese cloth; 11: pot; 12: sieve; 13: quern; 14: basket; 15: winnowing basket; 16: dried herb.

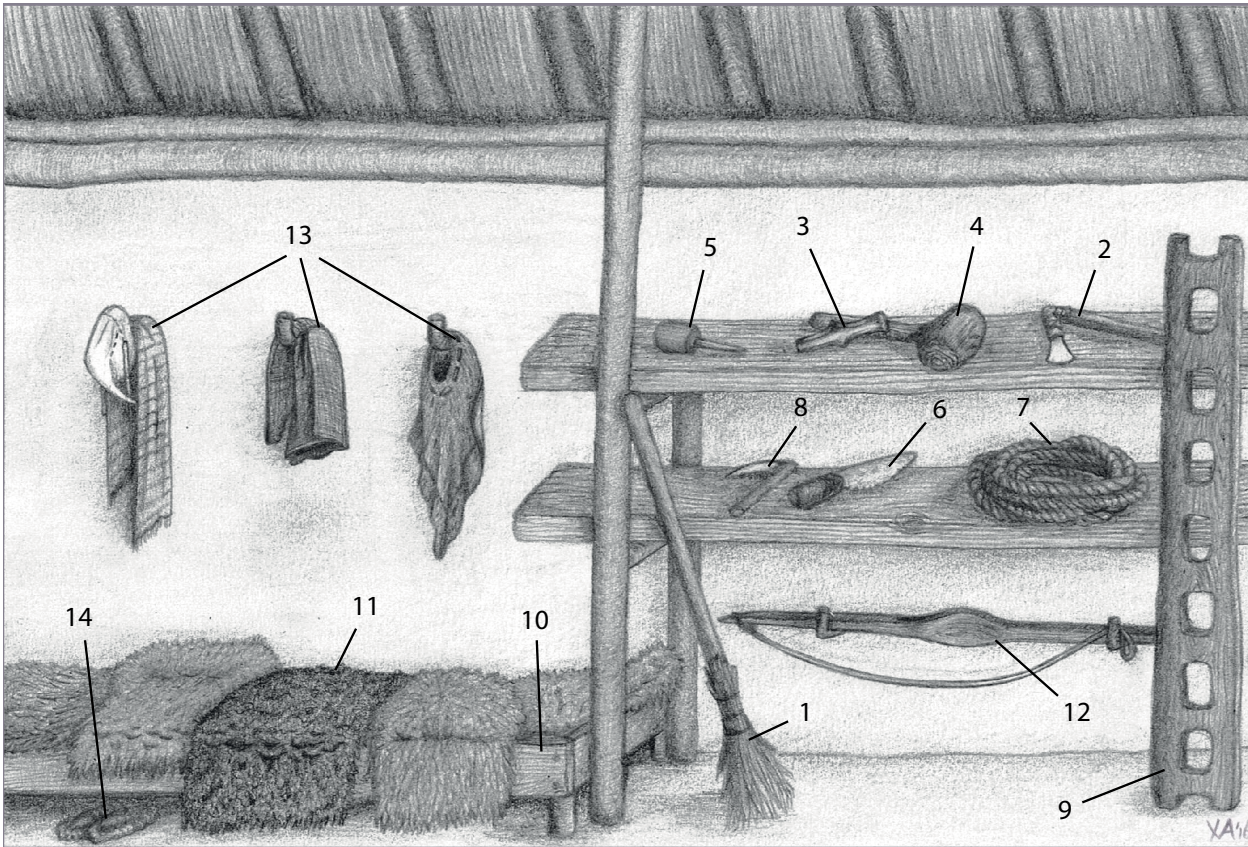


Figure 8.47. Tool storage area and beds. 1: broom; 2: axe; 3: chisel; 4: wooden hammer; 5: awl; 6: slaughter knife; 7: rope; 8: sickle; 9: ladder; 10: bed; 11: sheep skin; 12: wooden bow; 13: clothing; 14: shoes.

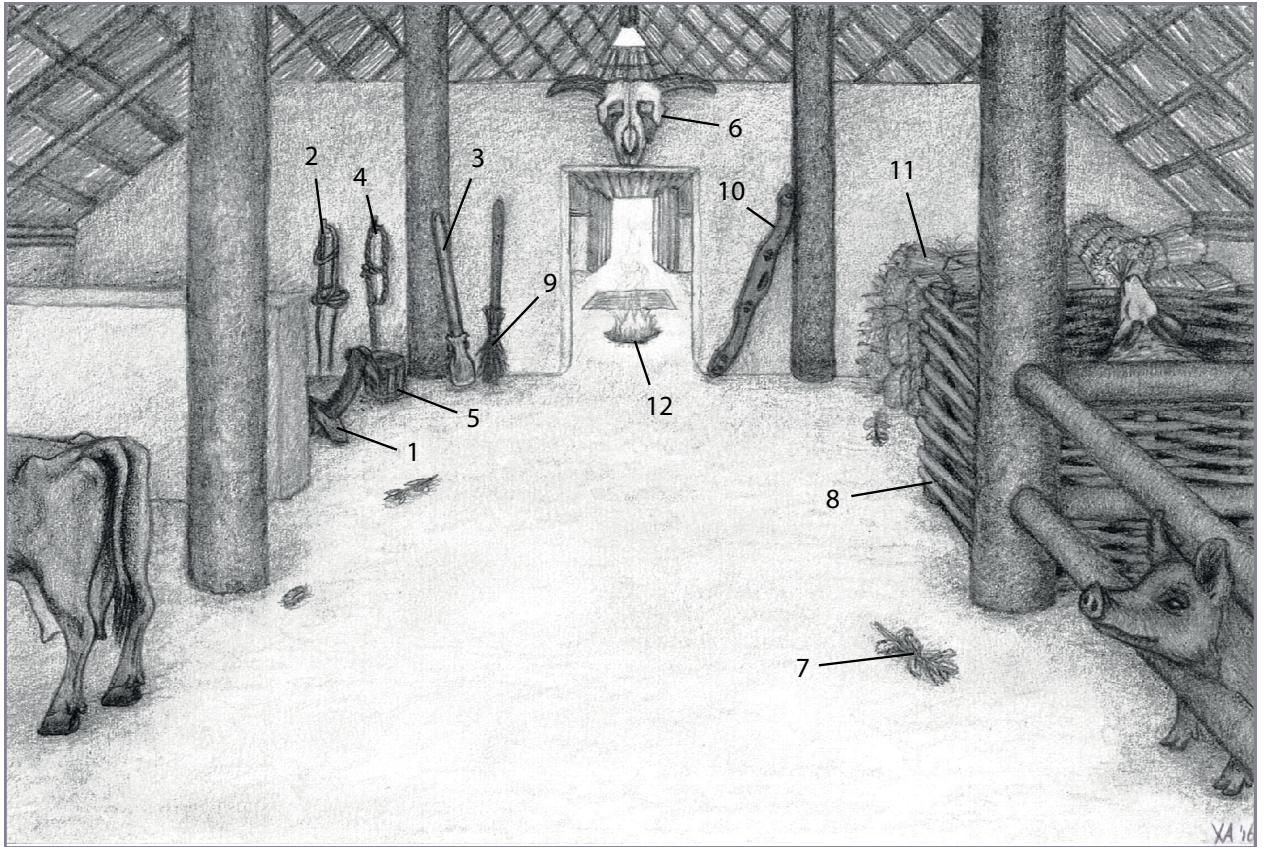


Figure 8.48. Barn. 1: ard; 2: bit and bridle; 3: shovel; 4: rope head gear 5: milking bucket; 6: cattle skull hung from leather straps (found in Tiel-Medel; Cavallo & van Groenesteijn 2005, 139); 7: repellent (see Chapter 7); 8: wattle pen; 9: broom; 10: yoke; 11: fodder; 12: hearth.

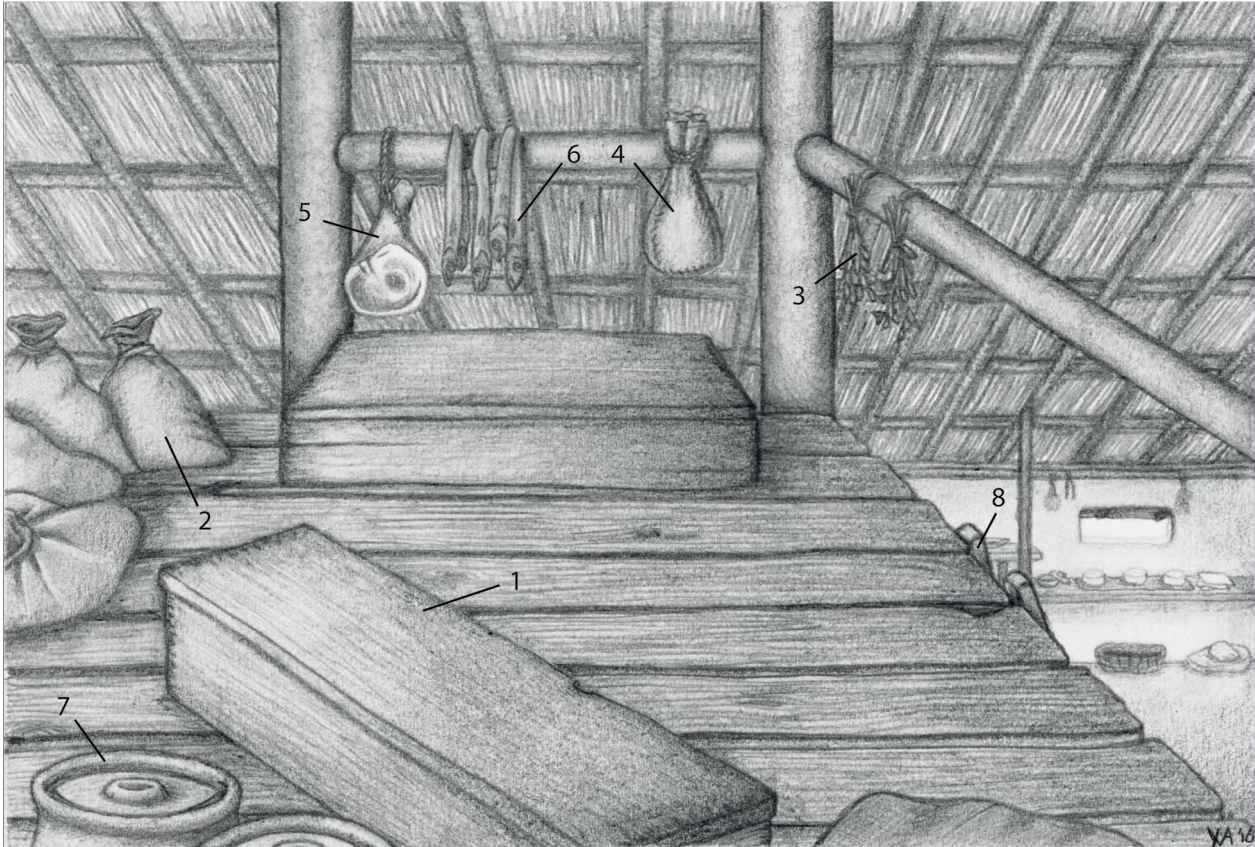


Figure 8.49. Attic with food storage. 1: wooden container; 2: linen sack; 3: dried herb; 4: leather bag; 5: dried meat; 6: dried fish; 7: ceramic container; 8: ladder.

8.4 RECONSTRUCTION OF ACTIVITIES RELATED TO SUBSISTENCE

In this third section, the research is focused on how the different activities related to subsistence were practiced throughout the year. Furthermore, besides synthesizing the seasonality data from Chapters 4-7, the relation of activities to the distance from the settlement is assessed (cf. Chapter 2 and this chapter, section 8.2.3), as well as the influence of a (changing) environment through time (cf. Chapter 2). The characterization of these activities includes both farming activities and activities related to wild resource exploitation, and both types of activities are researched for the Middle and the Late Bronze Age. This differentiation in two time periods is chosen to attempt to identify possible changes in activity related to the environmental changes that occur in the Late Bronze Age (cf. Chapter 2).

The resulting activity diagrams, or year cycles, provide clear insight into the work required in a farming system on an annual basis, the adaptability to environmental change, as well as the interconnectedness and complexity of a farming system that includes wild resource exploitation.

The year cycles produced in this chapter are comparable to the work of Clarke (1972; Figure 8.50). In his research, Clarke included activity, distance, landscape type, and climatic influence, thus capturing complex concepts related to subsistence in one image.

Activity practices in West Frisia are similarly summarized by combining the influence of the environment and the distance from the settlement with human activity, based on the conclusions of the previous chapters. A total of four cycles is constructed (Figures 8.51-8.54): one for each time period (MBA and LBA), for both domestic (crop and animal husbandry) and wild (hunting and gathering) resource exploitation.

In each of the circles for the MBA and LBA, the centre of the circle represents the settlement; the inner circle the arable fields; the middle circle the dry land areas (dry grasslands, dry forest); and the outer circle the wetland areas (wet grasslands, wet

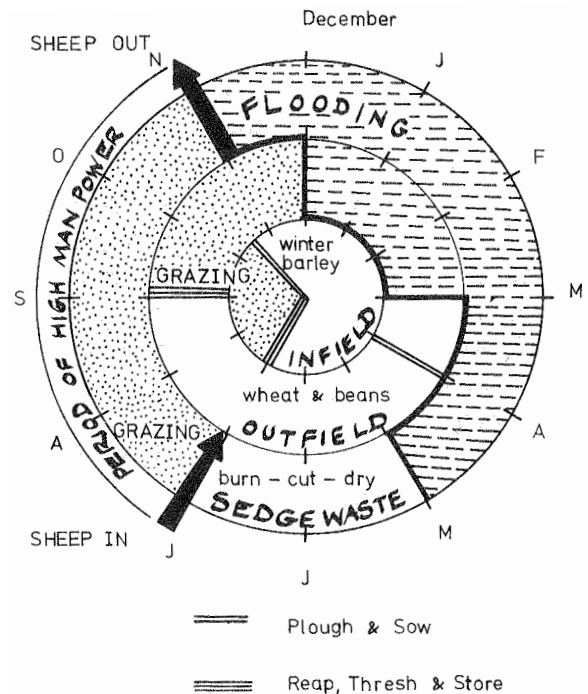


Figure 8.50. Year cycle of Iron Age subsistence (from: Clarke 1972, 856, fig. 21.10).

forest, waterside vegetation, cf. Appendix A1.2). In the overall cycles, arrows denote movement of livestock from areas where the arrow originates to the area where the arrowhead ends. Dashed lines are employed to indicate activities such as harvesting, manuring/ploughing, and sowing. Starting the year in September, the beginning of autumn, the year cycle is discussed separately for each period and resource exploitation type.

8.4.1 Middle Bronze Age

Autumn: domestic resources

In September, sheep, having grazed on both wet and dry land areas in the summer, would have been transferred to only dry land areas. In autumn, wetland areas would have become increasingly wet and an increasing risk for infectious diseases for the already susceptible sheep. Cattle, being more resilient to wet conditions, would have continued to graze on both dry and wet areas throughout autumn.

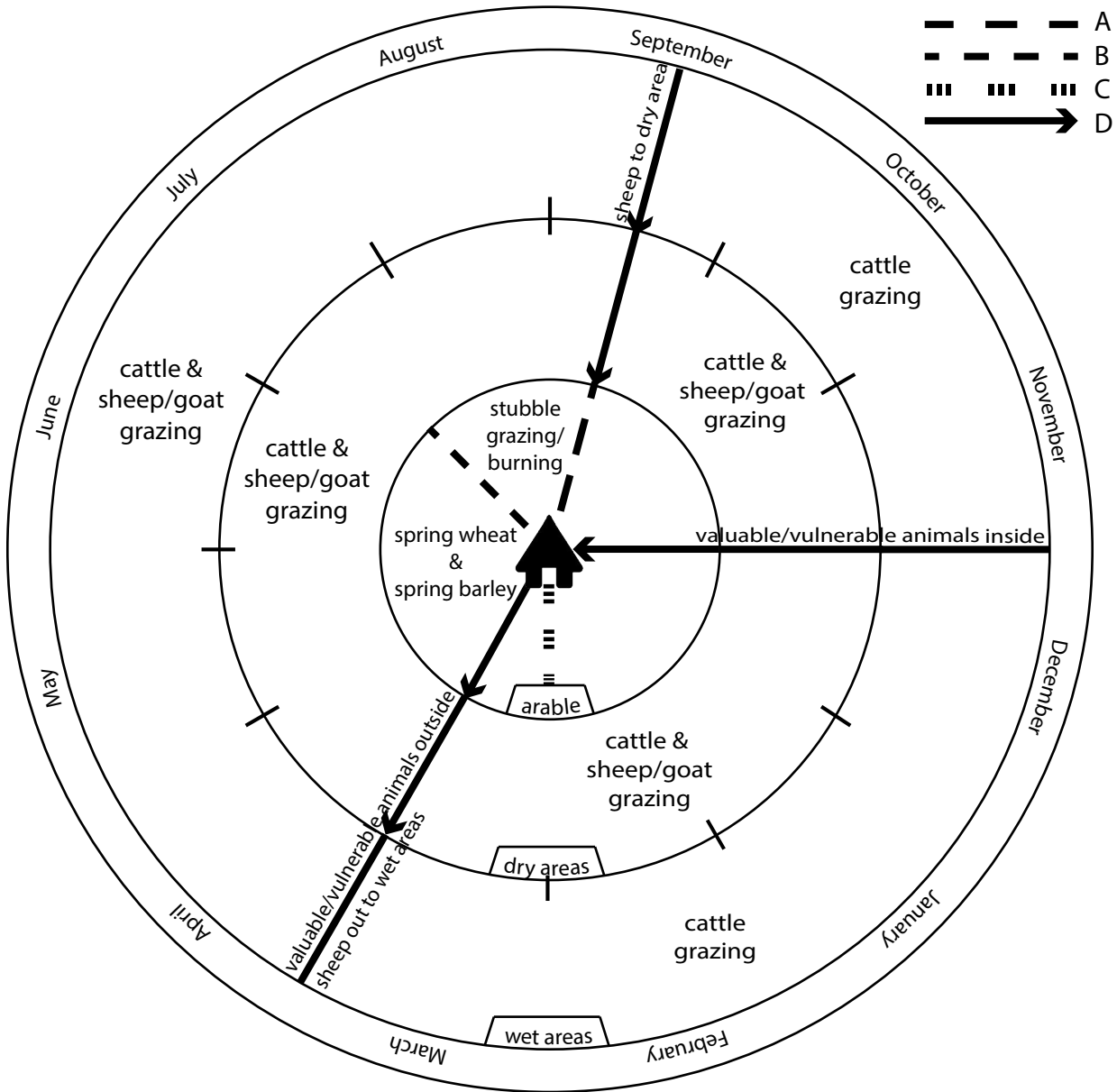


Figure 8.51. Middle Bronze activity year cycle for domestic resources (including crop and animal husbandry). A: harvesting; B: manuring/ploughing; C: ploughing/sowing; D: movement direction of livestock.

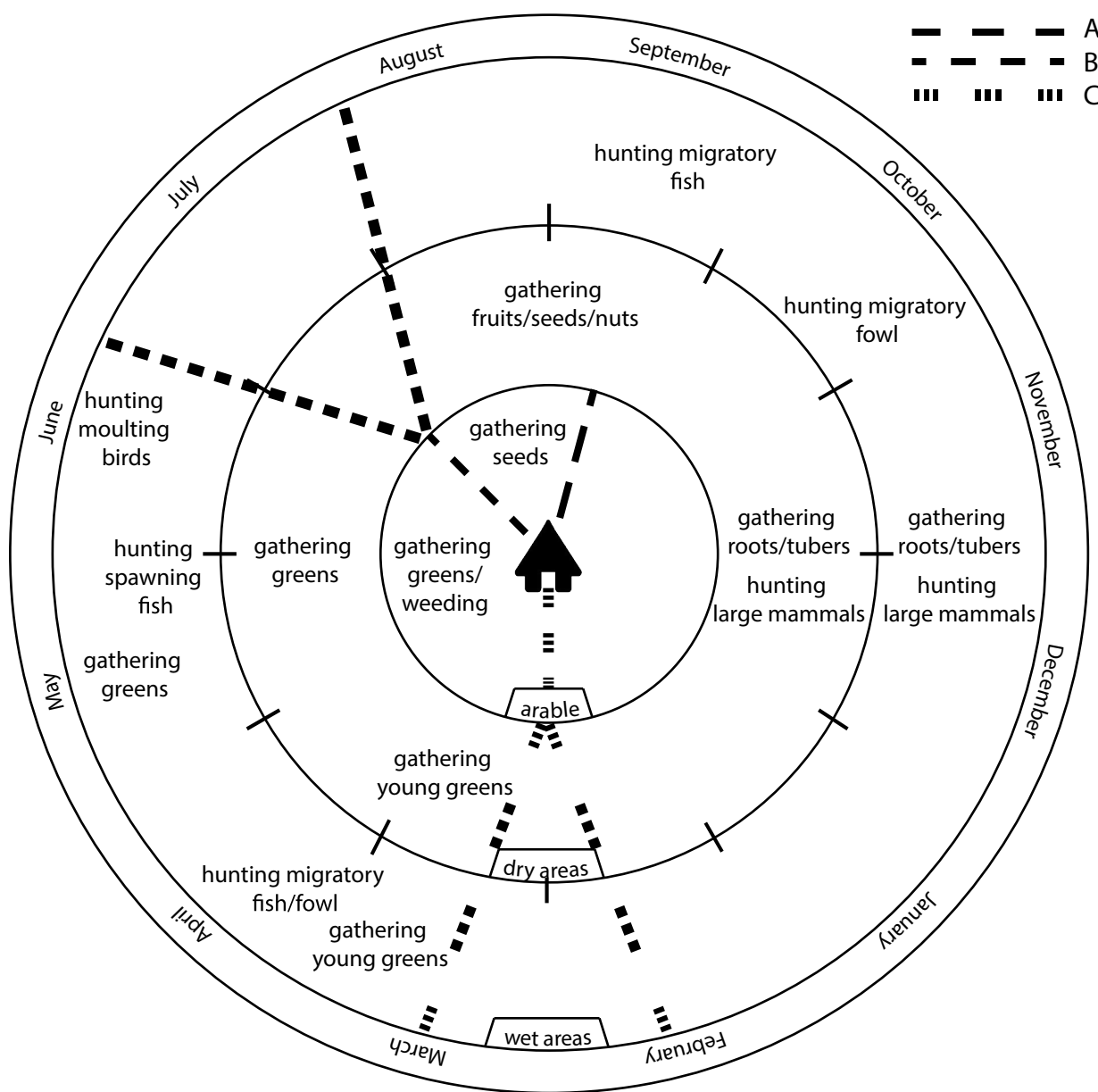


Figure 8.52. Middle Bronze activity year cycle for wild resources (including hunting and gathering). A: harvesting; B: manuring/ploughing; C: ploughing/sowing.

Breeding of cattle, sheep, and goat would also have occurred during this time.

On the arable fields, manuring and ploughing would have taken place in order to prepare the fields for the sowing of new crops in the spring.

Autumn: wild resources

During this time, domestic resources such as meat and milk would have been running out. Therefore, towards the end of autumn, the importance of hunting wild animals would have increased.

Most of the fruits, seeds, and nuts would have been available during most of autumn, but would have decreased in number towards the end of this season. In November, however, roots of wild plants would have become available as a viable food source.

Winter: domestic resources

Winter, being the harshest of seasons in terms of weather conditions, would have prompted people to bring valuable and vulnerable animals, such as horses or pregnant and old animals, inside their houses. In this manner, animals could be more easily protected and cared for. Remaining livestock would have been kept outside, with the possibility of foddering them when winter was extremely harsh. During this time, pigs would have been breeding.

Arable fields were left alone for most of the winter. Second ploughing, weeding, and sowing of fields, however, might possibly have started as early as February, weather permitting. Still, most of winter would have been a quiet period for animal and crop husbandry practices, leaving room for other activities such as repairing, making tools/equipment, etc.

Winter: wild resources

Winter would have been the most active game hunting time in the farmer's year. Fur animals were most valuable in this period because of their thick furs, and large game would have been a nice addition to both the diet as well as an extra source of protein and raw material. Towards the end of winter, fish and fowl became more available, as migration started. Smoked fish and meat may have been consumed during this time as well.

Throughout winter, roots and tubers would have been the main wild plant resource available to people.

Spring: domestic resources

As soon as weather conditions became more favourable, the animals which were kept inside during winter, would have been transferred to their grazing areas in March/April. During this time, vegetation would have begun to grow, providing fresh food for livestock. Most animal species would have been giving birth during this season, starting with sheep and goat, followed by pig, and cattle. Animals dying either during or after birth would have been processed to become the meat supply for the year ahead. Milk supply would have been highest in this period, and would have decreased steadily during summer and autumn.

If weather conditions were unfavourable in February, second ploughing, weeding, and sowing would have taken place at this time instead.

Spring: wild resources

The very high supply of domestic meat in spring would have reduced the need for hunting for subsistence in this season. However, eggs of wildfowl would have been available at this time, forming an extra food source, and most fish would have been spawning during this time, making them easy targets for capture.

Wild plants, similar to pasture, would have been growing, meaning young shoots and leaves rich in vitamins would have been widely available.

Summer: domestic resources

Summer would have meant grazing of livestock in different areas. Wetland areas would have been dry enough in summer for sheep to also graze here. After harvest, the arable fields may have become available for stubble grazing as well. At the start of summer, cattle may still have been producing offspring, but cattle that had already given birth in spring could have been used for breeding purposes again at the end of the summer.

Depending on the time of sowing and the growing conditions for the crops, weeding would have taken place in early summer, and harvest in July/August.

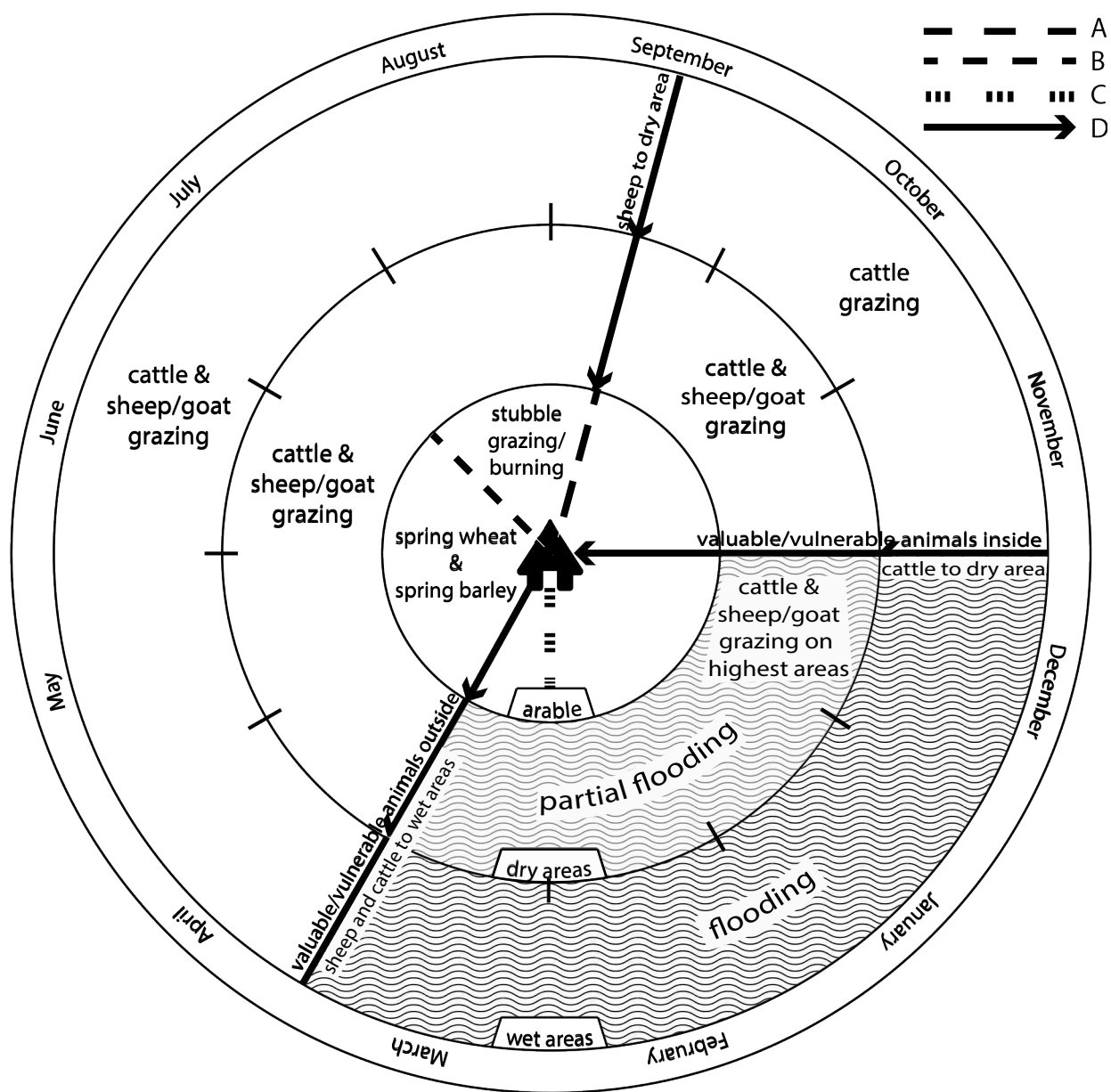


Figure 8.53. Late Bronze activity year cycle for domestic resources (including crop and animal husbandry). A: harvesting; B: manuring/ploughing; C: sowing; D: movement direction of livestock.

After harvest, the stubbles would have been either available to livestock for grazing, or burned. After grazing, manuring and ploughing can start, weather permitting. After burning, rain would have helped to transport nutrients released through burning into the soil.

Summer: wild resources

Eggs would have been less available during summer, but due to moulting, (aquatic) birds themselves would have become a new resource. Fish would also have been available still, with the availability of eel increasing in the late summer, when migration started.

Wild plants would still have provided greens, although edibility would have decreased throughout summer, when seed- and fruit-bearing stages started. Seeds, nuts and fruits would therefore have become the new resources at the end of summer.

8.4.2 Late Bronze Age

Domestic resources

The main difference between the Middle and Late Bronze Age was the increasing wetness. During autumn and winter periods, wetland areas became more inhospitable to livestock because of flooding. This aspect of the Late Bronze Age environment would have caused the transfer of cattle to dry areas in winter during this time, whereas it would not have been necessary in the Middle Bronze Age. Both sheep and cattle would have been kept on the highest and driest areas in the landscape, as most areas would have been (partially) flooded in winter and early spring. In summer however, the areas previously flooded would have been dry enough for grazing both sheep and cattle.

This flooding phenomenon would have created a large impact on other farmer's activities during autumn and winter as well. Although crop and animal husbandry were still practiced during this time, the area available, especially for grazing, would have been much smaller in comparison with the Middle Bronze Age (cf. Chapter 2, section 2.5.3). Transport or travel routes would also have become restricted during this time, unless transportation across water

was occurring. The reduced amount of suitable land would not have accommodated the same amount of people as in the previous period (section 8.2.1).

Spring sowing was (still) being practiced, indicating that growing crops was possible, but only on dry enough locations. Harvesting, burning and/or ploughing might, however, have been affected by the increasingly wet environment, shortening the available time to safely process and store the harvest before autumn rains and winter floods arrive.

Wild resources

Wild resource exploitation in the Late Bronze Age would also mostly have been affected by the increasing wetness in comparison to the Middle Bronze Age. Large areas of the landscape would have been virtually inaccessible for hunting and gathering during the wet autumn and winter months. Although both were still practiced in the Late Bronze Age, the reduced amount of available hunting grounds may have restricted the potential number of people exploiting these resources.

For both the Middle and Late Bronze Age, it has become clear that people were living in harmony with their surroundings, and were not willing to evacuate an area just because of increasing wetness. Rather, they were adapting to the gradually changing environment by for example throwing up *terp* mounds and adjusting their subsistence practices according to the available resources. Once more, it is obvious that farming should never be called optimal, but rather adaptable to availability of resources, and environmental conditions.

8.5 SUBSISTENCE IN FOCUS:

BOVENKARSPEL HET VALKJE

One settlement, Bovenkarspel Het Valkje, was chosen in order to investigate how the researched aspects of subsistence relate to each other within a settlement. This site has data available for analysis of all subsistence strategies, as well as information on many of the house plans. Combining the information from Chapters 4-7 on crop and animal husbandry, hunting, and gathering from multiple houses of Bovenkarspel

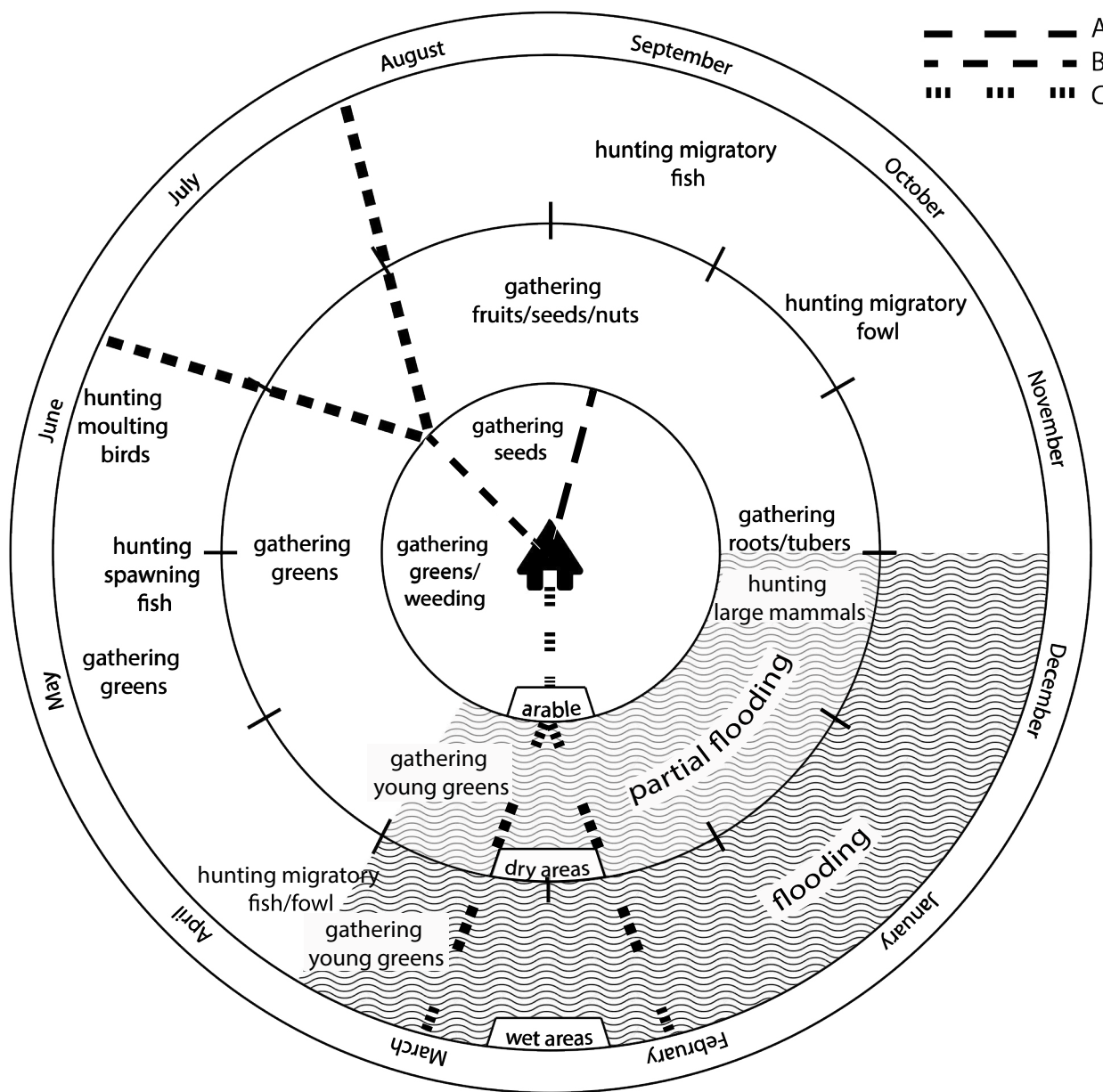


Figure 8.54. Late Bronze activity year cycle for wild resources (including hunting and gathering).
A: harvesting; B: manuring/ploughing; C: sowing.

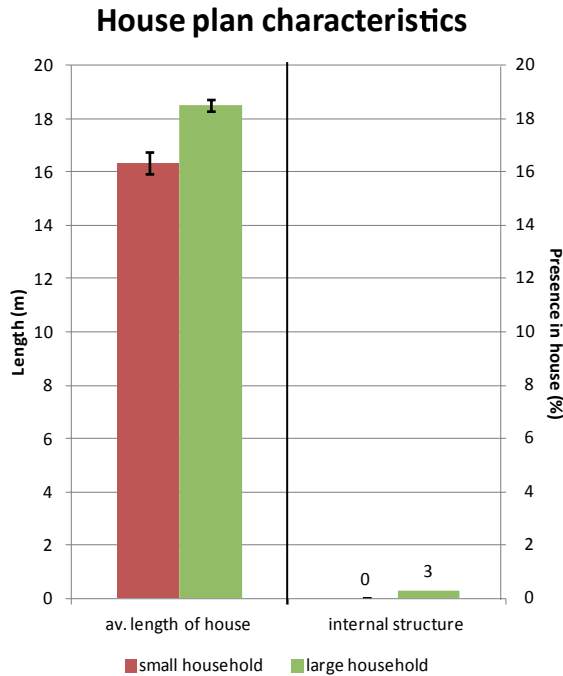


Figure 8.55. House plan characteristics of small and large households. No significant differences between households were observed.

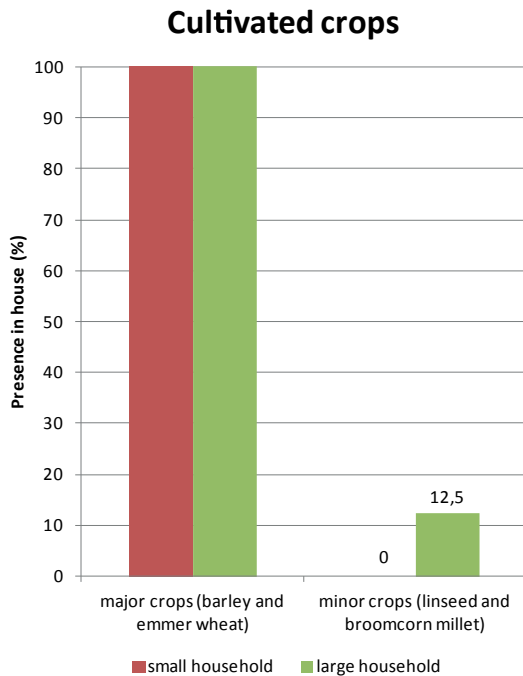


Figure 8.56. Cultivated crops present in small and large households. No significant differences between households were observed.

has enabled an inter-house comparison of subsistence practices based on remains from house ditches.

Crop husbandry harvesting practices yielded a clear division between the houses of Bovenkarspel (see Chapter 6, section 6.4.4), and this is therefore used as the main factor for comparison between small and large households. Other aspects related to crop husbandry in this comparison include the presence of other cultivated plants (linseed/flax and millet). Aspects of animal husbandry include the average number of domestic animal species kept (cattle, sheep/goat, pig, dog, horse), and presence or absence of each of these species within the household. Furthermore, the hunting-related aspect is the presence of large game. Small game could not be included due to difference in collecting and sieving practices for smaller animals at the site. Aspects related to gathering practices finally, include average number of wild plant species present, number of species of which the eco group is known, number of species from local, settlement, arable field, and off-site locations (cf. Chapter 7, section 7.4.1). The number of different uses of wild plants are also summarized, as well as the presence of specific uses. Factors which are not related to food strategy are also included in the comparison, such as the house structure. The average length of the house is taken into consideration, as well as the possible presence of an extra internal structure, which might be related to storage (Roessingh in prep.).

Of the available samples house plans, only 24 yielded enough data of each subject to be included in the comparison. Of these houses, four could be characterized as having a small household size/limited hands available for harvest, and eight as large households/having enough time or hands during harvest (Chapter 6, section 6.4.4). The remaining twelve houses showed a mixed signal and are not included in further analyses.

The results for the MBA houses are shown in Figure 8.55-8-58. Unfortunately, the LBA contexts did not yield enough data for a detailed comparison, so only a general discussion is provided for this time period.

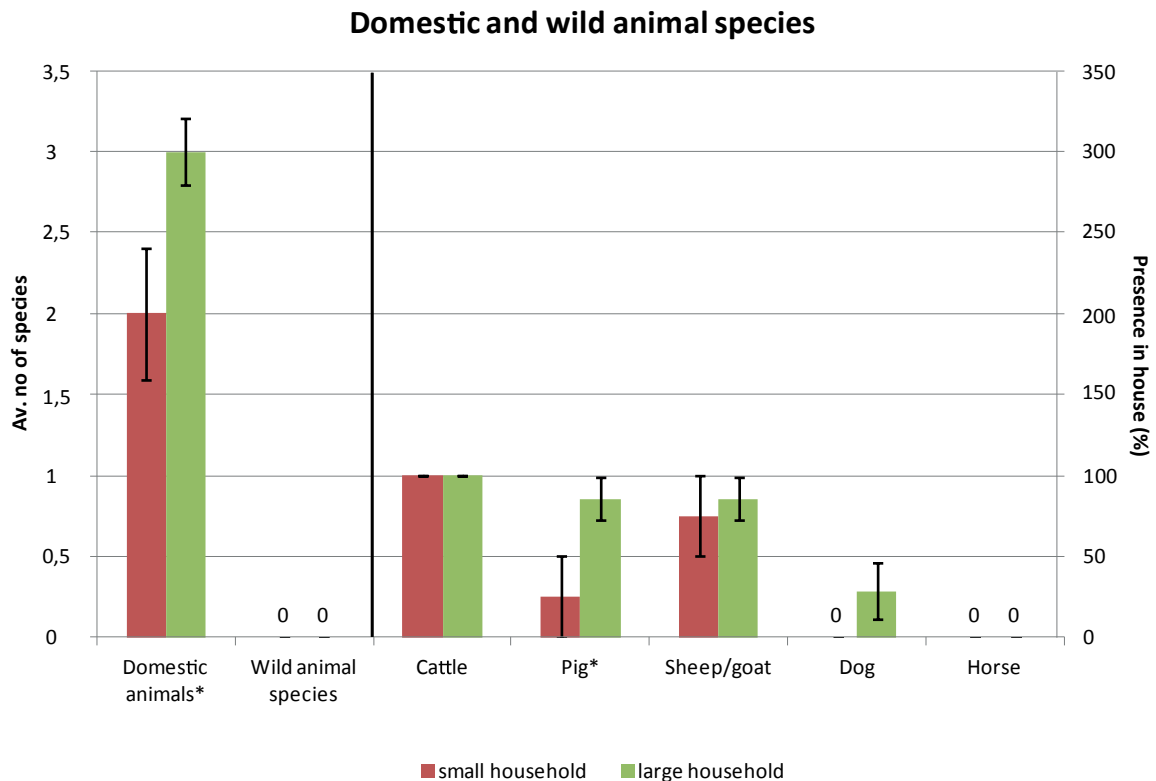


Figure 8.57. Number and type of domestic and wild animal species present in small and large households. *= significant difference between small and large households (domestic animals: two-sample $t(df) = t\text{-value}$, $p = 0.04$; pig: two-sample $t(df) = t\text{-value}$, $p = 0.048$).

8.5.1 Middle Bronze Age

Houses

The first aspect which becomes apparent from Figure 8.55 is that the average length of the house is not significantly different between small and large households. This means that throughout the Middle Bronze Age, houses were of similar size, but the size of the households within them varied. This result is consistent with the research of Roessingh (in prep.), who also concludes that there is no clear differentiation observed in house sizes through time in Bovenkarspel.

Another interesting aspect of Figure 8.54 is that internal structures are observed in large households, but not in small households. Although this may be a result of the limited number of small households present, it may also reflect an actual difference in practice. Perhaps larger households needed to store

larger amounts of grain and fodder, increasing the need for a supported attic.

Crop husbandry

Cultivated plants other than barley and emmer wheat were only present in large households (Figure 8.56). This may still be due to the limited number of small households as comparison, but it may fit well with the fact that larger households would have been more capable of cultivating more than two crops than small households with limited means and people. More research is needed to further confirm this picture.

Animal husbandry

There are some differences between small and large households with regard to animal husbandry (Figure 8.57). Small households have a significantly (two-sample $t(df) = t\text{-value}$, $p = 0.04$) lower number of different domestic animal species in their house ditches. In small household ditches, cattle is the

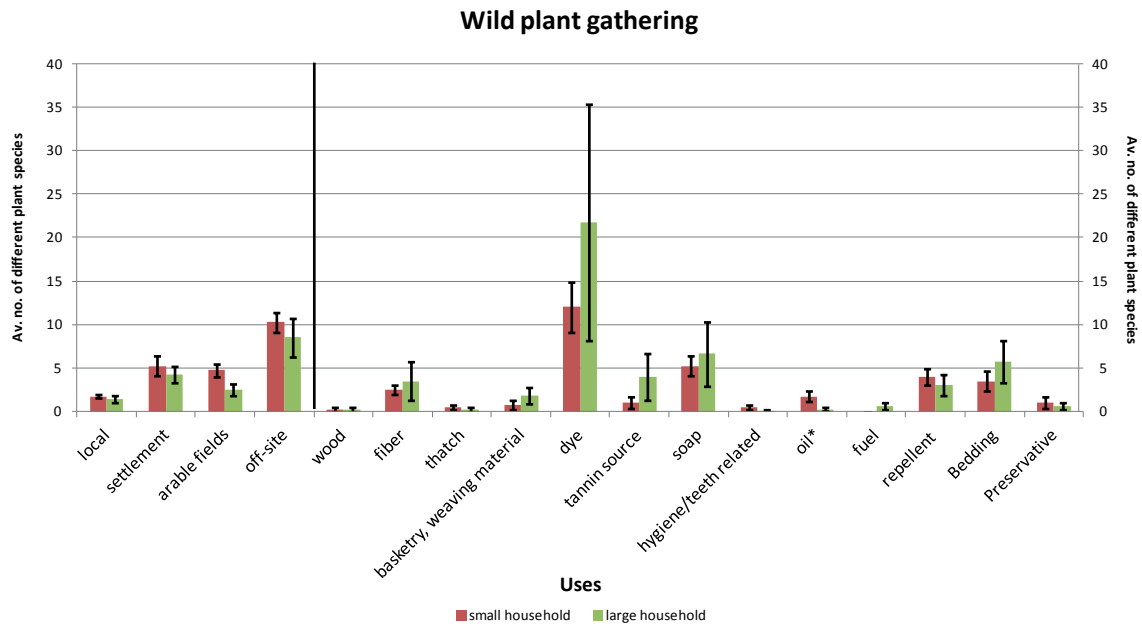


Figure 8.58. Frequency, gathering location and type of wild plant species present in small and large households. *= significant difference between small and large households (two-sample $t(df) = t\text{-value}$, $p = 0.02$).

species that is always present, followed by sheep/goat, and finally, sometimes pig. This may be related to the limited number of animal species that can be cared for with a limited amount of people in a household.

Larger households would have consisted of more people and means to keep a wider variety of animal species. Indeed, pig is nearly always present in the larger household contexts, and significantly more so (two-sample $t(df) = t\text{-value}$, $p = 0.048$) than in small households. This is consistent with the model presented by Gregg, who also places pigs in the largest households (Gregg 1988: 150, Table 40). The presumed greater potential for keeping a variety of animal species in large households is further supported by the fact that dogs are never present in the small households, whereas they are present in the larger households. Horses are so rare however, with no remains of horses found in the house contexts available.

The fact that cattle is so common, even in small households, shows their importance for subsistence. Where in Africa poor/small families usually only possess ovicaprids, often seen as the poor-man's livestock, cattle seems to be the minimal species kept

by small households in West Frisia. The importance of cattle to Bronze Age people was outlined by Brusgaard (2014), who postulated their role in daily life, social interaction, and burial practice. Apparently, Bovenkarspel and West Frisia in general were no exception to this "rule".

Hunting

The total absence of large game animals in house ditches of both small and large households is striking. Several remains from large game animals were found in different contexts at Bovenkarspel, however not in house ditches, so they were logically not included in this inter-house comparison. Furthermore, the bias with which the bone material of Bovenkarspel was examined by IJzereef (1981, 24) may also have resulted in a misidentification of large mammal bones as domestic rather than wild animals. Lastly, the inconsistent sieving strategy of smaller animal bones means that fish, birds, and small mammals could not be included in the comparison, limiting the assessment whether and to which extent these hunting practices were practiced by the different households in Bronze Age Bovenkarspel.

Gathering

No significant difference between households was observed with regard to the collection of wild plants (Figure 8.58). This is consistent with the observations made in the selected cultures from the ethnographical work by Murdock (1981) (Appendix A1.4), as well as the ethnobotanical work by Ertuğ (2000; 2004), where plant gathering for consumption occurs independent of the size or wealth of the community. There is also no difference between small and large households in the location from which the plants are gathered, or the average number of plant uses indicated by the content of the ditches (data not shown). Specific uses of wild plants are mostly not significantly different between households. The uses identified for the plants found most frequently in house ditches are fibre, dye, soap, repellent, and bedding, which can all be related to activities which would take place close to or inside the house. However, two uses were significantly different: plants possibly used for their oil are found more in small households (two-sample $t(df) = t\text{-value}, p = 0.02$), and plants possibly used for fuel are only found in large households. The reason for this difference remains elusive.

8.5.2 Late Bronze Age

Although most houses in the Middle Bronze Age reflect a large household based on the harvesting practices, the Late Bronze Age house contexts unanimously reflect small households. This would fit very well with the reconstructed landscape in the Late Bronze Age, which would be able to accommodate, and did seem to harbour far fewer people than in the Middle Bronze Age (section 8.2.1).

8.5.3 Middle and Late Bronze Age compared

The results above have given a more detailed insight into the lives of people in Bovenkarspel Het Valkje in the Middle and Late Bronze Age. It can be postulated that Bovenkarspel began as a small settlement with a few small households (cf. Chapter 6, section 6.4.4). Throughout the Bronze Age, households increased in size and number, allowing people to cultivate and breed more different species of domestic plants and animals, although houses stayed largely the same in size and layout. In the Late Bronze Age, when

environmental conditions reduced the amount of available land, households, but not houses, started to diminish again in size.

In each time period however, people exploited the resources in their surroundings in a similar fashion, using both domestic and wild plant and animal resources to maintain subsistence. Small and large households show some differences in their domestic animal species and uses of wild plants, although no clear specialisation of practices between households in each group could be observed.

Household size can thus have been related to different practices, but it has become apparent that this is, at least in West Frisia, unrelated to the size of the actual house.

8.5.4 A structure layout does not necessarily immediately reflect (the function of) a house

A further indication for the fact that in West Frisia, the size of the house does not necessarily inform about what occurred on the inside, derives from an analysis of the Bovenkarspel houses based on the work by Grabowski & Linderholm (2014). In their work, Grabowski & Linderholm aim to identify areas of activity within an house, based on a range of different types of analyses. These analyses include loss-on-ignition, which can provide information on enriched soils; magnetic susceptibility, which can inform about the location of hearths; phosphate analysis, providing indications for the presence of a kitchen space, as well as animals and manure; and ratios between cereals and non-cereals, which can signify areas in the house where grains were processed or stored (Grabowski & Linderholm 2014, 331-3). Using these techniques on an Iron Age house, Grabowski & Linderholm were able to identify different areas of activity within a house, and even tentatively distinguish between different functions of neighbouring buildings (Grabowski & Linderholm 2014, 340).

Many of these techniques are not accessible for the present study, although they will be further explored by Grabowski in the near future (Grabowski in prep.). What is currently available however, is information on ratios between cereals and non-

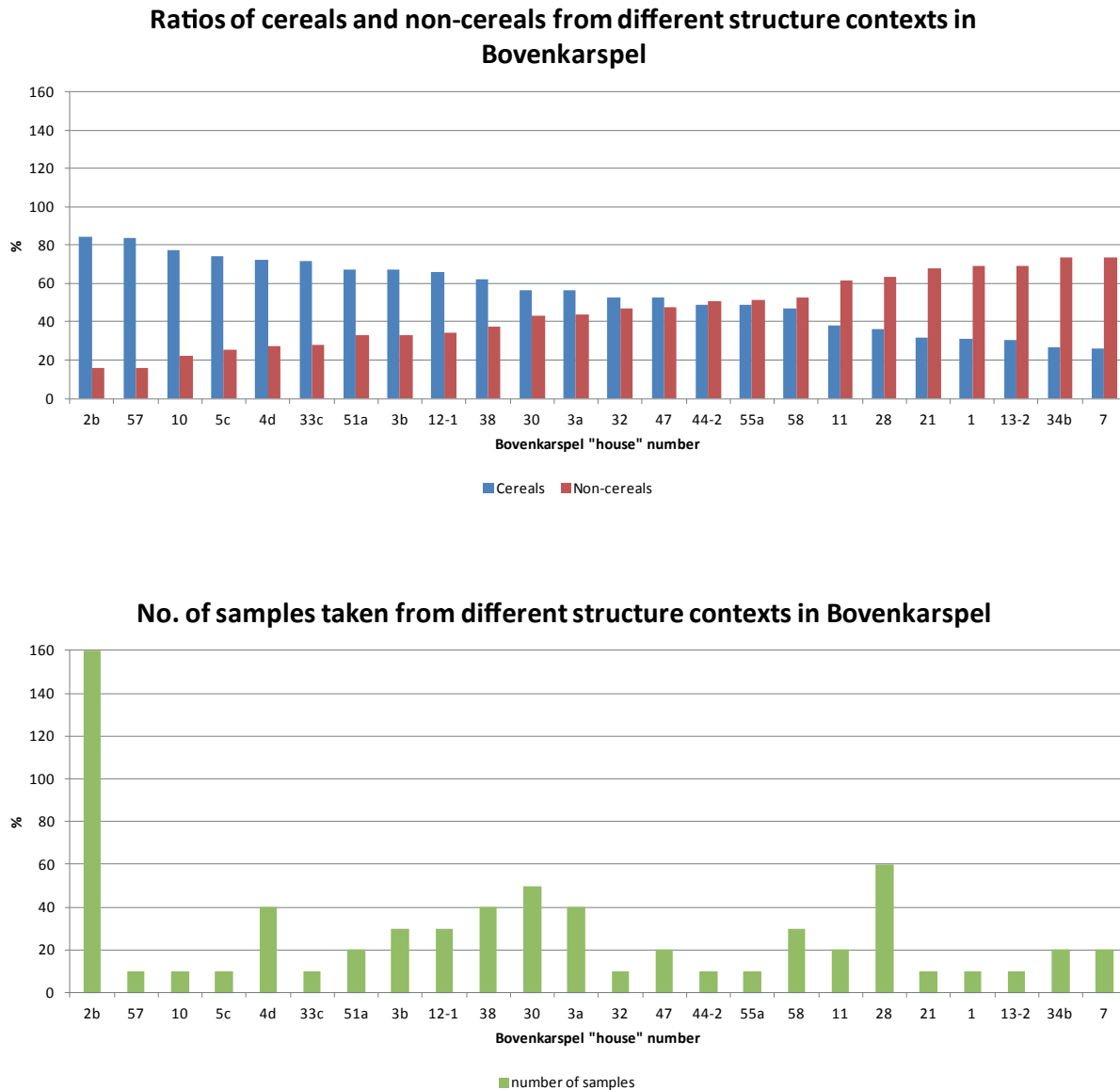


Figure 8.59. Ratios of cereals and non-cereals, and number of samples taken from several structure interpreted as houses based on lay-out from Bovenkarspel Het Valkje.

cereals, the analysis of which is presented here. Of each house from Bovenkarspel analysed in the previous section, the ratios between cereals and non-cereals were calculated according to Grabowski & Linderholm (2014). The results of these calculations can be observed in Figure 8.59. When more than one sample was available, the values of these samples were averaged. Since house contexts were not systematically sampled in Bovenkarspel, it

was not possible to distinguish between different activity areas within the house. However, a general differentiation between buildings was observed.

The houses at the left of Figure 8.58 show a high ratio of cereal remains, which, according to Grabowski & Linderholm (2014, 340) should be interpreted as a farmhouse. Conversely, the buildings on the right of the graph show a high ratio of non-cereal remains, which

according to Grabowski & Linderholm may reflect a byre/barn (Grabowski & Linderholm 2014, 340). Still other houses, located in the middle of the graph, show a mixed signal of farm and byre. Interestingly, there is no correlation between the number of samples taken with and the differentiation observed.

The results from Figure 8.59 also did not correlate with any of the differentiations made in the previous section, including length of the house, or size of the household. It is therefore possible that some households, regardless of size, owned a house as well a separate outbuilding, or that communal byres for multiple households existed in Bovenkarspel. In addition, combined houses may have existed, which possessed both a living part and a barn section. These possibilities need to be confirmed however, by the study currently being performed by Grabowski (in prep).

To summarize, it is clear that when features are interpreted as a building, the function of the building cannot be directly deduced based on only the house plan. Not every plan necessarily reflects a house, and not every house need necessarily have contained both a living area and a barn part. Instead, the function of a building should be interpreted based on a combination of types of evidence including the finds from its contexts, not solely its appearance.

8.6 SUMMARY

In this chapter, all aspects related to subsistence (except fire and drinking water) have been researched for West Frisia by combining the results obtained from the previous chapters 2-7.

The impact of humans, livestock, and wild animals on the Middle Bronze Age landscape in eastern West Frisia was assessed. From this analysis, it has become clear that people (with their crops and livestock) impacted their immediate surroundings by requiring on average around 0.3 km² per household. Further away from these locations, however, large forests could still develop. Wild animals also impacted the environment, but not to such an extent that the succession towards forests stopped entirely. In addition, the distribution of settlements has enabled pinpointing of certain locations where forests were

most likely present during this time. Finally, the number of settlements present in the landscape has reinforced the assumption that farms in West Frisia were small-scale, since larger farms could not have been supported by the available appropriate land for habitation, and crop and animal husbandry.

The diet of Bronze Age farmers in West Frisia was researched based on a multiple of disciplines, including ethnography, archaeology, nutritional studies, and physical anthropology. The resulting image was surprising, at least in comparison with older views on this subject, because Bronze Age people still required wild resources in their diet to remain healthy. A diet consisting of only cereals, meat, and milk (*i.e.* the farmers diet) has been shown to be completely lacking in essential vitamins A and C, which would eventually have led to blindness or death by scurvy, respectively. The role of wild plants (and especially their vegetative parts) in providing these critical micro-nutrients has been greatly underestimated in earlier research, which normally only considers calories as a measure for the completeness of a diet. Analyses performed on the skeletal remains of Bronze Age individuals indicate that the general health level of people was good, evidenced by their stature and ability to heal from ailments, although some periods of minor nutrient-deficiency (*e.g.* winter) will have remained present throughout this time period.

Activities related to acquiring the different types of food, including cereals, meat, milk, wild animals, fish, and wild plants have been projected into year-cycles. These images have enabled the understanding of how domestic and wild resource exploitation was combined: both activities complement each other in different seasons, or possibly even during different times of the day. During busy periods related to crop and animal husbandry, hunting and gathering seem to have been kept to a minimum as far as can be established based on seasonality. During quieter times of the year, such as during winter, these latter activities could be practiced to a larger extent. The year-cycles have indicated that all the activities related to the four subsistence strategies can be integrated without having to compromise on either domestic or wild resources.

Clothing, another important part of subsistence, was investigated for West Frisia based on both the available sources of raw material, indications for its construction, and Bronze Age finds from other areas. Although no textiles have (yet) been uncovered in West Frisia, this overview has provided indications for the possible appearance of clothing here, such as potentially used fabrics/skins, different garment types, and colour usage.

The third subsistence element researched was shelter, in particular the appearance of the inside of a West Frisian Bronze Age house. Rather than accepting an empty reconstruction, a summary of expected basic objects related to Bronze Age subsistence was presented, as well as an overview of the uncovered examples of these objects from West Frisia and other countries. This information was subsequently translated into a “science-based artist impression”, which, for the first time, shows what the inside of a West Frisian Bronze Age house may have looked like. The creation of this artist impression has revealed that instead of only focussing on what is found on the excavated site, a more complete image of the past might be obtained by combining and extrapolating objects and knowledge present during the time period at other locations. At the very least, it will provide a new topic of discussion towards one of the aspects most closely related to a prehistoric household.

Finally, all aspects related to subsistence, which were available from one of the West Frisian sites, Bovenkarspel Het Valkje, were combined to investigate how the different subsistence strategies were reflected within a settlement, and between individual households. Results of this analysis have indicated that neither the size of household nor the function of a building could reliably be reconstructed based on the size of the house plan. Conversely, both household size and possible function were elucidated from the composition and frequency of botanical remains. Furthermore, several aspects related to the relative size of the household could be established. Large households possessed significantly more different domestic animal species, of which pigs are significantly more often present than in smaller households, and dogs are even exclusively found here. Gathering practices seem to target similar

species and occur at similar locations regardless of household size, which is in concurrence with what is observed in ethnographic studies of small-scale farming communities today.

8.7 CONTRIBUTION OF THE DIFFERENT SUBSISTENCE STRATEGIES IN BRONZE AGE FARMING IN WEST FRISIA

This chapter has provided different types of evidence that all four subsistence strategies were in one way or another required to complete subsistence in the Bronze Age. The combination of domestic and wild resource exploitation ensured that people had access to a near-constant flow of food and raw material sources available in and around the settlement.

From section 8.3.1 in particular, it has become clear that the Bronze Age diet will have consisted of a range of different types of food from all subsistence strategies, in which cereals formed the staple diet throughout the year (around 60%), and where additional food sources may have fluctuated from season to season. The remaining part of the diet will have consisted of, on average, 15% meat, 5% fish, 10% milk, and 10% wild plants (cf. Figure 8.11). In section 8.3.1 the dietary composition was not based on caloric intake, but rather on a healthy and balanced diet consisting of adequate micro-nutrient intake.

Raw material was required for the construction of all the basic needs to survive in the Bronze Age, including acquiring food, making clothing, and building houses and their interiors (sections 8.3). Especially the contribution of wild resource exploitation to the fulfilment of these basic needs should not be underestimated. Most tools and equipment for hunting, gathering, and crop and animal husbandry, as well as daily life require wild plants (including trees) for their construction (section 8.3.3); Bronze Age clothing will still have (partly) consisted of wild animal hides and pelts (section 8.3.2).

The activities related to the different subsistence strategies could be practiced in a such a manner, that none of these strategies were negatively affected

(section 8.4). The relatively flexible nature of hunting and gathering (in terms of targeted species, visited locations, and the time of the day/year at which these activities were practiced), allowed for it's combination with the relatively rigid system of farming. This ability for integration of both types of exploitation could be exemplified by a possible reduction or change in hunting and gathering during busier times of the farming year (*i.e.* during sowing and harvesting), when these activities occurred more passively or at different times of the day, whereas during quieter times of the farming year (*i.e.* winter), more intense (active) hunting could, and did occur (cf. Figures 8.52 and 8.54).

The contribution of hunting, animal and crop husbandry, and wild plant gathering is difficult to assess in detail, since it is clear from the above that each strategy has its own merits, which cannot always be expressed quantitatively. However, considering both the importance of the different subsistence strategies in the diet, as well as their contribution in providing raw material, a tentative adaptation to the graph based on the work by Murdock, and Gregg was made (Fig 8.7; Appendix A1.4 and A1.15), and is presented here (Figure 8.60). This graph is important to show, because it takes into account that food is not the only necessity of life, and simultaneously incorporates the fact that Bronze Age farmers presumably did not have the luxury to buy created objects to aid their subsistence: they needed to create everything from what was available in their surroundings. In this respect, Figure 8.60 should reflect Bronze Age life more closely than the information based on modern-day small-scale farming communities, although more research is required in the future to confirm this view.

8.8 CAN WEST FRISIA BE CONSIDERED A GOOD CASE STUDY FOR BRONZE AGE COASTAL COMMUNITIES IN NORTH-WESTERN EUROPE?

The conditions of the West Frisian soils have ensured the preservation of extensive amounts of Bronze Age botanical and zoological remains. The resulting

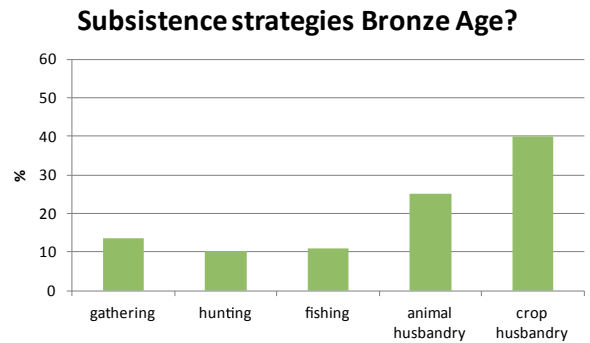


Figure 8.60. Tentative graph of the relative importance of the different subsistence strategies in Bronze Age farming, including their role in providing food, as well as raw material for the construction of products related to the other basic life necessities (clothing and shelter). For calculations and reasoning behind the construction of this graph see Appendix A1.16.

large dataset has enabled a holistic reconstruction of subsistence, which is normally not possible because of the absence of either or both types of organic remains. Subsistence practices which have been analysed based on the West Frisian data have allowed for a more detailed understanding of Bronze Age life, and the role of the different subsistence strategies in providing people with adequate food and raw material throughout the year. The inherent characteristics of the area of West Frisia, covering an area from the North Sea in the west to the freshwater lakes in the east, has furthermore provided a wide range of possible habitats and species exploited by man, which has made this area an even more valuable parallel for freshwater and saltwater coastal communities alike.

West Frisia can therefore be regarded as an excellent case study for coastal communities in the Bronze Age, especially for north-western European sites. Due to the fact that this part of Europe experiences largely similar flora and fauna, as well as mostly comparable climatic conditions, the subsistence economy can be compared on a relatively equal basis: observed local differences need not be due to differences in these variables. In addition, time periods are comparable, meaning that (long-distance) connections between regions (such as for exchange), and distribution of (domestic) plants and animals through time can be researched.

