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

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2. Reconstruction of the Landscape

2.1 INTRODUCTION

It is of great importance that the landscape which was present around settlements is established before the reconstruction of subsistence can commence. The environment is essential for all aspects related to subsistence: the stage needs to be set before the actors come into play.

A model for the Bronze Age landscape in West Frisia already exists, but seems largely inconsistent with observations made at recent excavations in the area. In this introduction, a short overview of the inconsistent main components of the current model, which are of relevance to this thesis, will be discussed below, each followed by a number between brackets. These numbers will later be reiterated in the methods section (section 2.2) and will be used for specific approaches towards the research of each of the inconsistencies of the current model. For further specific information on the current palaeo-geographical and habitation models and their re-interpretation, the reader is referred to the other sub-projects (Roessingh in prep; van Zijverden forthcoming).

2.1.1 Previous research

In the current landscape reconstruction model, the Middle Bronze Age West Frisian landscape consisted of mostly wet grassland, with a few higher sandy ridges, and trees were absent from the area. In the Late Bronze Age, the landscape was still treeless, and deteriorating weather conditions and a rising sea level during this time led to an increasingly wet environment consisting of expanding peat growth. These factors ultimately led to the abandonment of West Frisia altogether at the end of the Late Bronze Age.

It is clear that several influences of water on the land were postulated for West Frisia, basically forming the main components of the current model. First of all, it was expected that no marine influence of the North Sea was present in (eastern) West Frisia after ca. 1550 cal BC, because the Bergen inlet (*i.e.* the connection to the sea to the east of West Frisia; Figure 2.1) was assumed to be closed during that time (Roep & van Regteren Altena, 1988, 219) (1). Although further physical geographical research in this area has been performed, no change in the closing time of the inlet has so far been proposed. Recent excavations have, however, revealed indications of marine influence at several Middle Bronze Age sites, which clearly date after the previously proposed closure of the inlet (Lohof & Vaars 2005, 65; Schurmans 2010, 144; Roessingh & Lohof 2011, 319; van Zijverden 2013). Related to this first example of water influence based on the current model, the water around the settlements in both the Middle and Late Bronze Age was characterized as a purely freshwater environment (2). This was established based on the fish bone assemblage (IJzereef 1981, 126), small mammals (Buurman 1996, 149), botanical macro remains and molluscs (Buurman 1996, 149-50), and algae (van Geel *et al.* 1997, 159-161). Recently observed marine influences at several sites again seem to contradict this statement.

The postulated wide-spread occurrence of peat growth in the Late Bronze Age (3) is another major aspect of the current landscape model. This peat growth, supposedly caused by a worsening of the climate in combination with a rising groundwater level during this time, was postulated as the reason why people abandoned West Frisia around 750 BC (van Geel *et al.* 1982, 274; van Geel *et al.* 1997, 45). However, several indications for habitation dating to the Iron Age are present in West Frisia (Woltering 1985, 225; Buurman 1993; van Wijk 2008), indicating that indeed people were still present here after the Bronze Age. In addition, so far, no peat layers dating to the Bronze Age were identified, even at locations where they were expected (Roessingh & Lohof, 2011, 46; Geerts 2012).

A final aspect of the current landscape reconstruction, and possibly the most important, is that the terrestrial

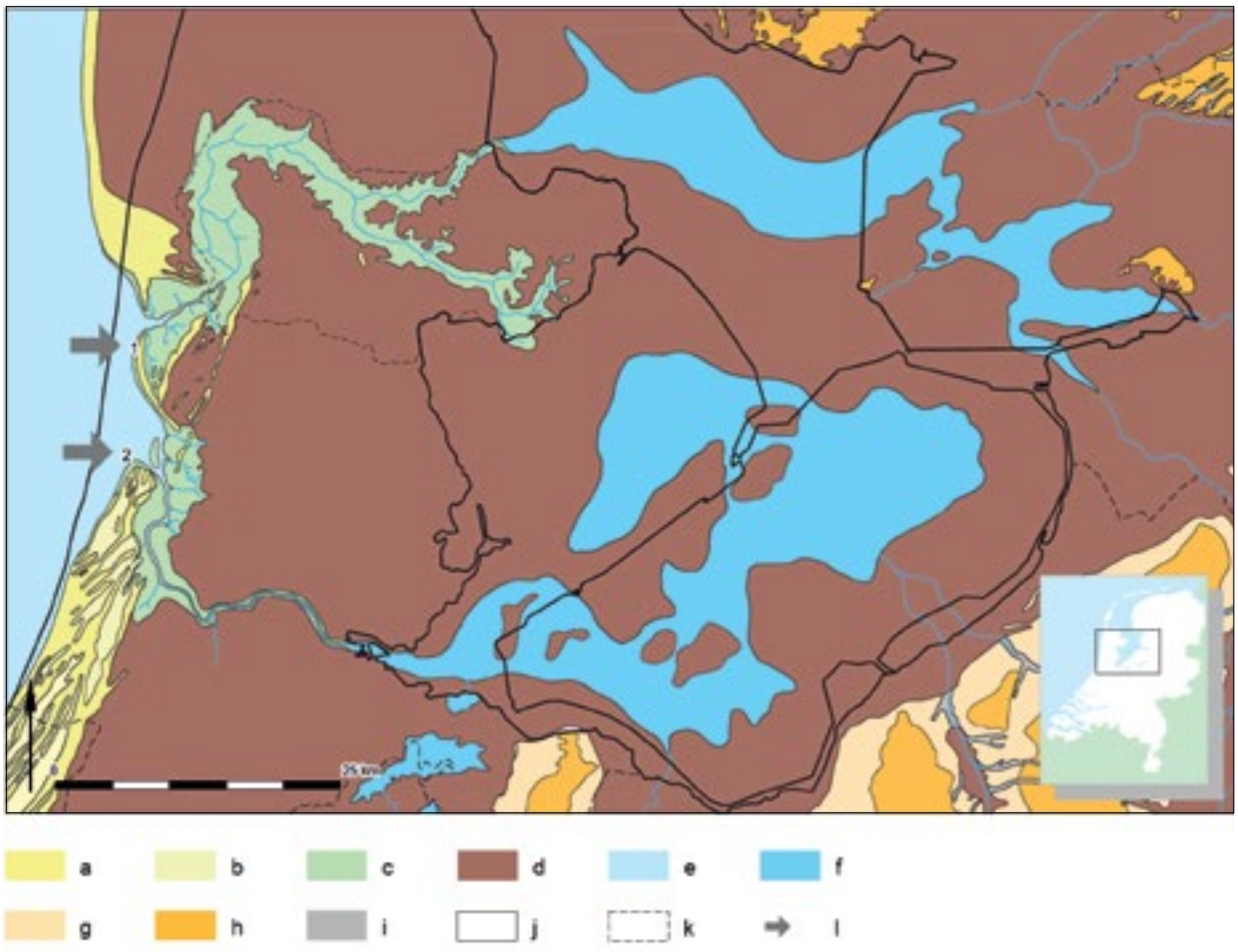

Figure 2.1a. Position of West Frisia and its drainage basins in the Bronze Age according to the current model (from: Vos 2011, 55). a: low dunes; b: beach-plain and dune valleys; c: intertidal areas: sand- and mudflats; d: peat; e: outer water: mainly brackish and marine areas, North Sea, tidal channels and lagoons; f: inner water: mainly freshwater areas, river channels and lakes; g: Pleistocene sand areas above 0 m –NAP; h: ice pushed moraines and drumlins; i: fluvial areas and brook valleys; j: outline of the recent Netherlands; k: outline of the recent area of West Frisia; l: coastal inlet/estuary; 1: Bergen inlet; 2: Oer-IJ estuary.

landscape of West Frisia has been reconstructed as a treeless, open landscape (Bakker & Brandt 1966, 188 and references therein) (4). Pollen analyses based on data from several old excavated sites indicated a general absence of trees, of which Bovenkarspel Het Valkje is the most prominent example (Buurman 1996, 83). New excavations however, have yielded multiple indications for the presence of trees (*e.g.* Kooistra 2010, 134), which undermine previous conclusions.

Besides affecting the West Frisian landscape, the supposed deteriorating weather conditions in the Late Bronze Age have also resulted in several statements concerning the habitation in West Frisia. The (increasing) wetness would have urged people to inhabit only the higher areas in the landscape after the closure of the Bergen inlet, and this changing climate allegedly also affected the subsistence strategies practiced. The accurateness of this major statement will be further investigated in Chapters 4-7.

2.1.2 The sites and the proxies

The landscape model presented here is a collaborative effort between drs. W.K. van Zijverden (another

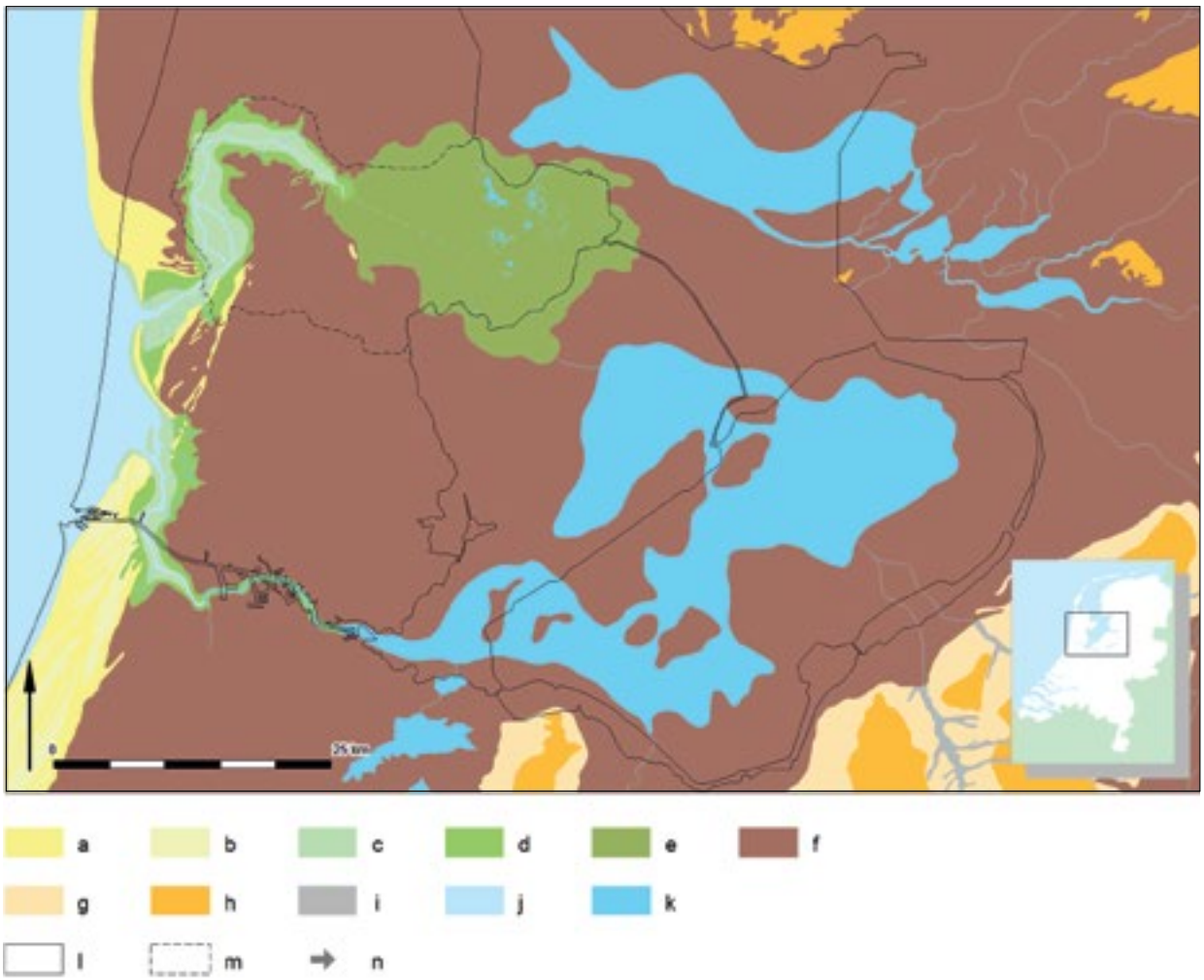

Figure 2.1b. Position of West Frisia and its drainage basins in the Bronze Age according to Van Zijverden (forthcoming). a: low dunes; b: beach-plain and dune valleys; c: intertidal areas: sand- and mudflats; d: fluvial flood plain and marine salt marsh areas; e: former mudflats (now freshwater environment); f: peat; g: Pleistocene sand areas above 0 m –NAP; h: ice pushed moraines and drumlins; i: fluvial areas and brook valleys; j: outer water: mainly brackish and marine areas, North Sea, tidal channels and lagoons; k: inner water: mainly freshwater areas, river channels and lakes; l: outline of the recent Netherlands; m: outline of the recent area of West Frisia; n: location of an excavated site; o: coastal inlet/estuary; 1: Bergen inlet; 2: Oer-IJ estuary.

member of the Farmers of the Coast project) and the author. Therefore, several ideas from and references to Van Zijverden's palaeo-geographical work will be used in this chapter, as well as the new maps created for the Bronze Age (*e.g.* Figure 2.1b). Whereas drs. Van Zijverden focuses mainly on the physical landscape from a geographical point of view, the research in this chapter is concerned with the added information potential for landscape reconstruction based on organic remains.

The data from both the old and new excavations was researched in order to re-evaluate the current landscape reconstruction model (cf. Figure 2.1a). As was introduced in Chapter 1, the new approach here was to first establish an expectation of what could be found in the West Frisian environment based on a combination of proxies (section 2.2). This approach ensured that the reconstruction of the landscape was not only made by merely summarizing what was found, but also by taking into consideration what

Table 2.1. Information on the sites of West Frisia used for the reconstruction of the landscape.

Site location	Toponym	Excavated	Date	Dating method	Sieving mesh size	Reference(s)
Andijk		1954	Subboreal	continuous *Fagus* curve	n/a	unpublished old StiBoKa data (off-site pollen)
Andijk	Zuid and Noord	1973	1500-1100 cal BC	14C-dating and pottery typology	unknown	Mensch & IJzereef 1975 (mammals) Aal 2016(mammals)
Bovenkarspel	Het Valkje	1974-1978	1500-800 cal BC	14C-dating and pottery typology	0.25-4.0 mm	Buurman *et al*. 1995; van Geel *et al.* 2012 (on-site pollen) Buurman unpublished (botanical macro remains) IJzereef 1981 (fish, birds, and mammals)
Enkhuizen	Kadijken	2007-2009	1500-800 cal BC	14C-dating and pottery typology	0.25-4.0 mm	Bos & Bouman 2011, 271-74 (on-site pollen) Moolhuizen & Bos 2011, 259-69 (botanical macro remains) Zeiler & Brinkhuizen 2011, 191-216 (fish, birds, and mammals)
Grootebroek		1949	1500-1100 BC	pottery typology	n/a	van Giffen 1954 (on-site pollen)
Hoogkarspel	Klokkeweel	1976	Subboreal	14C-dating and continuous *Fagus* curve	n/a	Pals *et al.* 1980 (off-site pollen)
Hoogkarspel	Tolhuis DEF	1964-1969	1500-800 cal BC	14C-dating and pottery typology	unknown	Smits 1978 (mammals) Suwijn 1981 (mammals)
Hoogkarspel	Watertoren	1973-1978	1500-800 cal BC	14C-dating	0.25-1.0 mm (mammals unknown)	Bakels 1974 (on-site pollen) Pals 1977 (botanical macro remains Clason 1967 (mammals)
Hoogwoud		1991-1992	Subboreal	14C-dating and continuous *Fagus* curve	n/a	Havinga & van den Berg van Saparoea 1992 (off-site pollen)
Hoogwoud	Opmeer	2004	1300-1100 BC	pottery typology	0.25-4.0 mm	van Haaster 2005, 50-4 (botanical macro remains) Beerenhout 2005, 43-50 (fish) van Dijk 2005, 36-43 (birds and mammals)
Medemblik		1954	Subboreal	continuous *Fagus* curve	n/a	unpublished old StiBoKa data (off-site pollen)

Site location	Toponym	Excavated	Date	Dating method	Sieving mesh size	Reference(s)
Medemblik	Schepen-wijk II	2007	1450-800 cal BC	14C-dating and pottery typology	0.25-4.0 mm	Kooistra 2010, 125-42 (on-site pollen and botanical macro remains) Beerenhout 2010, 105-20 (fish) Groot 2010, 83-104 (birds and mammals)
Opmeer		1964	Subboreal	continuous *Fagus* curve	n/a	unpublished old StiBoKa data (off-site pollen)
Schagen	de Hoep-Noord	2003-2004	2200-1600 cal BC	14C-dating	1.0, 2.0, 5.0 mm	Zeiler *et al*. 2007 (fish, birds, and mammals)
Twisk		1980	1300-1100 BC	14C-dating	0.25-1.0 mm	Buurman 1996, 37-68 (botanical macro remains)
Warmen-huizen		2004	1000 cal BC	14C dating	n/a	Bakels 2005, 36-8 (off-site pollen)
Westwoud	1988	1988	1400-800 cal BC	AMS-dating	0.25-1.0 mm	Buurman 1996 (botanical macro remains, fish, small mammals)
Zuid-Scharwoude		1967	Subboreal	continuous *Fagus* curve	n/a	unpublished old StiBoKa data (off-site pollen)
Zwaagdijk	1961	1961	1500-1100 cal BC	14C-dating and pottery typology	unknown	Clason 1964 (mammals)
Zwaagdijk	Oost	2003	1500-1100 cal BC	14C-dating	unknown	de Roller 2003, 189-202 (botanical macro remains) Halici & Buitenhuis 2003, 155-88 (mammals)

was missing from an assemblage and why. After the expectation was established, the West Frisian data was compared to it, and the results of the analysis of again several proxies (section 2.3 and 2.4) was combined into a new landscape model for the Bronze Age in West Frisia (section 2.5).

The usual proxies used for this type of research are pollen and macro-botanical remains. However, in this chapter, this usual set of proxies is supplemented with the proxy of animals (*i.e.* fish, birds, and mammals). By combining both botanical and zoological remains, a more complete image of the past environment is obtained, with the incorporation of the most frequently researched (and available) proxies for landscape reconstruction. Clearly, this set of environmental indicators is far from complete, but future research may incorporate other proxies when enough data becomes available.

The researched sites are summarized in Table 2.1, including the references to the various reports on the different proxies. Sites mentioned in this table include the complete site names. For readability reasons, these names will be abbreviated in the text by only referring to the locality (*e.g.* Bovenkarspel Het Valkje becomes Bovenkarspel). When multiple site names exist for the same locality, however,

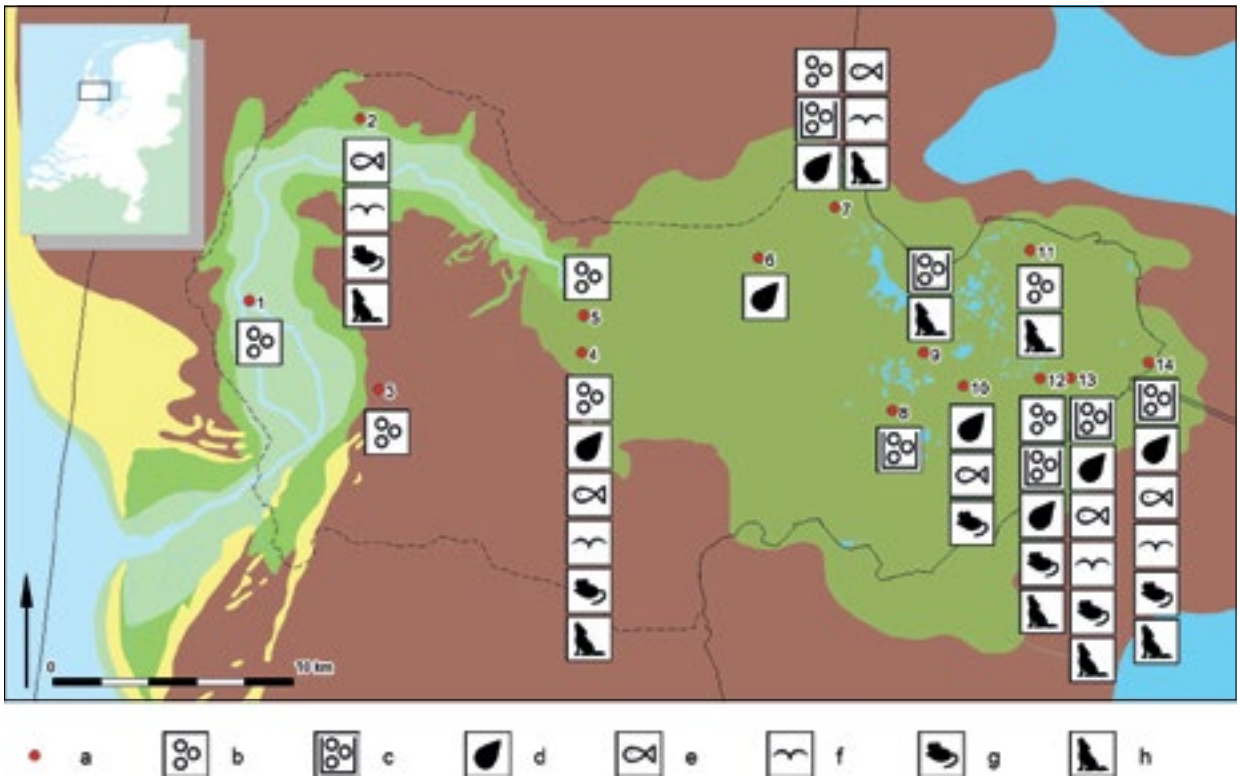

Figure 2.2. The different environmental proxies available at the West Frisian sites. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: off-site pollen; c: on-site pollen; d: botanical macro remains; e: fish remains; f: bird remains; g: small mammal remains; h: large mammal remains; 1: Warmenhuizen; 2: Schagen; 3: Zuid-Scharwoude; 4: Opmeer; 5: Hoogwoud; 6: Twisk; 7: Medemblik; 8: Grootebroek; 9: Zwaagdijk; 10: Westwoud; 11: Andijk; 12: Hoogkarspel; 13: Bovenkarspel; 14: Enkhuizen.

the entire site name will be indicated instead. The different proxies present at each site are shown in Figure 2.2.

2.1.3 Main current model components

The main components of the current model, which will be challenged in this chapter, are as follows:

(1) The seacoast to the west of West Frisia is closed around 1550 BC therefore making an influx of marine water impossible after this time.

(2) A purely freshwater environment existed around the settlements in eastern West Frisia throughout the Bronze Age.

(3) Wide-spread peat growth occurred in the Late Bronze Age, resulting in the abandonment of West Frisia.

(4) The terrestrial landscape of Bronze Age West Frisia is characterized by treeless, open areas.

2.2 METHODS

Proxies which are used to challenge the above main components include: pollen, botanical macro remains, animals (*i.e.* fish, birds, and mammals), and physical geography (van Zijverden forthcoming). The manner in which each of the different proxies are used in the reconstruction of the landscape will be discussed in more detail below. It was assumed that the climate in the Bronze Age was largely similar to the present (cf. Zagwijn 1991) and that biotic communities remained largely the same. However, when clear indications for differing situations between the past and present occurred, these were taken into account during further analysis.

For both macrobotanical plant remains and animal remains, it was assumed that they were brought by people to the site at which they were uncovered. It is also assumed that they derived from the immediate surroundings of the settlement, since the action radius of the Bronze Age farmers is assumed to be limited (Chapter 3, section 3.3.5). These remains should therefore represent the immediate surroundings of the sites at which they were found. Qualitatively, individual plant and animal proxies are considered to be good indicators for the habitats (see section 2.2.3) present around the settlements, and when multiple proxies overlap in the habitat types represented by the plants and animals, a more firm image of the environment can be obtained. When one of the proxies differs from the image provided by the other proxies for a certain habitat type, however, it is considered an outlier. For such cases, different explanations for these observed differences are discussed (cf. sections 2.3.5 and 2.4.5).

2.2.1 Pollen

For pollen research, both on-site and off-site pollen samples were re-analysed. Off-site pollen reports were collected at the TNO (Netherlands Organisation for Applied Scientific Research) in Utrecht, the Netherlands, which housed old StiBoKa data. StiBoKa, short for Stichting Bodem Kartering, was concerned with performing soil surveys during the second half of the twentieth century before large scale re-allotments destroyed most of the topsoil in West Frisia. Consulted pollen reports were only selected if they included a peat layer, and only samples that fell well within the limits of this layer were analysed further. In addition, the sampled peat layer needed to date to the sub-boreal time period, which includes the Dutch Bronze Age. This date was established by checking whether a continuous*Fagus* curve was present, which signifies the sub-boreal time period (van Gijssel & van der Valk 2005, 61). In some cases, additional radiocarbon dates were available. Subsequently, the raw data of these samples was reinterpreted. First, species present in the peat layer were assigned to specific groups, each signifying a unique ecotype (*i.e.* general types of growth locations of plant communities). These groups are summarized in Table 2.2.

Table 2.2. Ecotypes used for the analysis of botanical remains for the reconstruction of the landscape.

A	upland trees and shrubs
B	wetland trees and shrubs
C	upland herbs
D	salt marsh
E	wetland herbs
F	oligotrophic peat
H	ecologically indeterminate
J	moist to wet disturbed open grounds, low humus

In this manner, environmental indicators could be separated for trees versus an open landscape, wet versus dry conditions, saline versus non-saline conditions, and raised peat formation. The ecologically indeterminate group (H) included taxa which could not be identified to the species level, as well as species belonging to the *Cyperaceae* family, since these plants can grow in many different ecotypes. Subsequently, a pollen sum was created of the groups which signified regional vegetation (*i.e.* vegetation not present amongst the local eutrophic peat vegetation), including group A, C, D and F. Non-local vegetation growing under dry, saline, and/or oligotrophic peat, potentially present in the pollen record, could then be identified. Because dryland vegetation was separated from vegetation from wetlands in the applied method, there was no interference of local wet trees and shrubs, therefore allowing for an accurate assessment of the presence of upland trees in West Frisia.

The on-site pollen was analysed in exactly the same manner. On-site pollen included both settlement and burial mound contexts. Although burial mounds are by no means necessarily located within a settlement, they are included under this category because they are

part of the human activity realm, whereas (extensive) peat layers are natural phenomena occurring at off-site locations, or at least in the absence of human activity.

2.2.2 Botanical macro remains

Botanical macro remains for the reconstruction of the environment were analysed from every available settlement. In this analysis, macro remains from all preservation states and contexts were grouped to create an overview of the existing eco groups (*i.e.* specific types of growth locations of plant communities). With this overview, and using the same ecotype groups as for pollen in Table 2.2, it was possible to assess the salinity of the water present around the sites, as well as the presence of peat, and trees.

2.2.3 Animals: fish, birds, mammals

The animals presented here are not always included in integrated environmental research. Especially mammals have received little attention for this purpose, even though their potential indicative value for the reconstruction of the environment is high. Animals can provide such indications for the surroundings only when it is assumed that they were caught relatively close to the settlement. For West Frisia, it is indeed assumed that people hunted relatively near-by, because they were full-time farmers (cf. Chapter 3).

The manner in which animal remains are used for landscape reconstruction can be summarized under the term the "habitat approach". In this research, animal remains are not analysed quantitatively, because of the varying sampling strategies and mesh sizes applied (Table 2.1). Rather, the species itself is used as an indicator for the direct environment around the site where it was found, irrespective of the number of bones found of each species. Additionally, a list of possible habitats, as well as the possible animal species they could support was composed for West Frisia (Appendix A1.1 and A1.2). The expected species were then compared with the observed species at the West Frisian sites in order to reach conclusions about the environment.

Fish are used as indicators for the water type present around the sites, as well as water salinity. The main assumption made here is that fish in the Bronze Age lived in the same habitats and associations as today and exhibited the same behaviour. It is assumed that these elements have remained relatively the same for long periods of time, and therefore, fish are used in this research as representative indicators of the environment.

Table 2.3. Salinity groups based on grams of salt/kg of water (expressed in parts per thousand, or ppt).

	Salinity (ppt)
Fresh water	< 0.5
Brackish water	0.5 - 30
Slightly brackish water	0.5 - 10
Medium brackish water	11 - 15
(Very brackish water)	(16 - 30)
Salt water	31 - 50

NB. Since no species were found in West Frisia that prefer a salinity between 16-30 ppt, this group is placed between brackets, and will not be used in further analyses.

The habitat preferences of the fish species found, as well as their maximum salinity tolerances were assessed (Vissengids 2016, Marine Fish Map 2016, Copp *et al.* 2009). This information was grouped into five types of aquatic habitat: stagnant to slow-flowing water, (fresh) open water, fast-flowing water (river), connection to the sea, and open sea. Finally, some fish species have no specific preference for their habitat, and these are placed into a separate group, named "non-specific". When fish have more than one water type habitat preference, they are placed in every preferred habitat. Conversely, the maximum salinity that a fish can tolerate depends on the type of fish, but will always be represented by one preferred value (*i.e.* the maximum tolerance value). Salinity tolerance can be divided into salinity groups based on the amount of grams of salt dissolved in 1 kg of water (*i.e.* parts per thousand, or ppt). The groups that are used in this research are summarized in Table 2.3.

Freshwater fish cannot survive under high salinity conditions, but will usually tolerate low levels of salt in the water (0-15 ppt), although often only for a limited time (Vissengids 2016). Saltwater fish can tolerate saline conditions of more than 30 ppt. Migratory fish are capable of living in all salinity groups, because they travel back and forth between fresh water and the open sea. Therefore, their maximum salinity tolerance is >30, although these fish can also be found in fresh water. Because in this research no species with a preference for highly brackish water were found, this category will not be used further.

The different water type preferences as well as maximum salinity tolerances were grouped for each site and plotted in pie diagrams. These site-related diagrams were subsequently placed on a map of West Frisia to investigate regional trends in salinity and water type, and to assess the influence of salt and freshwater in western and eastern West Frisia in the Middle and Late Bronze Age. Within the pie diagrams, *N denotes* the number of species found per site.

Birds can provide a general indication of the habitat types present in the environment. Furthermore, they can confirm the presence of certain landscapes already indicated by other animals and/or botanical remains. The associations and habitats in which birds lived in the past are assumed to be similar to the present situation, as well as their behaviour.

It is also assumed that bird migratory routes in the past were similar to the routes at present. Although fluctuations do occur, the main migratory routes have remained relatively the same for the past 5000 years (Alerstam 1993, 226). Therefore, information on bird migration will be used in this research, combined with an open mind towards slight deviations from these patterns, especially regarding breeding grounds.

The same general methodology that was applied to fish was used for birds. Of every bird species found, information was gathered on their preference for certain habitats (Europese Vogelgids Online 2012; Nederlands Soortenregister 2015; Soortenbank Nederland n.d). However, since birds mainly provide information on the terrestrial landscape, and only indicate the general presence of fresh or saline water in the environment, the following habitat types were used: grassland, shrub land, trees, (freshwater) wetlands, and seacoast.

When the identification of a bird did not reach beyond the genus or family level, only preferences common to the entire genus or family, if present, were identified and included in the analysis. If these general preferences could not be applied to all the expected species within the genus or family, these birds were excluded. When a certain genus only had two possible expected species and more than two bones were found, preferences of both these species were included. Furthermore, since migratory birds may in fact prefer different habitats depending on their location, only the habitat types preferred by each species whilst present in these regions (*i.e.* mainland north-western Europe) were used. This information was obtained based on present-day migration patterns (Alerstam 1993). Widgeon (*Anas penelope*) for example, prefers grassland in the summer, when it is present in Scandinavia. In winter, however, when it is present in mainland north-western Europe, it prefers wetlands, and this habitat preference is thus used in this research. The habitat types preferred by the birds found on each site were again grouped and plotted in pie diagrams on a map of West Frisia in order to identify local and regional trends. The N denoted in each of the pie diagrams represents the number of species found on each site.

Mammals can be very good indicators of the environment. When small mammals (*i.e.* mice, voles, moles, etc.) are found at a site, they provide a local image of the direct environment surrounding a settlement. Large mammals can provide a more regional image, which can depend on migratory behaviour, as well as the size of the home range (*i.e.* the area in which the animal lives and travels). The size of the home range can furthermore give an idea of the distance of a certain habitat from the settlement.[2] The same general methodology that was applied to fish and birds was used for mammals. Of every

2. A home range analysis of mammals was performed in combination with the available botanical evidence in order to further assess the availability and extent of forest in the Bronze Age in West Frisia (Cronau 2016; Chapter 8, sections 8.2.2 and 8.2.3).

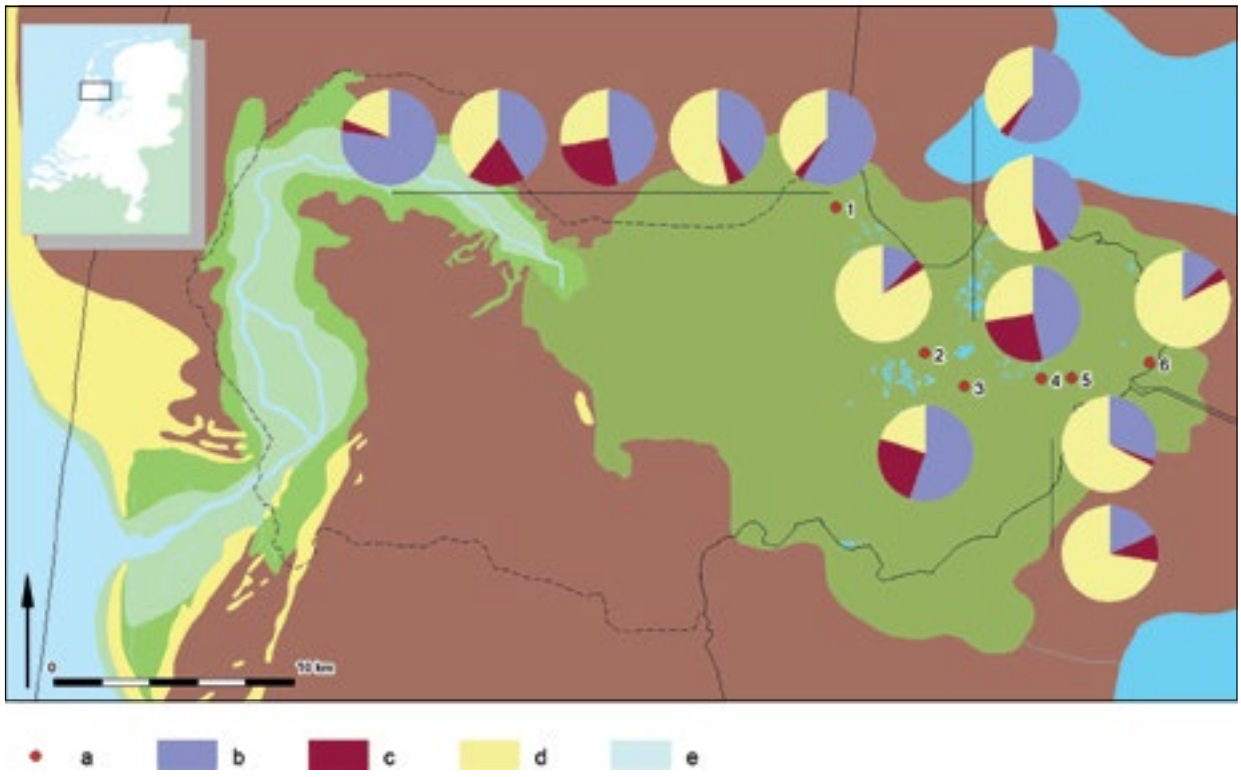

Figure 2.3. Indications for the regional landscape of West Frisia based on on-site pollen data. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: upland trees and shrubs; c: oligotrophic peat; d: upland herbs; e: salt marsh; 1: Medemblik (deep pit, ard marks and settlement ditches); 2: Zwaagdijk (ditch); 3: Grootebroek (burial mounds); 4: Hoogkarspel (burial mound); 5: Bovenkarspel (deep pit and ditch); 6: Enkhuizen (ditch).

mammal species found, information was gathered on the preference for certain habitats (Twisk *et al.* 2010). These habitat preferences are based on present-day situations and it is assumed that these would have been comparable to preferences of animals in the Bronze Age. For small mammals in particular, it is assumed that they derived from the immediate environment within or around the settlement. However, in some instances, exceptions to this assumption could exist (section 2.4.5).

The types of habitat used here are the same as for birds: grassland, shrub land, trees, wetlands, and the seacoast. For mammals, the most characteristic habitat(s) for each animal was/were used for the construction of the pie diagrams; multiple preferences again resulted in inclusion in multiple habitat type groups. In cases where the identification of a mammal did not reach beyond the genus or family level, it was not possible to find common habitat preferences. Therefore, these were left out of this analysis. When there was uncertainty about the precise identification of a species, usually only two possible species were indicated by the identifying specialist. In such cases, if more than two bones were found, both of these species' preferences were included. The habitat types preferred by the mammals found were grouped for each site and pie diagrams were plotted separately for small and large mammals on a map of West Frisia in order to see local and regional trends.

In general, it must be kept in mind that in all animal groups, the habitat preferences shown in the pie diagrams do not necessarily reflect the actual ratios of habitats present in the surroundings. People actively selected certain animals from their surroundings, for reasons of abundance, personal preference, availability, etc., meaning that some species, and therefore habitat types, may have become over- or under-represented compared to the originally present

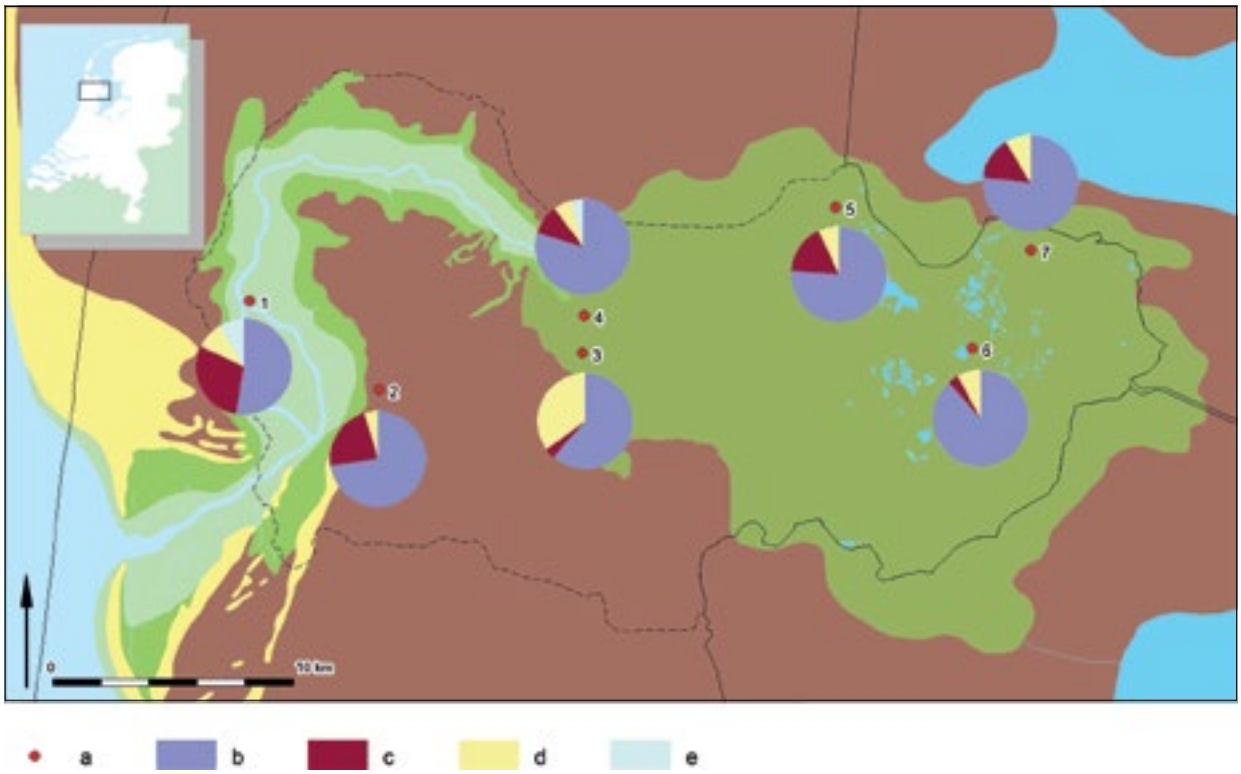

Figure 2.4. Indications for the regional landscape of West Frisia based on off-site pollen data. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: upland trees and shrubs; c: oligotrophic peat; d: upland herbs; e: salt marsh; 1: Warmenhuizen; 2: Zuid-Scharwoude; 3: Opmeer; 4: Hoogwoud; 5: Medemblik; 6: Klokkeweel bog; 7: Andijk.

ratios (section 2.4.5.2). The pie diagrams should therefore only be used as a general indication of available habitats.

2.3 ARCHAEOBOTANICAL RESULTS

2.3.1 Pollen

The results of both the on-site and off-site pollen analyses are shown in Figure 2.3 and Figure 2.4, respectively. The on-site pollen deriving from settlement contexts, including Medemblik, Enkhuizen, Bovenkarspel, and Zwaagdijk, all demonstrate a very open landscape, which is a similar conclusion to that drawn in the current model. However, some of the settlement contexts of Medemblik, as well as all the burial mounds indicate a higher presence of trees in the surroundings. Seemingly, based on this new analysis of regional indicators, on-site pollen does reflect that trees grew in the surroundings of the settlements, although they do not appear to have been present in high numbers. Moreover, at several locations the presence of oligotrophic peat can also be observed, such as in burial mound and ard mark contexts, but this seems largely absent within actual settlement contexts (*e.g.* pits, ditches). Finally, no clear indicators for saline conditions are present at any of the sites.

The off-site pollen analyses almost show the reverse image of the pollen from on-site locations. Upland trees and shrubs constitute a large portion of every diagram, indicating that the surroundings of the Bronze Age settlements were indeed far from treeless. In several of the diagrams, indicators of oligotrophic peat were present, suggesting that this type of peat did exist in the further surroundings of the settlements, although nearly none was found within settlement contexts. Finally, indicators of salt marsh

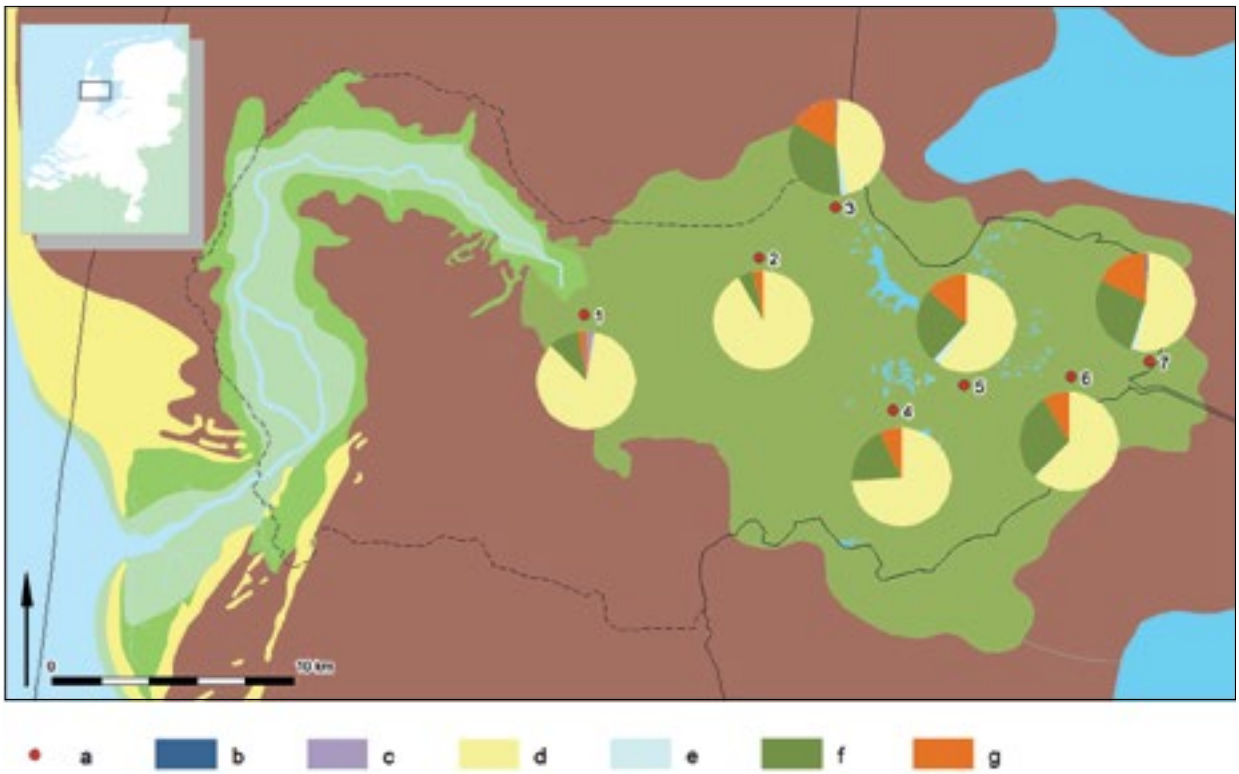

Figure 2.5. Indications for the regional landscape of West Frisia based on macro botanical data. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: upland trees and shrubs; c: wetland trees and shrubs; d: upland herbs; e: salt marsh; f: wetland herbs; g: wet, trodden soils; 1: Hoogwoud; 2: Twisk; 3: Medemblik; 4: Westwoud; 5: Hoogkarspel; 6: Bovenkarspel; 7: Enkhuizen.

were mainly present in Hoogwoud and Schagen. One salt marsh indicator was also found in the Klokkeweel bog (near Hoogkarspel), but this was not a definitive identification (*i.e. Plantago* cf *coronopus*), so it does not necessarily reflect (local) saltwater conditions. Other proxies will have to indicate whether salt marshes existed in the eastern part of West Frisia.

2.3.2 Botanical macro remains

In Figure 2.5, the results of the botanical macro remains analysis are plotted. For this analysis, all the remains from the Middle and the Late Bronze Age are pooled. Besides these remains, remains of wood are relatively scarce in West Frisia, but at Bovenkarspel and Westwoud, several wood remains were found, which are summarized in Figure 2.6.

The major share of each of the pie diagrams consists of upland herbs, followed by wetland herbs, and herbs from wet, trodden soils. Although this by no means signifies a mainly dry landscape, it does show that both wet (freshwater) and dry open areas were present in the surroundings of the settlements. Again, no indications for peat are found at any of the researched locations.

Salt marsh indicators were observed on several occasions. However, upon closer inspection, these plant remains were all found in deep pits or deep ditches, which were dug into former tidal marsh deposits. They can therefore be interpreted as contamination from earlier periods, and do not signify the presence of a salt marsh in the surroundings of the settlements.

Trees and shrubs, both of upland and wetland origin, are very sparsely represented in the macro botanical record by catkins, and some fruits and nuts. Their near-absence is often interpreted as evidence for

the presence of an open landscape (*i.e.* the current model). In the wood record however, although limited in quantity, it is clear that a wide variety of tree species must have been available during the Bronze Age in West Frisia.

2.3.3 Vegetation reconstruction of eastern West Frisia

The vegetation reconstruction of eastern West Frisia was divided into the Middle and Late Bronze Age periods. This division was made because a supposed deterioration of the climate occurs in the Late Bronze Age (section 2.1), and this may only become apparent when comparing the two periods.

Middle Bronze Age

The general indications for different types of habitat present in the surroundings of the settlements obtained from the archeaobotanical remains was researched in finer detail by creating an actual vegetation reconstruction.

The vegetation of West Frisia in the Middle and Late Bronze Age was reconstructed by Van Zijverden by using a combination of disciplines (van Zijverden forthcoming). Physical geography was employed to reconstruct the properties of the existing soils in the Bronze Age. Important soil characteristics and processes which influence the growth of vegetation include relief, hydrology, subsoil, and water fluctuation. Each of these factors was reconstructed for the West Frisian situation in the Middle and Late Bronze Age, thus creating a soil suitability map (van Zijverden forthcoming). Subsequently, this map, with its reconstructed combinations of indicator values for plant growth, was used to predict the possible vegetation types at different locations in the landscape. However, possible vegetation types were not only selected based on their preferences for the reconstructed soil conditions. The second selection step was based on the availability of plant species in the Bronze Age. With the aid of phytosociology, the presence of diagnostic species for certain vegetation types in the macro remains from settlements was used, since these diagnostic species can, per definition, signify either general phytosociological vegetation classes, or even specific plant associations. However, it must be kept

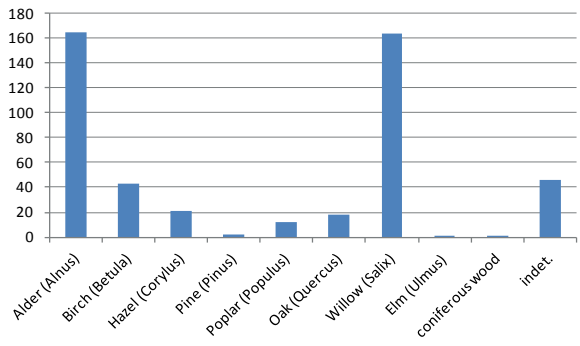

Figure 2.6. Frequency of wood remains from different species found at both Bovenkarspel and Westwoud. Data is pooled for the entire Bronze Age.

in mind that the name of a vegetation class is not necessarily linked to the diagnostic species within the underlying plant associations, so class names can be very misleading when not further examined. For example, the class *Querco-Fagetea* would suggest a forest with both oak and beech trees. However, several of the subdivisions within this class do not require beech at all. These aspects of phytosociology should be taken into consideration when applying vegetation to different soil types, since the different phytosociological classes and associations are often specific for certain soil conditions. They can therefore provide additional information on all the different succession stages which can occur on such soils. When diagnostic species cannot be identified, especially for multiple stages of succession, there is a possible indication for the absence of certain vegetation types in the surroundings.

Based on this approach, the following vegetation types were reconstructed based on the different soil properties within the Middle and the Late Bronze Age landscape, here exemplified by the area around Westwoud, with a focus on the climax succession stages where possible (van Zijverden forthcoming; Figure 2.7 and Figure 2.8):

In the Middle Bronze Age (Figure 2.7), alder carrs would cover lower lying areas with high ground water and stagnant, eutrophic water conditions. This class (*Alnetea-Glutinosae*), can further be subdivided in alder carr with an undergrowth of ferns (*Thelypterido-Alnetum*) or sedges (*Carici elongatae-*

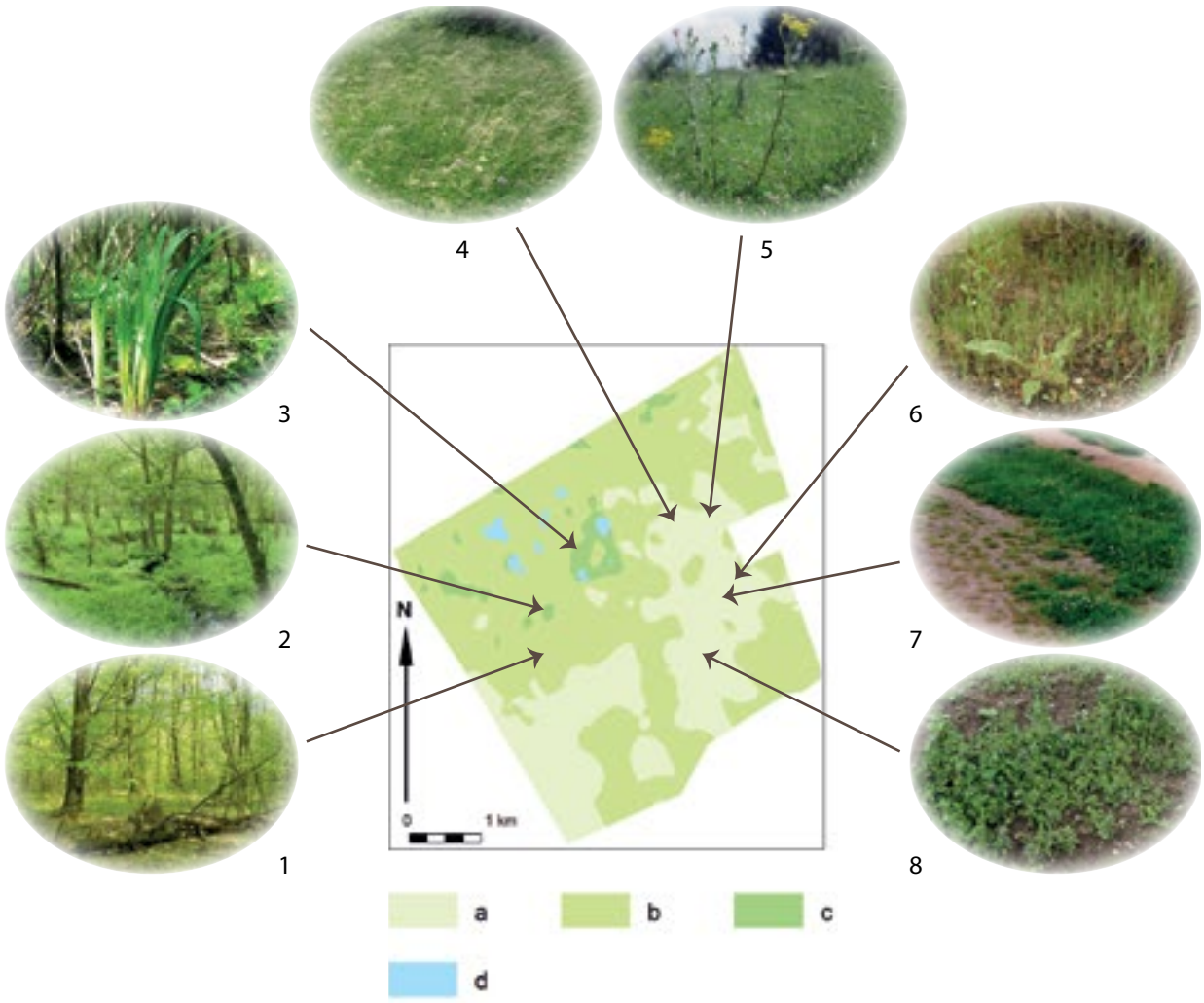

Figure 2.7. Overview of the different vegetation types[3] present in the Middle Bronze Age, exemplified by the area around Westwoud (map from: van Zijverden forthcoming). a: medium clay content in top and subsoil; b: high clay content in top soil and medium clay content in subsoil; c: medium clay content in top soil and high clay content in subsoil; d: high clay content in top and subsoil; e: fresh water lake; 1: *Fraxino-Ulmetum*; 2: Thelypterido-Alnetum; 3: *Carici elongatae-Alnetum*; 4: *Arrhenatherion elatorius*; 5: *Cynosurion cristati*; 6: *Salsolion ruthenicae*; 7: *Polygonion avicularis*; 8: *Fumario-Euphorbion*.

Alnetum). Both of these remain a possibility since no specific indications for each of these subdivisions were available in West Frisia. In the slightly drier areas of the landscape, the forest type *Querco-Fagetea* could exist. Further sub-divisions of this class were possible based on the specific soil conditions of West Frisia. The high calcium carbonate content, local high ground water level, and presence of several diagnostic species led to the identification of a *Fraxino-Ulmetum* forest type. Alternatively, a *Viola odorata-Ulmetum* forest could have developed, although no diagnostic species for this association were present in the West Frisian data.

3. Photos adapted from: *Carici elongatae-Alnetum* 2006; *Fraxino-Ulmetum* 2006; *Polygonion avicularis* 2006; Thelyptherido-Alnetum 2006; Arrhenatheretea elatioris 2007; *Artemisio-Salicetum albae* 2007; *Cynosurion cristati* 2007; Oenanthion-aquaticae 2007; Chytrý 2009, 129, fig 94; *Sparganio-Glycerion* 2010; *Fumario-Euphorbion* 2016

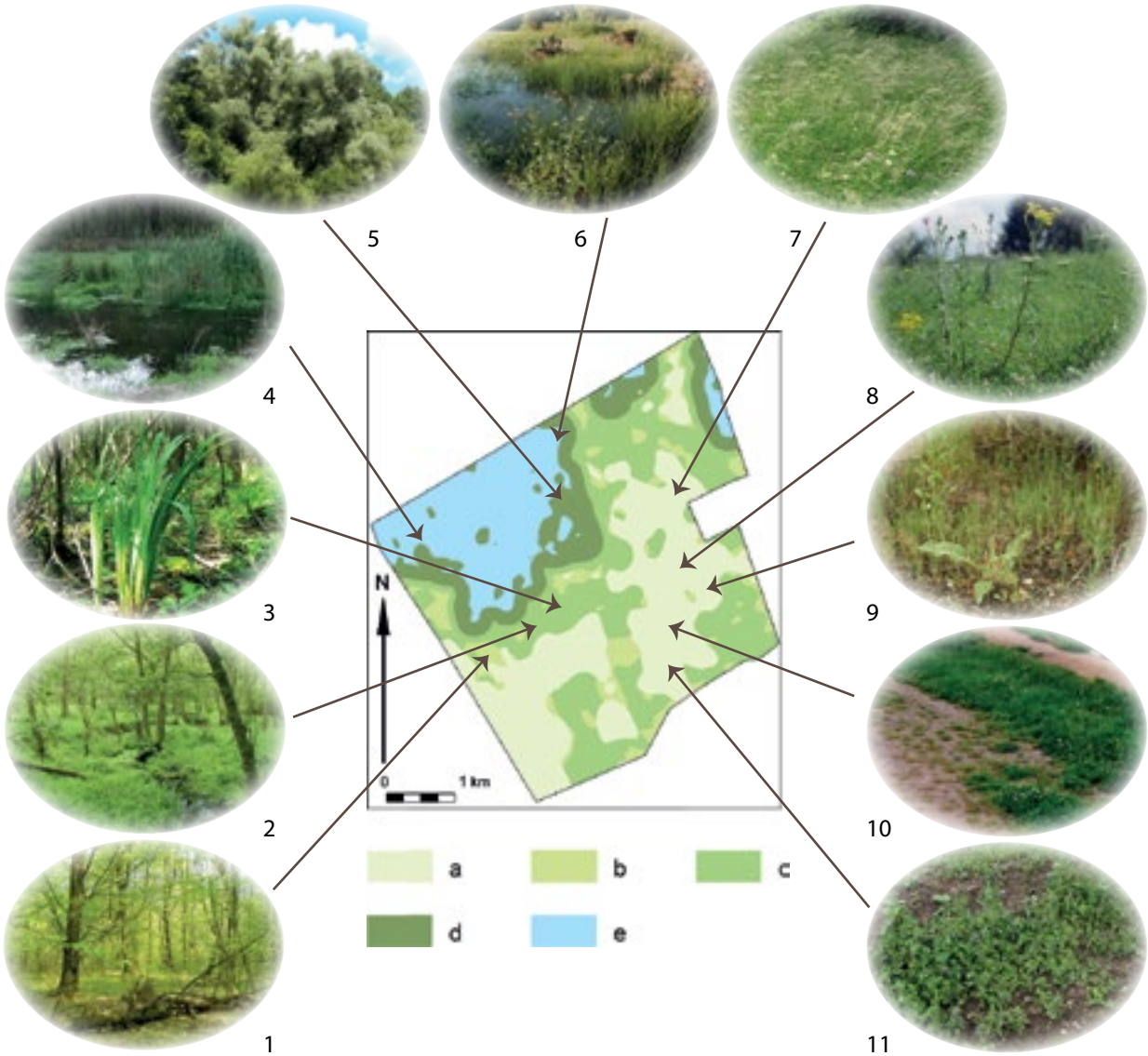

Figure 2.8. Overview of the different vegetation types[4] present in the Late Bronze Age, exemplified by the area around Westwoud (map from: van Zijverden forthcoming). a: medium clay content in top and subsoil; b: high clay content in top soil and medium clay content in subsoil; c: medium clay content in top soil and high clay content in subsoil; d: high clay content in top and subsoil; e: fresh water lake; 1: *Fraxino-Ulmetum*; 2: Thelyptherido-Alnetum; 3: *Carici elongatae-Alnetum*; 4: Oenanthion-aquaticae; 5: *Artemisio-Salicetum albae*; 6: *Sparganio-Glycerion*; 7: *Arrhenatherion elatorius*; 8: *Cynosurion cristati*; 9: *Salsolion ruthenicae*; 10: *Polygonion avicularis*; 11: *Fumario-Euphorbion*.

At the driest areas in the landscape, again a *Querco-Fagetea* type forest could develop, and based on the soil nutrition and the relatively lower ground water table at these locations, a *Carpinion-Betuli* forest subdivision was expected here. However, no diagnostic species for this succession stage were present in the pollen and macro botanical data. Diagnostic species for the edges of this type of forest, including sloe (*Prunus spinosa*) were also absent in West Frisia, although remains of its fruits

4. Photos adapted from: *Carici elongatae-Alnetum* 2006; *Fraxino-Ulmetum* 2006; *Polygonion avicularis* 2006; Thelyptherido-Alnetum 2006; Arrhenatheretea elatioris 2007; *Cynosurion cristati* 2007; Chytrý 2009, 129, fig 94; *Fumario-Euphorbion* 2016

are commonly found on Bronze Age settlements in other areas of the Netherlands. Clear diagnostic species of the plant community occurring in a succession stage before that of the forest edge (*Galio-Alliarion*), were also absent. Definite evidence of the succession related to the *Carpinion-Betuli* forest was only present in the form of moderately nutrient-rich grasslands (*Molinio-Arrhenatheretea*). These grasslands could be further subdivided into two possible grassland associations (*Arrhenatherion elatorius* and/or *Cynosurion cristati*). The definite absence of most of the succession stages towards climax vegetation on the driest soils of West Frisia indicates that this type of slow growing forest may never have had the chance to fully develop in the Bronze Age, or at least not to the extent that remains are visible in the researched settlement contexts. Although some patches of this forest type may have remained in some areas, overall, grasslands will have prevailed.

Human influence could be very well be the reason for this absence of dry forest, which becomes apparent based on the presence of human-induced open areas. Ruderal vegetation could be identified (*Artemisietea vulgaris*, *Salsolion ruthenicae*), as well as arable-related vegetation (*Stellarietea mediae*, *Fumario-Euphorbion*), and trampled, moderate nutrient-rich grassland (*Plantaginetea majori*, *Polygonion avicularis*).

Late Bronze Age

The Late Bronze Age landscape (Figure 2.8) largely contains the same vegetation types as the Middle Bronze Age. However, since during this time both ground water levels as well as surface water fluctuations increase, additional vegetation types appear, and previously present vegetation types sometimes experience a shift in location within the landscape.

In the Late Bronze Age, the lowest areas in the landscape develop into shallow lakes characterised by reed swamp vegetation (*Phragmitetea*), which could be further subdivided into two possible orders (*Sparganio-Glycerion* and/or *Oenanthion aquaticae*). Along the lake borders, wood willow shrubs thrived (*Artemisio-Salicetum albae*). The influence of the increased water table height and increased water fluctuation caused the remaining (drier) vegetation types to condense into smaller areas. The influence of the landscape on the subsistence farming economy and vice versa will be further explored in Chapters 4-8.

2.3.4 Summary

The use of off-site pollen has yielded several new results and insights. Off-site pollen reflects a very different image than the current model, showing the definite presence of trees in the (further) surroundings of the settlements. Also, based on the comparison with on-site pollen, it is clear that peat growth does occur in the Bronze Age, but not on such a large scale that it covered the settlement areas. Excessive peat growth can therefore not be viewed as the cause for abandonment of the area, since even in Late Bronze Age contexts, such as the deep pit sample from Bovenkarspel, almost no indicators for peat are present. Finally, some indications for saline influence in West Frisia are observed, mainly in Schagen and Hoogwoud. Other proxies will have to clarify whether this influence can be placed before or after 1550 BC, since such exact dates for the pollen diagrams were not available.

Botanical macro remains have provided information on several aspects related to the landscape as well. First, there is an absence of clear saltwater indicators throughout West Frisia, seemingly confirming the presence of a freshwater environment. However, the animal proxies need to be consulted before finally drawing this conclusion. Also, the obvious lack of peat indicators appears to confirm the conclusion based on pollen remains, namely that peat did not grow to the extent that it covered the settlements. Finally, the presence of a range of available tree species was only indicated well by the wood finds, rather than by the macro botanical finds.

The vegetation reconstruction finally, has provided a clear image of the possible vegetation types present around the settlements in each time period. In addition, it has enabled the identification of human influence through the absence of certain succession stages, and the presence of human-induced vegetation types. In this manner, the reconstruction has created

an idea of both the natural and cultivated landscapes during the Bronze Age.

2.3.5 Discussion

In order to assess the reason why the present results are so different from the past view of the West Frisian landscape, several aspects related to past and recent methodology regarding the archaeobotanical record will be discussed. In addition, possible indicators for the cultural landscape will be discussed, in order to identify markers of human impact on the environment based on the archaeobotanical proxies.

2.3.5.1 Methodology

Pollen

The striking difference in the amount of trees present in the surroundings represented by on-site and off-site pollen samples can mainly be explained by the applied methodology in the field. The sampling location of on-site pollen is often restricted to deep pits and deep ditches, where preservation conditions are relatively good. However, these contexts consist of a basin (*i.e.* location in which pollen can precipitate) with a very small diameter in which pollen can accumulate. Since a basin with a small diameter can, by definition, only be used to interpret the area surrounding the sampled location (Sugita 1994; Sugita *et al.* 1999), the resulting pollen diagram will therefore reflect only a very local image of the landscape. Ideally, pollen samples for interpretation of the wider surroundings of the sampled location should derive from basins of more than 5 meter in diameter (Sugita 1994; Sugita *et al.* 1999). Since the on-site sampled contexts all consist of a small diameter and all lie well within the settlement, the analysed pollen diagrams will naturally represent an open landscape, which is the settlement landscape itself. Samples from the peat layers present within the StiBoKa data from off-site locations, allow for a clear regional picture, indicating that trees formed a definitive part of the (wider) surroundings of the settlement. Therefore, in order to create a reliable regional vegetation reconstruction, pollen samples should preferably be taken from off-site locations or basins with an appropriate diameter. Furthermore, the usual methodology applied within palynological research could also be modified in order to more precisely identify regional vegetation, such as was performed here by creating a pollen sum of regional versus local vegetation, rather than tree versus herb pollen.

Macro remains

Trees and shrubs, both of upland and wetland origin, are very sparsely represented in the macro botanical record, including only the remains catkins, and some fruits and nuts. In the past, their near-absence has often been interpreted as evidence for the presence of an open landscape (*i.e.* the current landscape reconstruction model). Conclusions based on this single proxy have proven not to be adequate in reconstructing the presence of trees in the wider landscape. However, by combining this information with the remains of wood and off-site pollen, a clearer picture can be obtained of the variety of tree species available to people in the area.

2.3.5.2 Indicators for the cultivated landscape

Pollen

Indicators for the cultivated landscape within the pollen record may include several types of pollen. For example, pollen from cereals (*Cerealia*) and crop weeds can indicate cultivation in the near surroundings, declining tree pollen and increasing pollen of pioneer vegetation can indicate increased pressure of humans on the (forest) environment, and finally the occurrence of nitrophilous plants, can indicate use of manure (for an overview see Li 2008 and references therein). A combination of this pollen can be used to identify human activity. In general, several of these indicators were recognized in the West Frisian pollen diagrams. The on-site pollen showed the presence of cereal pollen, which is an extra confirmation of crop cultivation in the surroundings of the settlements. Off-site pollen showed a decreasing trend of tree pollen towards the end of the Subboreal period. The combination of on-site and off-site pollen does seem to indicate that throughout the Bronze Age, people were increasingly cultivating the available land at the expense of surrounding forests. The extent of this impact will be researched in Chapter 8, section 8.2.

Macro remains
Cereals and chaff provide the most direct indications for cultivation, and these are found in high frequencies in the archaeobotanical record (Chapter 5: Crop husbandry). Other indications for the cultivation of the landscape include many plants that signify wet, trodden environments (Figure 2.5), many nitrophilous plant species, as well as pioneer vegetation. The remains of wood from several different species from both the Middle and Late Bronze Age also confirm the use of the surrounding forest in both periods. No clear change in the use of wood could be established between these periods, indicating that even though people were impacting the forests in the Late Bronze Age, they were still present.

2.4 ARCHAEOZOOLOGICAL RESULTS

As shortly introduced at the beginning of this chapter, the new approach here is mainly concerned with the comparison between expectation and data. In addition, the use of three different groups of animals (fish, birds, and mammals) is presented and discussed, which is a rich, but often neglected potential source of information for landscape reconstruction.

2.4.1 Fish

Three main topics will be discussed here regarding the environment related to fish, firstly whether the fish species present in West Frisia match with what was expected (Appendix A1.2), so that outliers or missing species will become apparent. Secondly and thirdly, the water type preference as well as the maximum salinity tolerance of all the species from the West Frisian sites will be discussed, also in relation to the location where these fish remains were excavated. These three factors together will provide information on the aquatic landscape surrounding the settlements. An overview will be created for the entire Bronze Age, as well as for the Middle Bronze Age (MBA) and Late Bronze Age (LBA). This separation into two periods is necessary to be able to identify possible changes in the aquatic landscape through time.

2.4.1.1 Observed species and habitat types

A list of all the fish species found in West Frisia is shown in Table 2.4 and an overview of their presence per site in Table 2.5. In Table 2.4, the fish are sorted according to their preferred habitat type, and subsequently by alphabetic order. To increase the readability of the table, the different habitat types are identified by different colours. In addition, the general trends in water salinity and water flow are denoted by arrows alongside the axes of the table. The references for the information acquired on habitat type and salinity level are also included in the table. Species that do not list a reference for maximum salinity tolerance live under saline conditions and are therefore considered to have a salinity tolerance value of > 30 ppt (cf. Table 2.3).

The fish species found have representatives of all the expected aquatic habitats, so it is clear that there was great diversity in fish species present in West Frisia. Many of the fish species seem to prefer stagnant to slow-flowing waters. The open water habitat is also relatively well represented. Species that have an additional preference for fast-flowing water were also found, but many species preferring solely this habitat type were not uncovered. Migratory fish species, requiring a connection to the sea, are abundant and can be divided into two groups: anadromous fish, which travel from saltwater to fresh water to reproduce, and catadromous fish, travelling in the other direction. Another nine fish species prefer an open sea habitat, which are all the expected species for this habitat type (Appendix A1.2). Only two fish species have a non-specific habitat preference. Maximum salinity tolerances finally, range from very low salt levels to saline conditions. Interestingly enough, no salt-intolerant fish species were found.

To the right: General increasing salinity is denoted on the y-axis, whereas general increasing water flow is denoted on the x-axis. Differently coloured captions indicate different habitat types. f: fast-flowing water; sea conn: sea connection; sl: slow-flowing water; st: stagnant water; open: open water; ref: reference; 1: Vissengids 2016; 2: Marine Fish Map 2016; 3: Copp *et al.* 2009. Species that do not list a reference for maximum salinity tolerance can live under saline conditions and are therefore considered to have a salinity tolerance value of > 30 ppt.

Table 2.4. Overview of all the fish species found in West Frisia arranged by preferred water type and maximum salinity tolerance.

Water type preference	open sea	open sea	open sea	open sea	open sea	open sea	open sea	open sea	open sea
Taxa	*Clupea harengus*	*Dasyatis pastinaca*	*Dicentrarchus labrax*	*Eutrigla gurnardus*	*Gadus morhua*	*Pleuronectus platessa*	*Raja clavata*	*Solea solea*	*Sprattus sprattus*
English name	Atlantic Herring	Stingray	Sea bass	Grey gurnard	Atlantic Cod	Plaice	Thornback ray	Sole	Sprat
fish type (migratory)									
max. salinity (ppt)	saline	saline	saline	saline	saline	saline	saline	saline	saline
ref water	1	2	1	2	2	2	2	2	1

Water type preference	sea conn	sea conn	sea conn	sea conn, sl	sea conn, sl	sea conn, sl	sea conn, f	sea conn, f	sea conn, f	sea conn, f
Taxa	*Anguilla anguilla*	*Osmerus*	*Platichthys flesus*	*Alosa fallax*	*Liza aurata*	*Liza ramada*	*Acipenser sturio*	*Alosa alosa*	*Coregonus sp*	*Salmonidae* indet.
English name	Eel	Smelt	Flounder	Twaite shad	Golden grey mullet	Thinlip mullet	Sturgeon	Allis shad	Whitefishes	Salmon-family
fish type (migratory)	catadrome	anadrome	catadrome	anadrome	catadrome	catadrome	anadrome	anadrome	anadrome	anadrome
max. salinity (ppt)	saline	saline	saline	saline	saline	saline	saline	saline	saline	saline
ref water	1	1	1	1	1	1	1	1	1	1
ref salinity										

Water type preference	open	open, st, sl	open, st, sl	open, sl
Taxa	*Gymnocephalus cernuus*	*Perca fluviatilis*	*Siluris glanis*	*Alburnus alburnus*
English name	Ruffe	Perch	Catfish	Bleak
fish type (migratory)				
max. salinity (ppt)	10-12	4.4-8.3	<15	10
ref water	1	1	1	1
ref salinity	1	1	3	1

Water type preference	open, f
Taxa	*Leuciscus idus*
English name	Ide
fish type (migratory)	
max. salinity (ppt)	15
ref water	1
ref salinity	1

Water type preference	st,sl	st,sl	st,sl	st,sl	st,sl	st,sl
Taxa	*Abramis brama*	*Blicca bjoerkna*	*Esox lucius*	*Pungitius pungitius*	*Scardinius erythrophthalmus*	*Tinca tinca*
English name	Bream	Silver bream	Pike	10-spined Stickleback	Common rudd	Tench
fish type (migratory)						
max. salinity (ppt)	10	1-10	5-15	<15	1-10	<12
ref water	1	1	1	1	1	1
ref salinity	1	1	1	1	1	1

Water type preference	non-specific, sea conn	non-specific
Taxa	*Gasterosteus aculeatus*	*Rutilus rutilus*
English name	3-spined Stickleback	Roach
fish type (migratory)	anadrome	
max. salinity (ppt)	saline	4-5 (adults)
ref water	1	1
ref salinity		1

Increasing maximum salinity tolerance

Increasing water flow preference

Table 2.5. Overview of the frequency of fish species found at each of the Bronze Age sites.

Taxa	English name	Boven-karspel	Enk-huizen	Medem-blik	West-woud	Hoog-woud	Schagen	Freq.
Anguilla anguilla	Eel	x	x	x	x	x	x	6
Esox lucius	Pike	x	x	x	x	x	x	6
Abramis brama	Bream	x	x	x	x	x		5
Perca fluviatilis	Perch	x	x	x	x		x	5
Abramis bjoerkna	Silver bream	x	x	x				3
Gasterosteus aculeatus	3-spined Stickleback	x			x		x	3
Rutilus rutilus	Roach	x	x	x				3
Alburnus alburnus	Bleak	x	x					2
Dicentrarchus labrax	Sea bass					x	x	2
Liza ramada	Thin-lipped mullet					x	x	2
Platichthys flesus	Flounder					x	x	2
Pungitius pungitius	10-spined Stickleback	x			x			2
Raja clavata	Thornback ray					x	x	2
Scardinius erythrophthalmus	Common rudd		x	x				2
Siluris glanis	Catfish	x	x					2
Acipenser sturio	Sturgeon						x	1
Alosa alosa	Allis shad						x	1
Alosa fallax	Twaite shad						x	1
Alosa alosa/fallax	Allis/Twaite shad						x	1
Clupea harengus	Herring						x	1
Clupea harengus/ Sprattus sprattus	Herring/Sprat						x	1
Dasyatis pastinaca	Stingray						x	1
Eutrigla gurnardus	Grey gurnard		x					1
Gadus morhua	Cod					x		1
Gymnocephalus cernuus	Ruffe	x						1
Leuciscus idus	Ide	x						1

Taxa	English name	Boven-karspel	Enk-huizen	Medem-blik	West-woud	Hoog-woud	Schagen	Freq.
Liza ramada/aurata	Thin-lipped/ Golden mullet						x	1
Osmerus eperlanus	Smelt						x	1
Pleuronectus platessa	Plaice					x		1
Solea solea	Sole						x	1
Tinca tinca	Tench	x						1

Presence of a species is denoted by an 'x'. Salmonidae indet. could be either Atlantic salmon (Salmo salar) or sea trout (*Salmo trutta*). Cyprinidae, or cyprinids, could include the species bream, silver bream, roach, bleak, common rudd, ruffe, ide, and tench.

2.4.1.2 Bronze Age overview

The species, as shown in Table 2.4, are grouped together independent of their location in West Frisia, and also independent of the time period to which the site at which these fish were found was dated. This grouping was performed in order to first obtain a general idea of the habitat types present in West Frisia. This general idea allows for the recognition of major habitat types which were present throughout the Bronze Age. In Table 2.5, representing the Bronze Age overview of fish at the different sites, the species are arranged for each site to show which of the habitat type and salinity preferences were present in each area of West Frisia. The Bronze Age overview in addition allows for the inclusion of Schagen, an Early Bronze Age site.

A clear difference in habitat type preference can be seen between sites in the west and the sites in the east. Schagen and Hoogwoud mainly show preferences for open sea and a sea connection, whereas Medemblik, Enkhuizen, Westwoud, Bovenkarspel show preferences for stagnant-slow and open water.

Again, a clear difference can be seen between sites in the west and the sites in the east. Schagen and Hoogwoud show an abundance of saltwater tolerant species, whereas in Medemblik, Enkhuizen, Westwoud, and Bovenkarspel the fish overall show lower salinity tolerance levels.

In Figure 2.9, pie diagrams are plotted of the species composition of every site. The colours in these diagrams are related to the colours used in Table 2.4, denoting the different habitat type preferences. In this figure, no distinction in date of the sites was made, so the entire Bronze Age is included. Schagen, which is the only site dated to the Early Bronze Age, can only give indications for habitat types that existed before the occupation of the other sites. Although water habitat types of fish from Schagen might have remained relatively unchanged throughout the Bronze Age, there is no fish data available from that area during later periods, so this remains inconclusive.

It becomes clear from Figure 2.9 that a distinction can be made between sites in the west and the east of West Frisia. At Schagen and Hoogwoud, in the west of West Frisia, the most frequently preferred habitat types are the open sea and a connection to the sea. In Schagen, however, a wider range of habitat types is present than in Hoogwoud.

In the eastern sites, Medemblik, Enkhuizen, Westwoud, and Bovenkarspel, there is a tendency towards a preference for stagnant to slow-flowing water. In Enkhuizen and Bovenkarspel, the additional preferences for open water appear to be more prevailing than in Westwoud and Medemblik. Finally, fish that prefer a connection to the sea also appear at every site in the east of West Frisia.

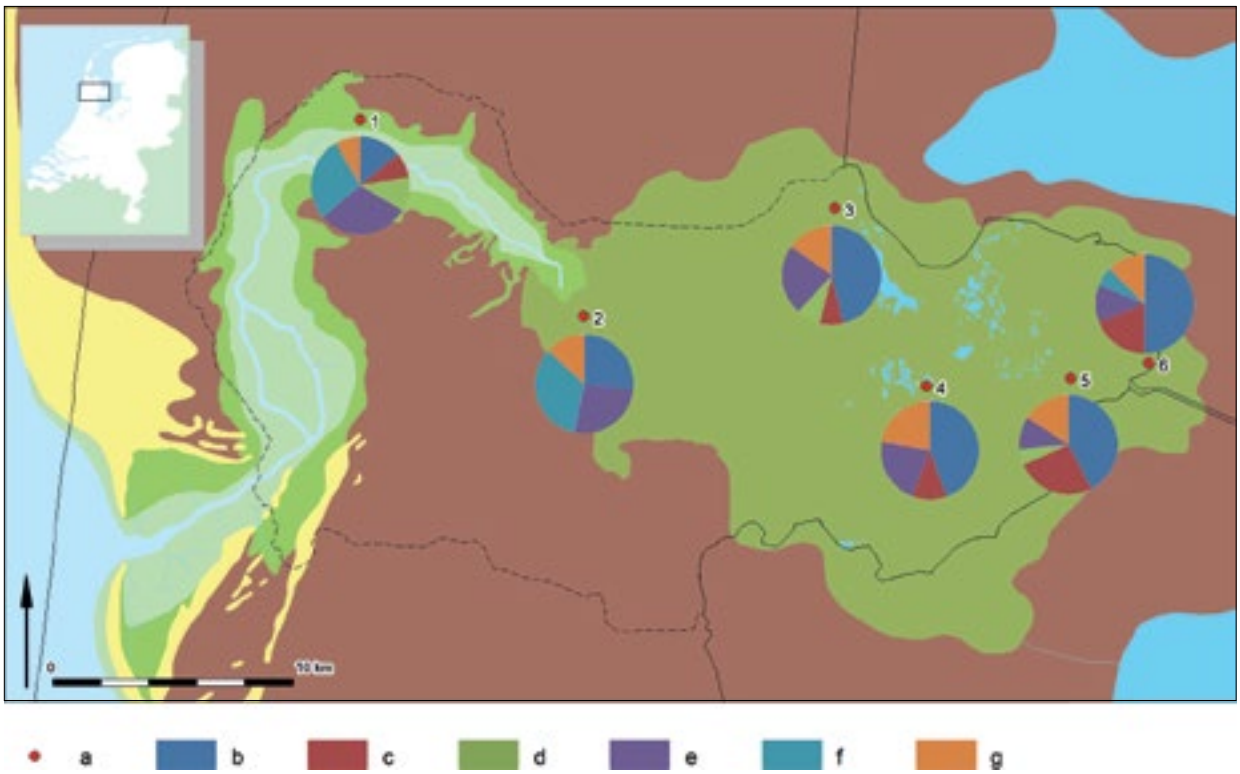

Figure 2.9. Map of Bronze Age West Frisia with the water habitat preferences of the fish species found at each site. N denotes the number of species found at each site. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: stagnant to slow-flowing water; c: open water; d: fast-flowing water (river); e: sea connection; f: open sea; g: non-specific preference; 1: Schagen, n=23; 2: Hoogwoud, n=11; 3: Medemblik, n=9; 4: Westwoud, n=6; 5: Bovenkarspel, n=13; 6: Enkhuizen, n=12.

Only one aberrant habitat preference (*i.e.* outlier) was observed, in the fish assemblage of Enkhuizen. Here, a preference for the open sea was apparent, represented by one bone of grey gurnard (*Eutrigla gurnardus*) found at this location. No indications for the direct influx of sea water in this area (yet) exist (including results based on other proxies), and no other open sea species were found here or at any of the other eastern sites. This one fish bone is considered an outlier that does not reflect the local environment of Enkhuizen in the Bronze Age because this saltwater species does not fit in the prevailing habitats based on the other species and proxies.

The diagrams for maximum salinity tolerance of the fish species found depict a similar trend, as seen in Figure 2.10. In Schagen and Hoogwoud, the maximum salinity tolerance of species is high; most species tolerate saltwater conditions. Conversely, in the eastern sites, the maximum tolerated levels of salinity are mostly light to medium brackish. Overall, in eastern West Frisia, the maximum tolerance level in Medemblik and Enkhuizen seems to be relatively lower than in Westwoud and Bovenkarspel.

2.4.1.3 Middle Bronze Age

Figure 2.11 shows the water type preference of fish from Middle Bronze Age (MBA) contexts.

From this figure, it is apparent that the trend observed in the general Bronze Age situation is maintained; Hoogwoud reflects a mostly saltwater environment. The maximum salinity tolerance diagrams for the Middle Bronze Age (Figure 2.12) show the division between Hoogwoud and the eastern sites during this time even more clearly. The presence of both saltwater fish species as well as migratory

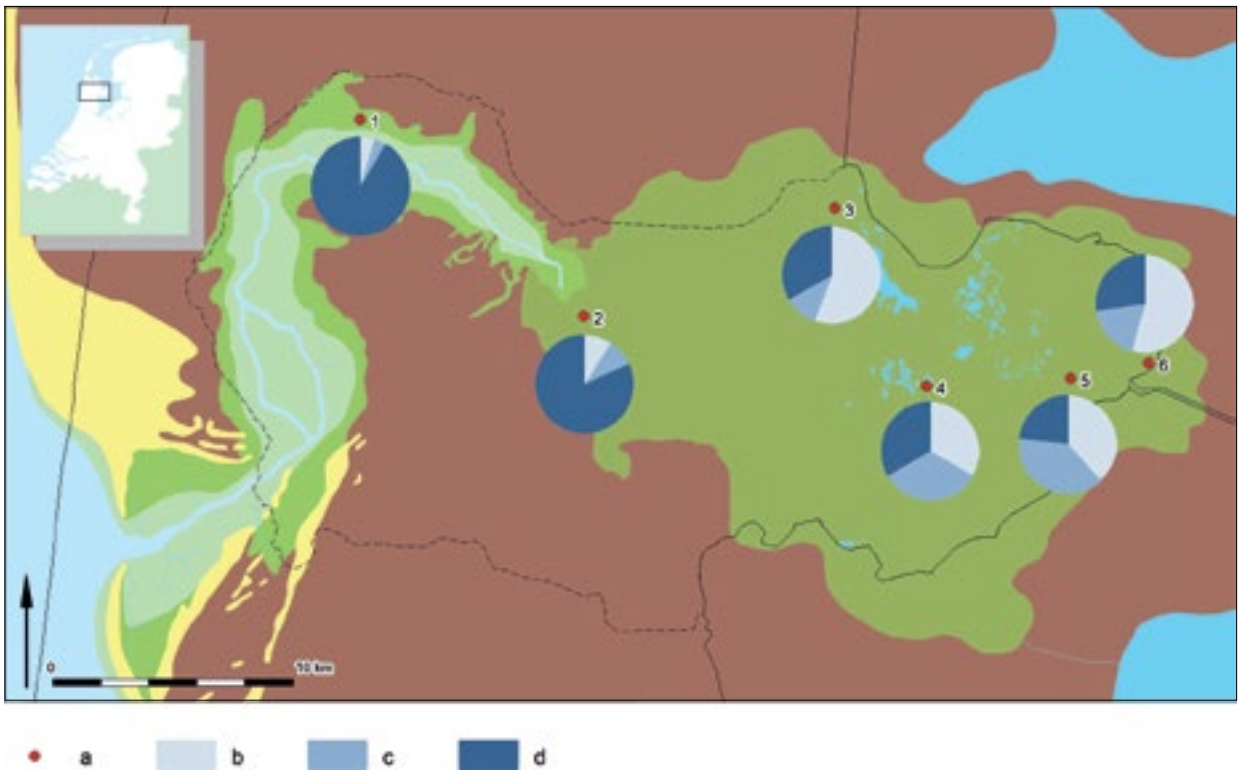

Figure 2.10. Map of Bronze Age West Frisia with maximum salinity tolerance of fish species found at each site. N denotes the number of species found at each site. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: fresh to slightly brackish water (0-10 ppt); c: medium brackish water (10-15 ppt); d: salt water (more than 30 ppt); 1: Schagen, n=23;2: Hoogwoud, n=11; 3: Medemblik, n=9; 4: Westwoud, n=6; 5: Bovenkarspel, n=13; 6: Enkhuizen, n=12.

fish species inherently means that saline influence in the hinterland (*i.e.* at least until Hoogwoud) was still present until at least 1300-1100 BC. This new observation starkly contrasts with the conclusions of the current model, which place the closure of the seacoast around 1550 BC. In this case, fish as an environmental proxy have provided clear evidence for the new sea coastal model[5].

The fish from the eastern sites of West Frisia, including Medemblik, Enkhuizen, Westwoud, and Bovenkarspel, display a maximum tolerance of only low levels of salinity. However, no species were uncovered that can only live in purely freshwater conditions, such as barbel (*Barbus barbus*) (Appendix A1.2). Therefore, (very) low levels of salinity are proposed for the surrounding waters of the eastern West Frisian sites, possibly even reflecting the salinity levels of the large lakes east of this area during this time (Figure 2.13). Rather than the previously proposed purely freshwater environment, there seems to have been a variety of freshwater and slightly brackish environments in the surroundings of the sites in the eastern part of West Frisia.

Related to this observation, another interesting trend is recognizable in Figure 2.11. At every eastern site of West Frisia there are examples of fish that require a connection to the sea. Species that prefer this habitat type are mostly eel and salmonids (*Salmonidae* spec., including salmon and trout species). Salmon or trout are known to travel far upriver to spawn, and during this time, they can migrate tens of kilometres inland. Eel on the other hand, spends most of its

5. For further reference regarding the dating of the closure of the seacoast at the Bergen inlet and the new sea coastal model, see Van Zijverden (in prep.).

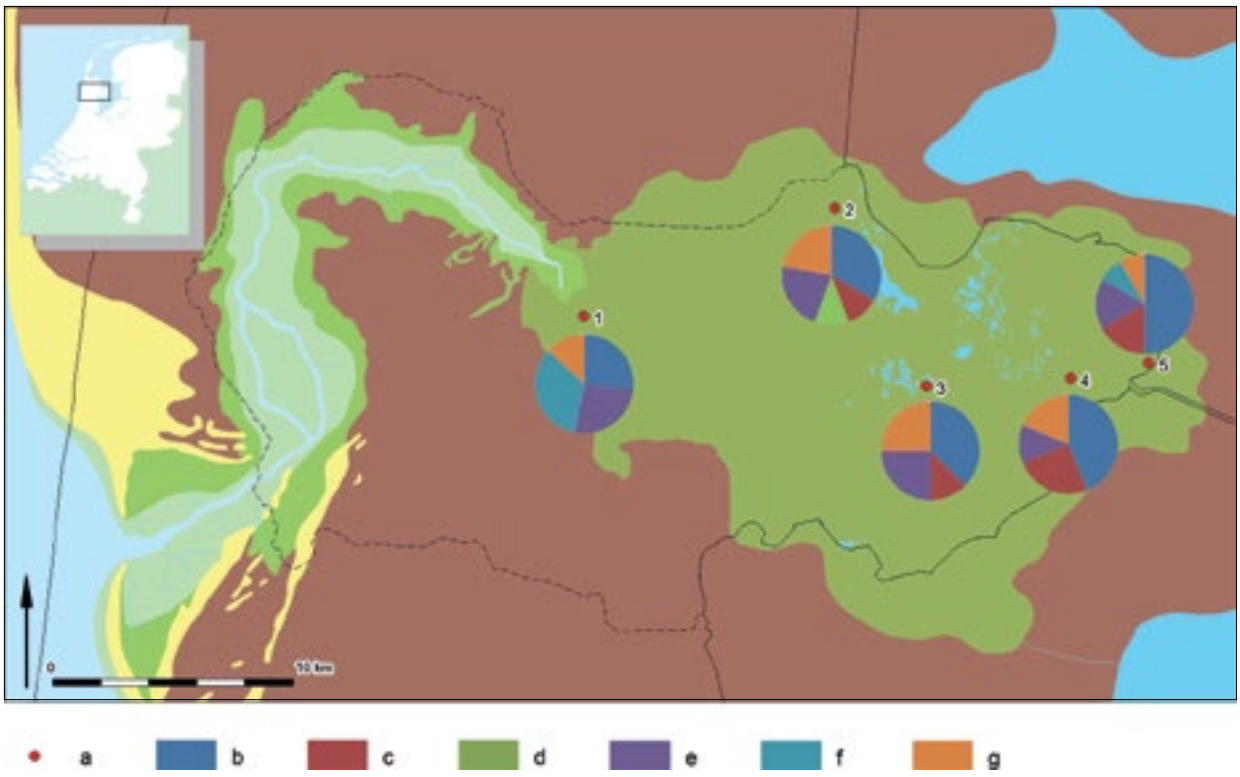

Figure 2.11. Map of Middle Bronze Age West Frisia with the water habitat preferences of fish species found at each site. N denotes the number of different fish species found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: stagnant to slow-flowing water; c: open water; d: fast-flowing water (river); e: sea connection; f: open sea; g: non-specific preference; 1: Hoogwoud, n=11; 2: Medemblik, n=6; 3: Westwoud, n=5; 4: Bovenkarspel, n=11; 5: Enkhuizen, n=8.

early years in fresh water, only returning to the sea when mature enough to reach its spawning grounds in the Atlantic Ocean (Vissengids 2016). These two species thus signify that migratory fish were able to reach waters in the vicinity of the eastern sites through a connection with the sea. However, if it is assumed that the Bergen inlet only reached as far as Hoogwoud, and fishing occurred relatively close to the settlement, the question of how these migratory species reached eastern West Frisian sites remains.

Since a(n) (in)direct connection to the sea with the eastern sites has never been established during excavations, another route for these migratory fish can also be postulated. One option could be that the saltwater influence did indeed reach much further inland than was previously proposed, for example during spring tides. Alternatively, a migratory route may have existed via the inland lakes east of West Frisia, which were in close proximity to the eastern sites, and were connected to the North Sea via the Oer-IJ estuary (Figure 2.13). The distance travelled by migratory fish via this route seems very long, but Atlantic salmon for example has been recorded to swim upriver, when unhindered by modern obstacles, as far as the Badem-Württemberg province in south-western Germany, roughly 700 km from the North Sea (Froehlich-Schmitt 2004, 4).

This latter route would explain the presence of both anadrome and catadrome fish species near the eastern sites. Such an indirect connection to the North Sea would also explain the slightly to medium brackish water conditions of the lakes to the east of West Frisia and the waters connected to them. Fish remains from a site bordering the eastern edge of the upper large lake, Emmeloord (Figure 2.13, number 9; Van Zijverden forthcoming), also seem to confirm this

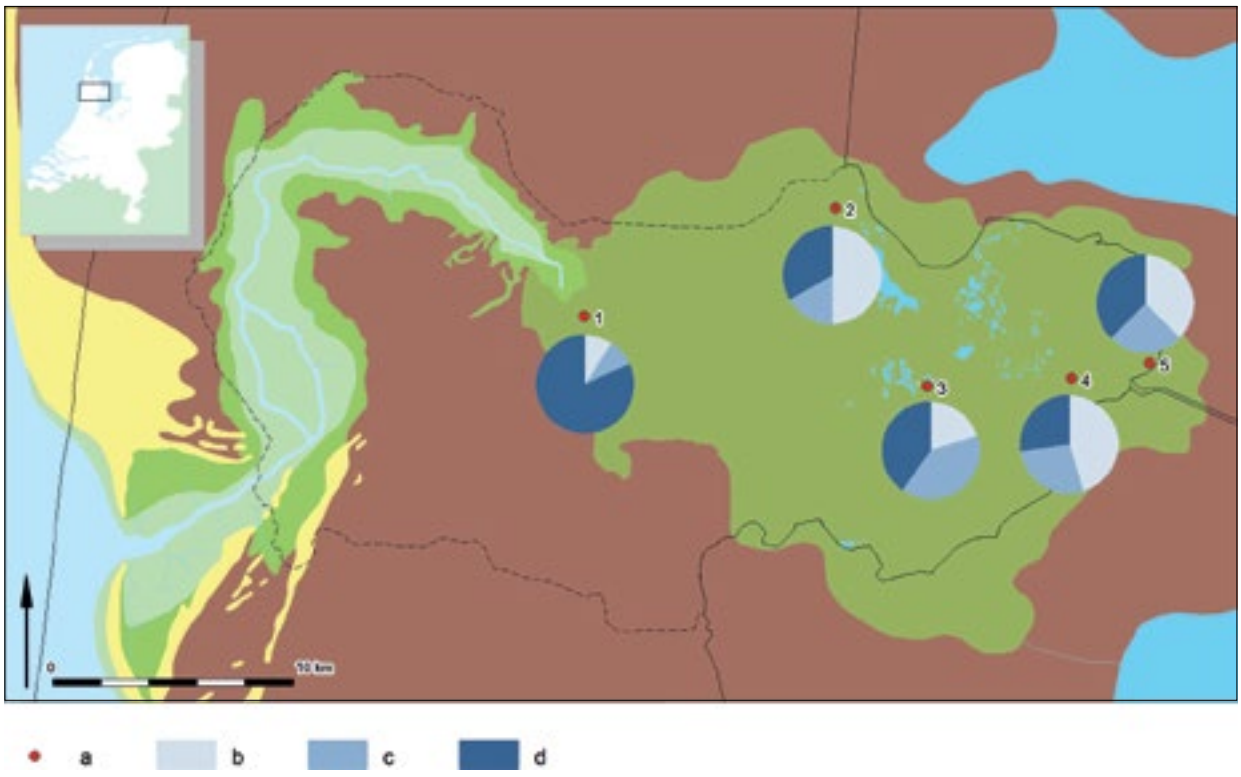

Figure 2.12. Map of Middle Bronze Age West Frisia with the maximum salinity tolerance of fish species found at each site. N denotes the number of different fish species found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: fresh to slightly brackish water (0-10 ppt); c: medium brackish water (10-15 ppt); d: salt water (more than 30 ppt); 1: Hoogwoud, n=11; 2: Medemblik, n=6; 3: Westwoud, n=5; 4: Bovenkarspel, n=11; 5: Enkhuizen, n=8.

image. The species from this site (Kerklaan 2012) very closely resemble the composition of species found at Bovenkarspel and Enkhuizen, and mostly show preferences for open water and a connection to the sea. Interestingly, Medemblik does not show such clear indications for open water, although it is supposedly closely situated to the upper lake.

2.4.1.4 Late Bronze Age

For the Late Bronze Age period, only the most eastern sites yielded fish remains. In Figure 2.14, the water type habitat preferences of fish from the Late Bronze Age are shown. In general, a slight increase in fish species preferring stagnant to slow-flowing water is visible, especially in Medemblik. Overall however, no apparent other major differences in water type ratios have occurred between the Middle and Late Bronze Age situation.

The salinity tolerance pie diagrams for the Late Bronze Age are shown in Figure 2.15. Again, species that prefer slight to medium brackish water prevail. Compared to the Middle Bronze Age however, there seem to be more species indicating slightly brackish water at the expense of water with higher salinity levels, with the largest difference observed at the sites Medemblik and Enkhuizen. It is difficult to interpret these observed differences, since they could be the result of an increased freshwater content in the eastern lakes.

2.4.2 Birds

Similar to the fish species, the bird species found will be compared with the expected species per habitat (Appendix A1.1). Also, indications for the habitats present near the sites will be discussed, and an overview of the environment in the Bronze Age as a whole will

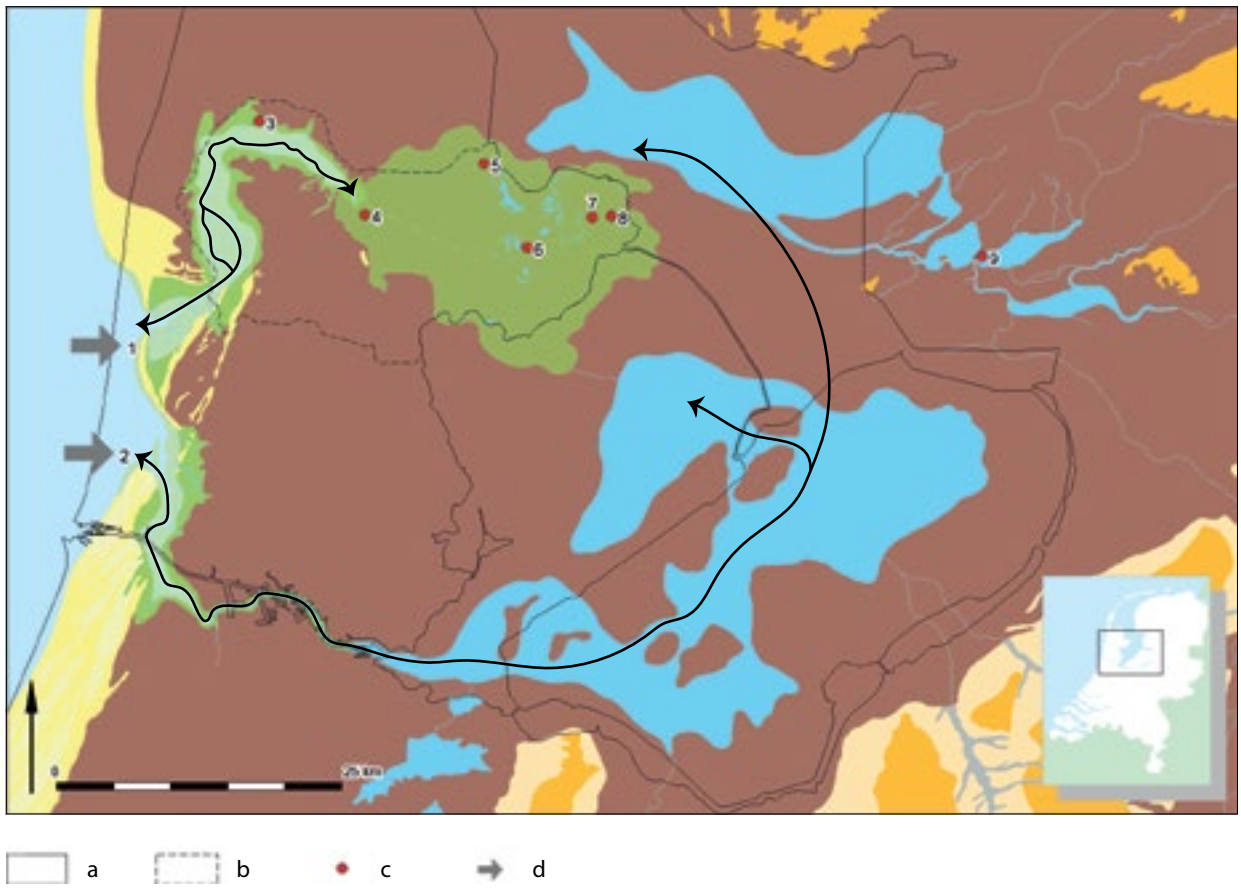

Figure 2.13. Overview of the possible migratory routes (black arrows) between the different sites in West Frisia and the North Sea. For the eastern West Frisia sites, it is proposed that fish most likely travelled via the Oer-IJ estuary, since the Bergen inlet supposedly did not allow saltwater to be transported far enough inland to reach these sites. For the legend of the underlying map, see Figure 2.1b. a: outline of the recent Netherlands; b: outline of the recent area of West Frisia; c: location of an excavated site; d: coastal inlet/estuary; 1: Bergen inlet; 2: Oer-IJ estuary.: 1: Bergen inlet; 2: Oer-IJ estuary; 3: Schagen; 4: Hoogwoud; 5: Medemblik; 6: Westwoud; 7: Bovenkarspel; 8: Enkhuizen; 9: Emmeloord.

be made, since remains were too few to distinguish between the Middle and Late Bronze Age periods.

2.4.2.1 Observed species and habitat types

In Table 2.6, the observed bird species with their preferred habitat types are shown and an overview of presence per site in Table 2.7. Similar to Table 2.4, the different habitat types are represented by different colours. Birds that specifically prefer a combination of two habitat types are placed in between those types in Table 2.6.

As becomes clear from Table 2.6, all of the expected habitats have representative species, indicating a varied landscape, although some habitats are represented by more species than others. Since most birds can live in many different habitat types, and many were expected for each habitat type (Appendix A1.1), the comparison made here between the expected and observed species will be very general. The majority of found species prefer a habitat that includes wetlands, although many species of waders were not found. Other birds, which also prefer wetlands in general, can live near the seacoast. Birds indicative of the presence of the seacoast, however, including many different species of gull, were not present in the bird assemblage. Water-related habitat types including both grassland and wetlands are also represented by birds.

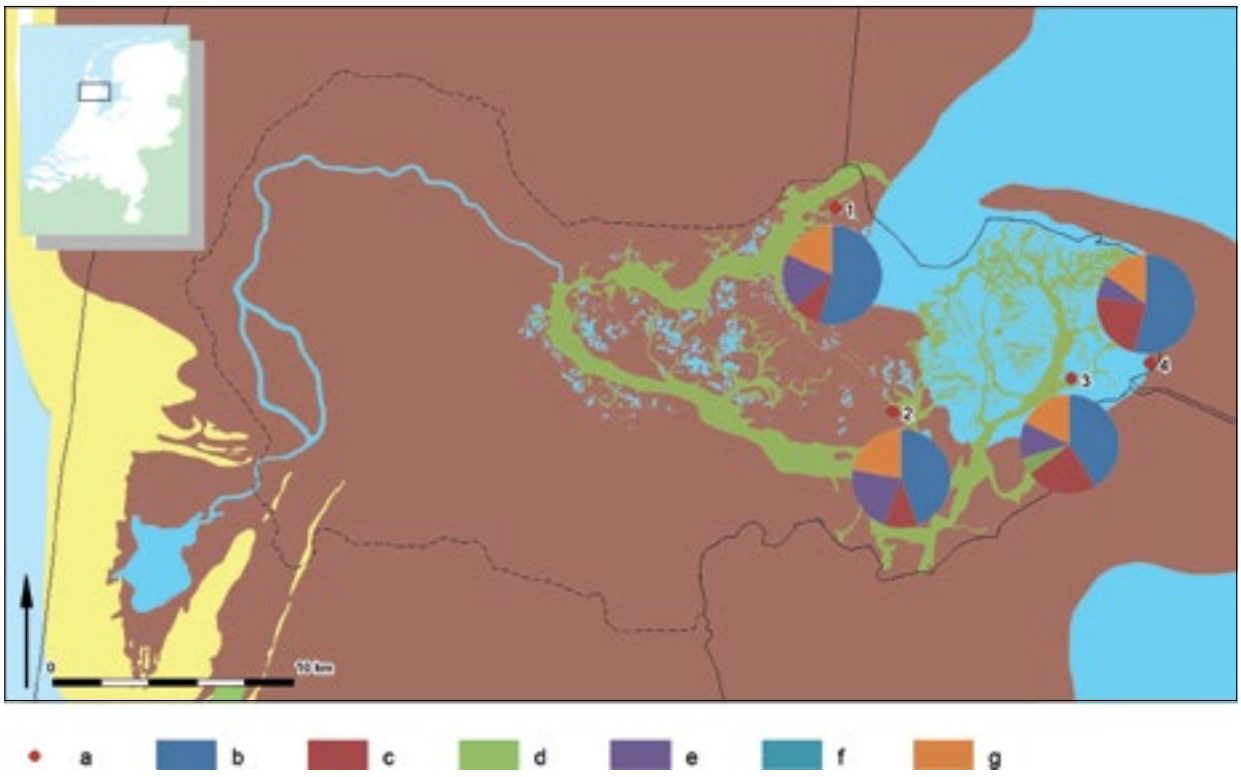

Figure 2.14. Map of Late Bronze Age West Frisia with the water habitat preferences of fish species found at each site. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: stagnant to slow-flowing water; c: open water; d: fast-flowing water (river); e: sea connection; f: open sea; g: non-specific preference; 1: Medemblik, n=8; 2: Westwoud, n=6; 3: Bovenkarspel, n=12; 4: Enkhuizen, n=9.

When Table 2.6 is observed, it is clear that birds that do not require wetlands in their habitat are present as well. Bird species that prefer grassland, both grassland and shrub land, or shrub land and trees are apparent as well.

Finally, of each of the specific habitats, trees, shrub land, and open sea, only one representative bird species was found in West Frisia. Since representatives for every expected habitat were found, it can in general be expected that more species preferring such habitats were present in West Frisia as well, provided that these species existed in these regions during this time.

2.4.2.2 Bronze Age overview

Only one site, Schagen, yielded information on the Early Bronze Age. However, unfortunately no distinction could be made between the Middle and Late Bronze Age, due to the limited number of bird remains found on the other sites. Therefore, only a general overview with a comparison between the Early Bronze Age and the Middle/Late Bronze Age is presented here. In Figure 2.16, the pie diagrams of the bird habitat preferences of the sites of West Frisia are presented. The colours used to denote the different habitat types in the pie diagrams are the same as those applied in Table 2.6.

Figure 2.14, which was composed in a similar manner to the research towards fish, indicates that the available bird species indicate a clear distinction between the eastern and western part of West Frisia, similar to what was observed based on fish species. In the west, in Early Bronze Age Schagen, all the expected habitat types are represented, with clear indications for saltwater environments. In Middle Bronze Age Hoogwoud, situated in the middle of West Frisia, only wetlands are represented by the bird species. The sites in the eastern part of West Frisia, in

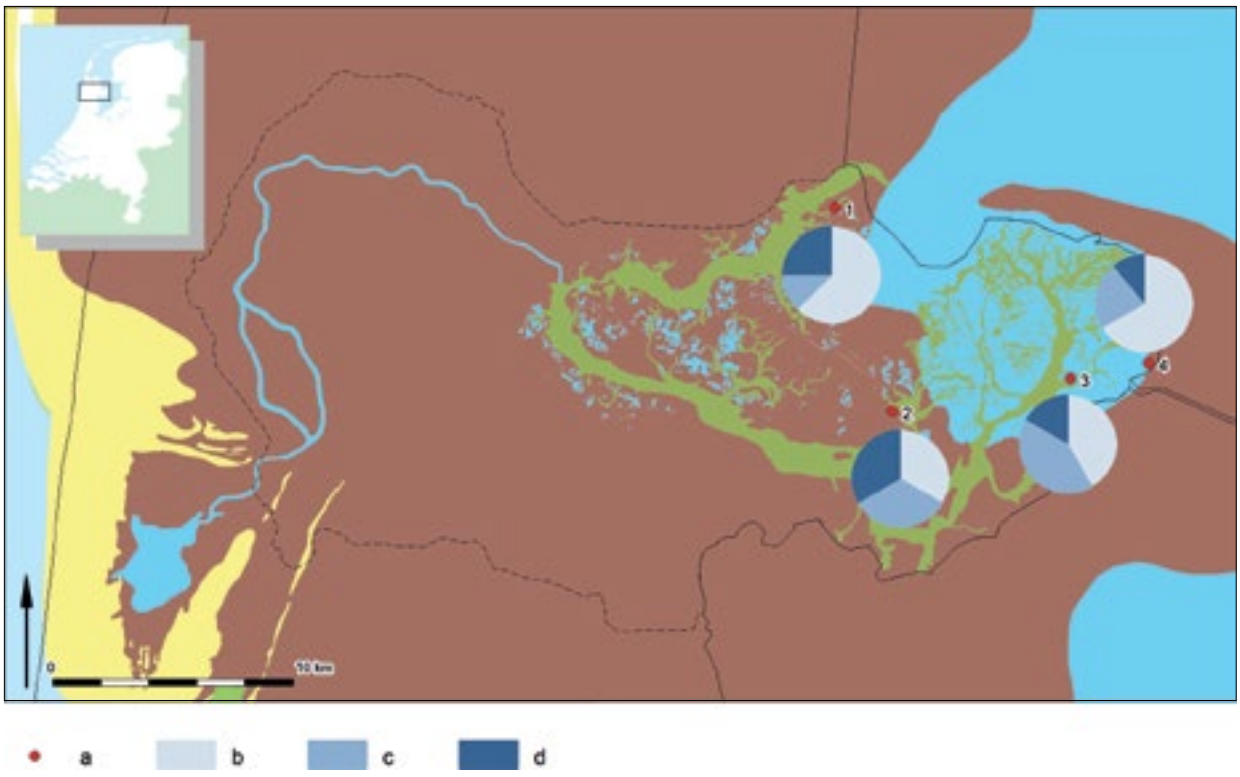

Figure 2.15. Map of Late Bronze Age West Frisia with the maximum salinity tolerance of fish species found at each site. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: fresh to slightly brackish water (0-10 ppt); c: medium brackish water (10-15 ppt); d: salt water (more than 30 ppt); 1: Medemblik, n=8; 2: Westwoud, n=6; 3: Bovenkarspel, n=12; 4: Enkhuizen, n=9.

this case Medemblik, Enkhuizen, and Bovenkarspel, each show a comparable image of the habitats present: wetlands, grassland, shrub land, and trees. However, each site shows a slight variation in ratio between these different habitats. In Bovenkarspel, a trend towards more wetlands can be observed, and in Medemblik it is towards more shrub land. Enkhuizen on the other hand, shows mostly indicators for trees.

Birds that have a preference for more than one habitat type are placed in between the two types. These are: crane, ruff, widgeon, brent goose, barnacle goose, and dunlin.

The group of birds that is most highly represented in the eastern part of West Frisia is waterfowl. At least 50% of the species on each site consists of aquatic birds, and even more when the families of ducks and geese are included, which could not be identified to species level.

The large lakes to the east of West Frisia would be an ideal habitat for such birds, but there must have been wetlands and smaller lakes reaching closer to the settlements in the east as well (van Zijverden forthcoming).

The presence of these bird species confirms the presence of freshwater wetlands in the east of West Frisia. However, the salinity level of these waters may also have been slightly brackish, since freshwater birds can often tolerate low levels of salinity (*e.g.* mallard: United States Department Interior 1998: 131, 133).

Hoogwoud only yielded species with a preference for wetlands, which means that wetlands were also present in the middle of West Frisia. Interestingly, there were no clear indicators for a saltwater environment, which was expected based on fish remains (section 2.4.1.3). This difference in indicators for salinity may very

Table 2.6. Overview of all the bird species found in West Frisia arranged by preferred habitat type.

Habitat preference	PRESENCE OF TREES
Taxa	*Scolopax rusticola*
English name	Eurasian Woodcock

Habitat preference	TREES/SHRUBLAND	TREES/SHRUBLAND
Taxa	*Accipiter gentilis*	*Bubo bubo*
English name	Northern Goshawk	Eagle owl

Habitat preference	SHRUB LAND
Taxa	*Sylvia spec.*
English name	Warblers

Habitat preference	SHRUB LAND/GRASSLAND	SHRUB LAND/GRASSLAND	SHRUB LAND/GRASSLAND
Taxa	*Corvus corone*	*Corvus frugilegus*	*Turdus spec.*
English name	Carrion crow	Rook	Thrushes

Habitat preference	GRASSLAND	GRASSLAND
Taxa	*Alauda arvensis*	*Coturnix coturnix*
English name	Skylark	Quail

Habitat preference	GRASSLAND/WETLANDS	GRASSLAND/WETLANDS	GRASSLAND/WETLANDS
Taxa	*Grus grus*	*Philomachus pugnax*	*Hirundinidae* indet
English name	Crane	Ruff	Swallows

Habitat preference	WETLANDS	WETLANDS	WETLANDS	WETLANDS	WETLANDS	WETLANDS	WETLANDS
Taxa	*Anas crecca*	*Anas querquedula*	*Anas platyrhynchos*	*Anser anser*	*Cygnus cygnus*	*Cygnus olor*	*Rallus aquaticus*
English name	Common teal	Garganey	Mallard	Greylag goose	Whooper swan	Mute swan	Water rail

Habitat preference	WETLANDS/COAST	WETLANDS/COAST	WETLANDS/COAST	WETLANDS/COAST	WETLANDS/COAST
Taxa	*Anas penelope*	*Branta bernicla*	*Branta leucopsis*	*Calidris alpina*	*Gavia arctica/stellata*
English name	Widgeon	Brent goose	Barnacle goose	Dunlin	Black-/ Red-Throated Loon

Table 2.7. Overview of the frequency of bird species found at each of the Bronze Age sites.

Taxa	English name	Boven-karspel	Enk-huizen	Medem-blik	Hoog-woud	Schagen	Freq.
Anas platyrhynchos	Mallard	x			x	x	3
Anas crecca/ querquedula	Common Teal/ Garganey				x	x	2
Anas penelope	Widgeon		x		x		2
Anser anser	Greylag goose	x	x				2
Bubo bubo	Eagle owl	x		x			2
Cygnus cygnus	Whooper swan	x		x			2
Rallus aquaticus	Water rail		x			x	2
Scolopax rusticola	Eurasian Woodcock		x			x	2
Turdus spec.	Thrush spec.		x			x	2
Accipiter gentilis	Northern Goshawk		x				1
Alauda arvensis	Skylark					x	1
Anas crecca	Common Teal	x					1
Anatidae indet	Duck-family					x	1
Anatinae	Ducks and Geese		x				1
Anser spec.	Grey geese			x			1
Branta bernicla	Brent goose					x	1
Branta bernicla/ leucopsis	Barnacle goose					x	1
Branta spec.	Black geese		x				1
Calidris alpina	Dunlin					x	1
Corvus corone	Carrion crow	x					1
Corvus corone/ frugilegus	Carrion crow/Rook			x			1
Coturnix coturnix	Quail					x	1
Cygnus olor	Mute swan	x					1
Gavia arctica/stellata	Black-/Red-throated loon					x	1
Grus grus	Crane	x					1
Passeriformes indet	Songbirds	x					1
Philomachus pugnax	Ruff		x				1
Sylvia spec.	Warbler spec.					x	1

Presence of a species is denoted by an "x".

well be related to human selection of specific species rather than actual absence of saline influence in this area, and this observation underlines the importance of multi-proxy research. The presence of trees was indicated by no less than three bird species, which is a relatively high number considering that the number of bird remains found throughout West Frisia was limited. This clear presence of tree indicators again seems to undermine the conclusions of the current model, which envisioned West Frisia as consisting of an open, treeless landscape.

Although birds appear to have provided several clues for the presence of habitat types, some remarks must be made nonetheless. It must for example be kept in mind that the range in which a certain bird can be found differs per species. Some birds have vast ranges in which they hunt, whereas others stay in the same small area year-round. The home range of birds furthermore, can include different areas for feeding, sleeping, breeding, and hunting. These grounds will mostly be located relatively close to each other, but for birds of prey and geese these different areas may lie several tens of kilometres apart. Such species can thus only provide regional indications for the environment. On the other hand, when birds have a particularly small home range, they can form excellent local habitat indicators. When these characteristics are considered, more detailed information about for example available forest cover can be obtained. Northern goshawk (*Accipiter gentilis*) and eagle owl (*Bubo bubo*), found in Enkhuizen, and Bovenkarspel and Medemblik, respectively (Table 2.7), both possess large living and hunting territories, and can travel many kilometres in search of food (Eifelnatur 2011). Therefore, the presence of these birds can provide regional indications for forest in the eastern part of West Frisia. The other forest indicator, Eurasian woodcock (*Scolopax rusticola*), found in both Enkhuizen and Schagen (Table 2.7), does not travel far within its home range (Houtsnip n.d). It prefers to remain in (wet) uninterrupted forests with dense undergrowth to forage and breed. Woodcock, therefore, does provide a firm local indication for trees, provided that it was not caught during migration. It is clear that only the combination of local and regional bird indicators for trees, such as present at Enkhuizen, really provide clues that at least patches of uninterrupted forest must have been located relatively close to a settlement.

2.4.3 Mammals

Mammal remains were divided into two groups: small and large mammals. In this research, mammals are considered small when they are smaller than a hare (*Lepus europaeus*). This distinction was made based on the size of the home range; mammals smaller than a hare usually possess a very small home range and can therefore only provide very local information about the environment.

Similar to the previous sections on fish and birds, all the found mammal species will first be compared to those expected for each habitat (Appendix A1.1), and small and large mammals will be discussed in separate paragraphs. Furthermore, based on the preferred habitats of the mammal species found, the environment of the sites will be discussed. This discussion will include both the Bronze Age in its entirety, as well as the separate Middle and Late Bronze Age periods. However, since very few finds were available from the latter period, only Late Bronze Age data from Bovenkarspel will be discussed here.

2.4.3.1 Observed species and habitat types

Table 2.8 shows a list of all the small and large mammal species found as well as their characteristic preferred habitat types, whereas Table 2.9 displays an overview of the presence of the small and large mammals at each site. Again, the different habitat types are denoted by different colours which correspond to the colours and habitat types used for birds in section 2.4.2.1. Mammals preferring multiple characteristic habitat types are placed in between the respective habitat types.

Small mammals

None of the small mammal species found seem to have a characteristic preference for the presence of trees. Instead, the species are evenly divided between shrub land, grassland, and wetlands, or a combination of these. Apart from one species of small mammal (*i.e.* yellow-necked mouse), no small mammals that were expected are missing from the assemblage.

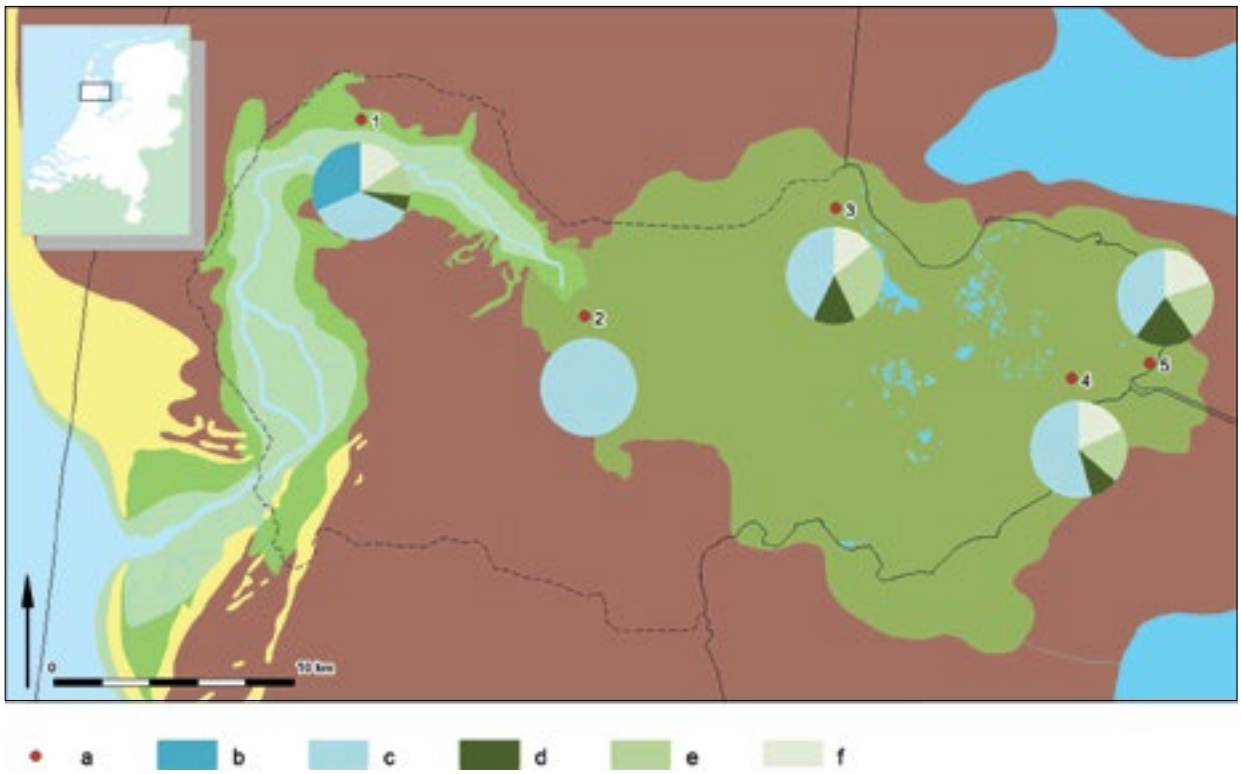

Figure 2.16. Map of Bronze Age West Frisia with the general habitat preference of the birds found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: seacoast; c: wetlands; d: presence of trees; e: shrub land; f: grassland; 1: Schagen, n=13; 2: Hoogwoud, n=3; 3: Medemblik, n=4; 4: Bovenkarspel, n=8; 5: Enkhuizen, n=7.

Large mammals

Table 2.8 immediately shows that all expected habitat types are represented by large mammals, even grassland. In contrast to the small mammals species however, it can be seen that the majority of species actually prefer a habitat which contains trees. Many large mammals clearly have a need for the presence for trees, albeit it for food, protection, or both. Still, many species that were expected for the forest habitats were not amongst the finds (Appendix A1.1). Besides a preference for trees, three large mammal species also prefer wet environments, including habitats with both (freshwater) wetlands and the seacoast. Again however, several species representing such habitats were not found.

2.4.3.2 Bronze Age overview

The relatively low numbers of (wild) mammal bones found on each site in West Frisia did not allow for a comparison between the Middle and Late Bronze Age, apart from the site of Bovenkarspel. At the site Schagen however, the Early Bronze Age is represented so therefore, this site can be used for comparison with the Middle and Late Bronze Age combined.

Since not all sites yielded remains from both small and large animals, several pie diagram maps were made: Figure 2.17 shows the pie diagrams of the habitat preferences of the small mammals, in Figure 2.18 the pie diagrams for the sites yielding large mammal remains can be seen, and in Figure 2.19, the small and large mammal remains were combined for the sites which contained remains of both small and large mammals. The colours of the diagrams correspond to the colours used for the different habitat types in Table 2.8. However, as for birds, mammals preferring a combination of two habitats are included in both habitat types in the diagrams.

Small mammals
The image obtained of the surroundings of the sites based on the preference of small mammals found in West Frisia is fairly similar for most of the sites, as can be seen in Figure 2.17. Hoogwoud, Westwoud, and Bovenkarspel have a similar ratio of small mammal species that prefer shrub land as well as equal parts for the habitats grassland, and/or wetlands. Schagen, Hoogkarspel, and Enkhuizen are also similar in their small mammal habitat preferences, with a slight tendency towards more shrub land than wetlands. Due to the fact that the small mammals were not selectively caught by humans (cf. Chapter 4), they are thought to be indicative of the immediate surroundings of the settlement only. Therefore, the immediate surroundings of the settlement appear to consist of mostly open, but also some wetlands: a similar conclusion as was obtained from on-site pollen (section 2.3.1).

Large mammals
The sites yielding large mammal remains are more abundant than those that yield small mammal remains, which is most likely due to differences applied in sieving strategies (Table 2.1). From Figure 2.18 it becomes apparent that on all the sites species are found that are indicative of the presence of trees. However, although some indications for trees can be found in both Schagen and Hoogwoud, definite indicators for large(r) forested areas, such as elk, wild boar, and brown bear, are not present. This absence of forest-dwelling large mammals at these sites could be the result of the saline influence on these sites, preventing the growth of (larger) patches of trees. Still, the presence of trees in the surroundings of many of the West Frisian settlements is confirmed: a similar conclusion to what was obtained from off-site pollen (section 2.3.1).

Other habitat preferences of the uncovered large mammal species include wetlands, shrub land, grassland, and the seacoast. In Andijk and Schagen, a relatively large portion of the large mammals include species that prefer wetlands, such as beaver and otter. Since both species can be found under both freshwater and brackish water conditions (Twisk *et al.* 2010, 206; Hood 2012), nothing in particular can be said about salinity levels of the water surrounding the settlements based on this single proxy. It does however indicate that in Schagen, sources of water also existed that possessed a salinity level of fresher than saline conditions, which was also indicated by the present fish species (Figure 2.9, Figure 2.10). More specific information about the water salinity surrounding the settlements is sadly not possible based on large mammal remains, but they do provide more information on the size of the present water bodies than small mammals and fish, since they require more space for their home ranges (Cronau 2015). Based on the presence of wetland-preferring large mammal species at Schagen, Medemblik, Andijk, Enkhuizen, and Bovenkarspel as seen in Figure 2.18, these sites appear to have possessed larger water bodies in the settlement surroundings. Hoogkarspel, Zwaagdijk, and Hoogwoud do not provide this image, but this may be due to the relatively low numbers of large mammal species and bones found at these sites. Therefore, these latter sites may provide a less representative image of the surroundings than the former sites. Nonetheless, the presence of the large lakes east of West Frisia seem to be confirmed by the large mammal remains of beaver and otter at eastern sites. Schagen will also have had larger water bodies in the environment, with salinity levels ranging from saline to brackish/freshwater, indicated by the presence of harbour seal, and beaver and otter, respectively.

As stated, the only larger assemblage of large mammal remains dating to the Late Bronze Age were found at Bovenkarspel (data not shown). From this data it has become clear that not many changes have occurred in the indications for the different habitats. Wetlands are still represented, as are shrub land and forest. Grassland is no longer represented, but this could be the result of the fewer species found for this time period.

Small and large mammals combined
Due to the fact that small mammals are mainly indicative of grassland, shrub land, and wetlands, and large mammals mainly prefer the cover of trees, the most representative image of the terrestrial environment will be obtained by combining both mammal groups for the sites at which they are both found. The results of this combination are shown in Figure 2.19.

Table 2.8. Overview of all the small and large mammal species found in West Frisia arranged by preferred habitat type. Names of the animals are according to the taxonomy used in the field guide of Twisk *et al.*, Van Diepenbeek and Bekker 2010. In Eurasia, *Alces alces* signifies elk, not moose.

LARGE MAMMALS

Habitat preference	PRESENCE OF TREES	PRESENCE OF TREES	PRESENCE OF TREES
Taxa	*Alces alces**	*Sus scrofa*	*Ursus arctos*
English name	Elk*	Wild boar	Brown bear

Habitat preference	TREES/SHRUBLAND	TREES/SHRUBLAND	TREES/SHRUBLAND	TREES/SHRUBLAND	TREES/SHRUBLAND
Taxa	*Capreolus capreolus*	*Cervus elaphus*	*Felis silvestris*	*Mustela putorius*	*Vulpes vulpes*
English name	Roe deer	Red deer	Wild cat	European Polecat	Fox

SMALL MAMMALS

Habitat preference	SHRUBLAND	SHRUBLAND
Taxa	*Mustela nivalis*	*Sorex minutus*
English name	Weasel	Pygmy shrew

Habitat preference	SHRUBLAND/GRASSLAND	SHRUBLAND/GRASSLAND	SHRUBLAND/GRASSLAND	SHRUBLAND/GRASSLAND
Taxa	*Apodemus sylvaticus*	*Micromys minutus***	*Microtus arvalis*	*Sorex araneus*
English name	Wood mouse	Harvest mouse**	Common vole	Common shrew

Habitat preference	GRASSLAND	GRASSLAND	GRASSLAND	SHRUB/GRASS/WETLAND
Taxa	*Lepus europaeus*	*Talpa europaea*	*Mus musculus***	*Microtus agrestis*
English name	Hare	Mole	House mouse**	Field vole

Habitat preference	WETLANDS	WETLANDS	WETLANDS	WETLANDS	WETLANDS
Taxa	*Castor fiber**	*Lutra lutra*	*Arvicola amphibius*	*Microtus oeconomus*	*Neomys fodiens*
English name	Beaver*	Otter	Water vole	Nordic vole	Water shrew

Habitat preference	COAST
Taxa	*Phoca vitulina*
English name	Harbor seal

* Although main habitat preference is as stated, Elk prefers wetter areas in summer, and Beaver requires the presence of trees.
** These mice can also have adapted to living in the presence of humans and can therefore also be found living within settlements.

Table 2.9. Overview of the frequency of mammal species found at each of the Bronze Age sites.

Taxa	English Name	Hoog-woud	Boven-karspel	West-woud	Enk-huizen	Medem-blik	Andijk
Small Mammals							
Capreolus capreolus	Roe deer	x	x			x	x
Castor fiber	Beaver		x		x	x	x
Cervus elaphus	Red deer		x		x	x	x
Vulpes vulpes	Fox	x	x			x	
Alces alces	Moose		x		x	x	
Sus scrofa	Wild boar				x	x	x
Lepus europaeus	Hare		x	x			
Lutra lutra	Otter					x	x
Cervus elaphus/ Alces alces	Red deer/Moose	x	x				
Ursus arctos	Brown bear				x		
Felis sylvestris	Wild cat					x	
Mustela nivalis	Weasel						
Mustela putorius	European polecat						
Phoca vitulina	Harbor seal						
Large Mammals							
Arvicola amphibius	Water vole	x	x	x	x	x	
Microtus oeconomus	Nordic vole	x	x	x	x		
Apodemus sylvaticus	Wood mouse	x			x		
Microtus agrestis	Field vole	x	x				
Microtus arvalis	Common vole		x		x		
Sorex araneus	Common shrew			x	x		
Mus musculus	House mouse		x	x			
Neomys fodiens	Water shrew		x				
Micromys minutus	Harvest mouse						
Sorex minutus	Pygmy shrew						
Talpa europaea	Mole	x					

Taxa	Schagen	Hoogkarspel Watertoren	Zwaagdijk	Zwaagdijk-oost	Oostwoud	Freq.
Small Mammals						
Capreolus capreolus		x	x		x	7
Castor fiber	x	x		x		7
Cervus elaphus	x			x		6
Vulpes vulpes	x	x	x			6
Alces alces		x		x		5
Sus scrofa			x			4
Lepus europaeus					x	3
Lutra lutra	x					3
Cervus elaphus/ Alces alces						2
Ursus arctos		x				2
Felis sylvestris						1
Mustela nivalis		x				1
Mustela putorius	x					1
Phoca vitulina	x					1
Large Mammals						
Arvicola amphibius	x					6
Microtus oeconomus	x					5
Apodemus sylvaticus	x					3
Microtus agrestis		x				3
Microtus arvalis		x				3
Sorex araneus	x					3
Mus musculus						2
Neomys fodiens	x					2
Micromys minutus	x					1
Sorex minutus	x					1
Talpa europaea						1

Presence of a species is denoted by an “x”.

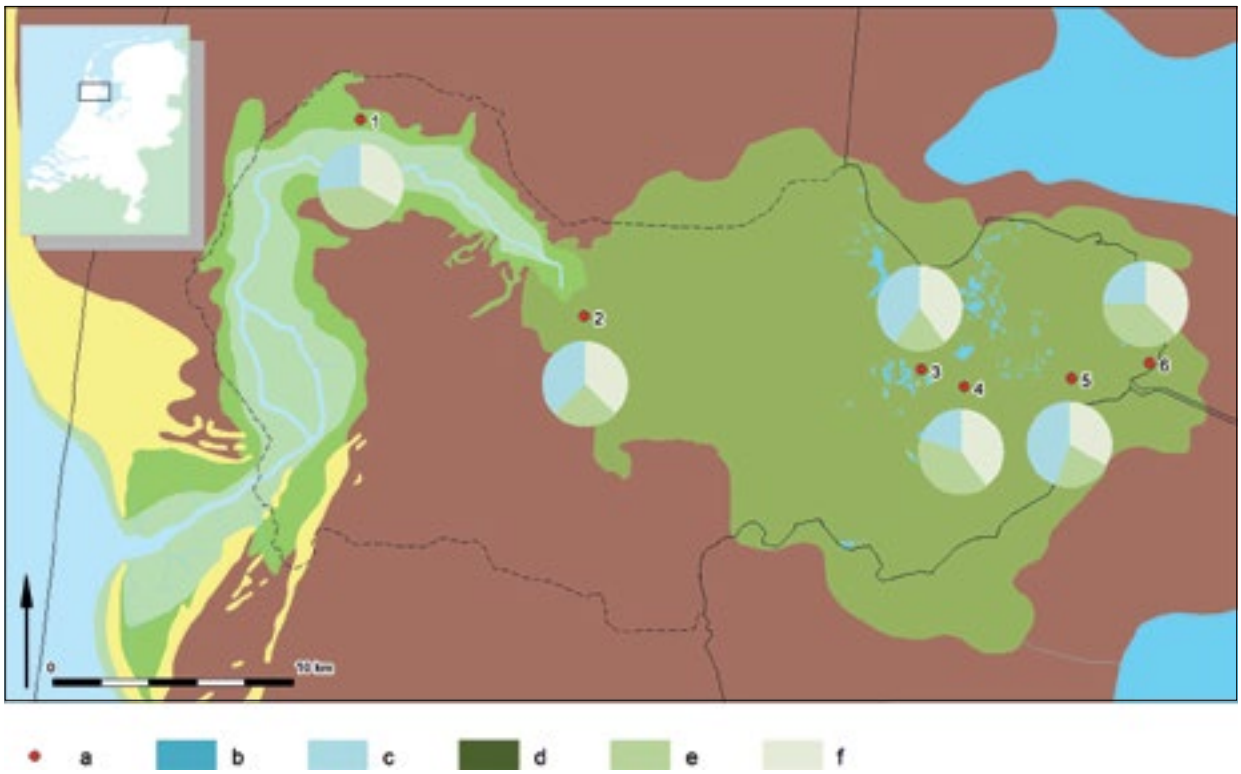

Figure 2.17. Map of Bronze Age West Frisia with the general habitat preferences of the small mammals found at each site. N denotes the number of different small mammal species found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: seacoast; c: wetlands; d: presence of trees; e: shrub land; f: grassland; 1: Schagen, n=7; 2: Hoogwoud, n=5; 3: Westwoud, n=4; 4: Hoogkarspel, n=2; 5: Bovenkarspel, n=6; 6: Enkhuizen, n=5.

It is clear that although in Figure 2.17 and Figure 2.18 some sites resemble each other based on habitat preferences of either small or large mammals, Figure 2.19 shows a different trend. Here, Hoogwoud, Enkhuizen, and Bovenkarspel are the most similar, with a relatively equal combination of habitat types representing wetlands, grassland, shrub land, and the presence of trees.

At Hoogkarspel, it seems that there are less indicators for wetlands, and more for shrub land. Schagen finally, has less indicators for trees, but does show an additional indicator for the seacoast. What these five sites show is that the landscape in Bronze Age West Frisia was apparently very varied, but generally composed of similar habitats depending on the salinity of the surrounding water. Exactly how these different types of natural landscape are situated in relation to the cultivated landscape of the settlements, and what impact each of these landscapes will have on the appearance of the other will be discussed in Chapter 8: Bronze Age farming in West Frisia.

2.4.4 Summary

The West Frisian fish species have shown a preference for a variety of water types and salinities, underlining the range of different aquatic habitat types present in the surroundings of the settlements: indeed, the east of West Frisia did not consist of a purely freshwater environment. Fish species have furthermore provided clear indications that the North Sea influenced West Frisia, both in a direct manner in the west until after 1550 BC, and in an indirect manner in the east, possibly via the Oer-IJ estuary. The available bird species deriving from the West Frisian sites have provided mostly general, but also some detailed indications for the environment. Most birds indicate the presence of wetlands in the surroundings, but also other habitat types such

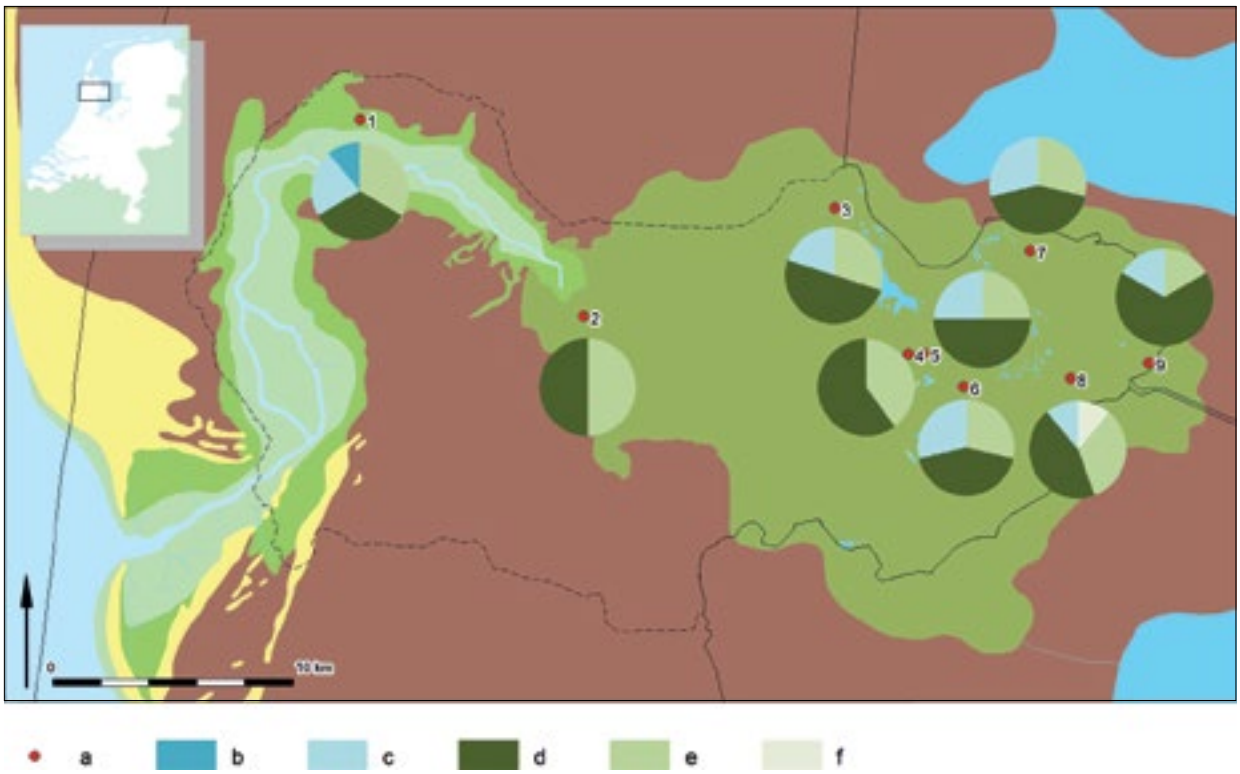

Figure 2.18. Map of Bronze Age West Frisia with the general habitat preferences of the large mammals found at each site. N denotes the number of different large mammal species found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: seacoast; c: wetlands; d: presence of trees; e: shrub land; f: grassland; 1: Schagen, n=6; 2: Hoogwoud, n=2; 3: Medemblik, n=7; 4: Zwaagdijk, n=3, 5: Zwaagdijk-Oost, n=3; 6: Hoogkarspel, n=3; 7: Andijk, n=5; 8: Bovenkarspel, n=6; 9: Enkhuizen, n=5.

as grassland, shrub land, and the presence of trees. Again, a varied landscape around all the settlements throughout West Frisia could be identified, and, for the surroundings of the eastern sites in particular, the presence of freshwater to slightly brackish habitats could be confirmed. The presence of trees could furthermore be identified on a regional, but also on a local level based on the different home ranges of three bird species. The presence of saline influence, such as was expected at Hoogwoud based on fish remains, could not be established based on bird remains. Mammals finally, can be considered a valuable addition for the reconstruction of the terrestrial landscape, providing both regional and local indications for the presence of different habitat types. Based on large mammals in particular, a general distinction can be made between the presence of saline and freshwater conditions present around the settlements, as well as a rough estimation of the size of the present (fresh)water bodies. Furthermore, due to the preference of most large mammals for cover, which needs to be high enough to remain unseen, these animals can also provide information on the presence of trees.

Small mammals can only provide very local information, probably only reflecting the habitats (in the near surroundings) of the settlements. Nevertheless, since small and large mammals have different main habitat preferences, the combination of these groups can provide a general insight into the composition of habitats present in the landscape.

2.4.5 Discussion

Similar to the discussion on methodology in section 2.3.5.1 for plants, factors affecting the zoological record will be discussed, which may influence

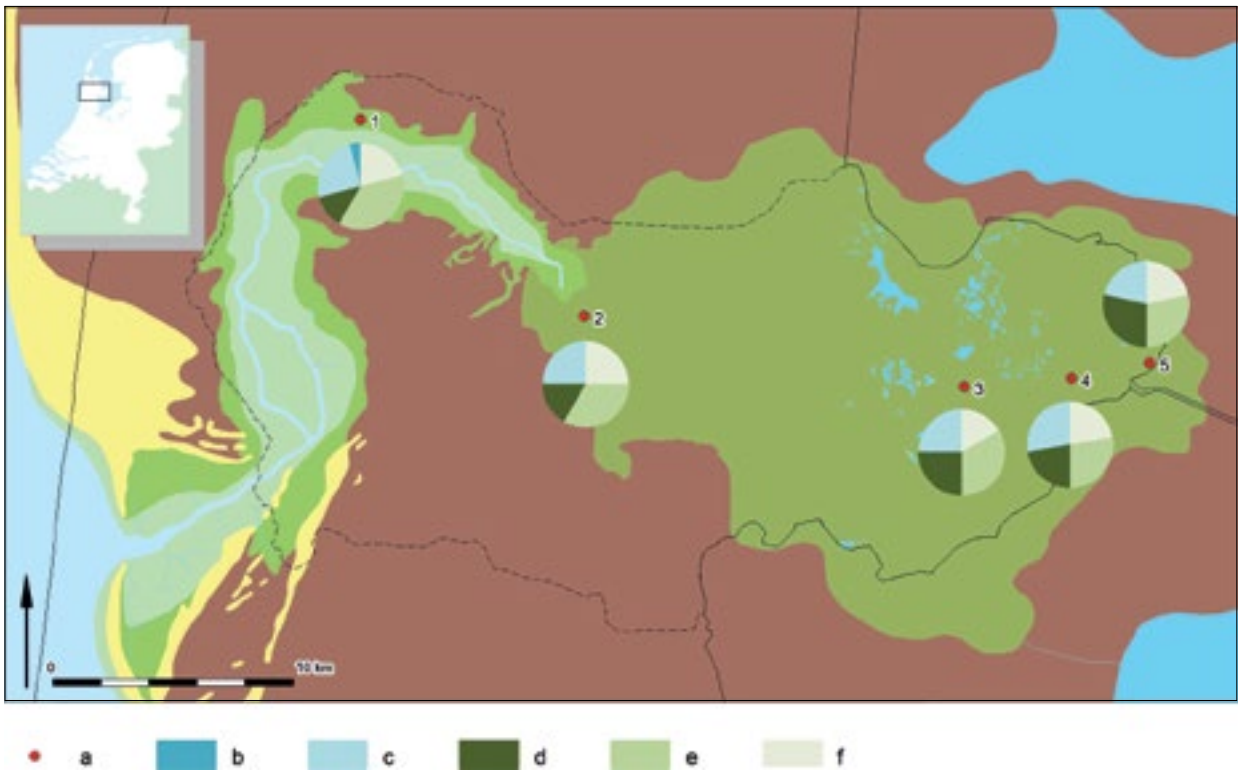

Figure 2.19. Map of Bronze Age West Frisia with the general habitat preferences of mammals found at each site yielding both small and large mammals. N denotes the combined number of different small and large mammal species found. For the legend of the underlying map, see Figure 2.1b. a: location of an excavated site; b: seacoast; c: wetlands; d: presence of trees; e: shrub land; f: grassland; 1: Schagen, n=13; 2: Hoogwoud, n=7; 3: Hoogkarspel, n=5; 4: Bovenkarspel, n=12; 5: Enkhuizen, n=10.

interpretation when not taken into consideration. The effects of (past and recent) methodology and taphonomy on the archaeozoological record will be examined first. In addition, two different cultural landscape indicators will be mentioned, which allow for the recognition of possible mutual changes in behaviour between wild animals, and humans living in a farming community.

2.4.5.1 Methodology

The main methodological issue which can greatly affect the assemblage of fish remains, is the practice of sieving (or lack thereof). When sites are sieved with different sieving methodologies, comparing the species composition on a quantitative level between such sites becomes impossible; the absence of species could have resulted solely from a difference in methodology, not from original past human practices. The difference in fish species composition observed in West Frisia for example (Table 2.5), can most likely be explained by the varying mesh sizes of sieves used at the sites, which range from 0.5-1.0 to 4.0 mm. Many fish and small mammal species possess such small bones, that sieving on a 4.0 mm mesh size results in a great loss of observed species diversity. Van Neer & Ervynck (1993) have used sieves as fine as 0.5 mm in mesh size for their research on fish remains, but sieves with 2.0 mm mesh sizes should suffice to uncover most of the fish species present in an assemblage. However, when as many fish species as possible need to be uncovered, a 1.0 mm mesh size is recommended (Meadow 1980, 69; Figure 2.20). Conversely, a sieving mesh size of 4 mm should be adequate to retrieve most of the bird and large mammal species, the number of obtained species only marginally increasing with the use of smaller mesh sizes. Still, when a complete picture of

the available species, and therefore habitat types, is required, sieves with mesh sizes ranging from 2.0-4.0 mm should be employed to retrieve bird remains, and 4.0 mm sieves to retrieve large mammal remains.

Besides sieving practices, a second problem related to the analysis of wild animal remains is that sampling is often performed in a non-specific manner. Often, samples are only taken when remains, especially of fish or birds, are identified within a feature with the naked eye. This kind of sampling thus only focuses on the find-rich features, which are often the features which are the result of much human influence in the past. In order to obtain a better understanding of the natural environment, including contexts located further away from the settlement, preferably natural waterways, should be sampled.

A final problem with the methodology applied to the analysis of large mammal remains in particular, is the probable presence of an identification bias that is specific for the Bronze Age period. Wild animals are often not deemed to be of relevance within a Bronze Age farming system (cf. IJzereef 1981, 24; Chapter 4). Since they are not expected to be present during this time period, the remains of some large mammals (*e.g.* red deer) may have therefore been falsely identified as cattle, which has similar proportions, reducing the visibility of wild large mammals in the archaeozoological record.

The methodological examples above indicate that sampling location, sieving practices, and identification biases can influence the interpretation of archaeozoological remains to a great extent. By adapting the sampling and sieving practices to match environmental questions, as well as maintaining an open mind towards the presence of wild animal species will considerably improve the reconstruction of past landscapes based on animal remains, especially when more than one animal proxy is employed before drawing final conclusions.

The analytical methodology applied in this research has shown that by using the habitat preferences of wild animals, past aquatic and terrestrial landscapes can be reconstructed, with both presence of different water types, water salinity levels, and vegetation. In addition, by comparing the expected and observed species, more insight was gained in presence and sometimes also absence of certain habitat types. So, by ensuring a wide range of wild animal species through adequate sampling and sieving methodologies, a more accurate understanding of the past environment may be obtained.

2.4.5.2 Taphonomy

Past human selection is one of the most important pre-depositional taphonomical processes, which should be taken into account when interpreting wild animal remains. Several reasons may exist for the absence or presence of certain species, and therefore habitat types, in the archaeological record. These reasons may include the human preference for some species over others, differences in (the ease of) their procurement, or (seasonal) abundance. Because this selection process can greatly affect the resulting deposited bone assemblage, definite conclusions on (the absence of) a certain habitat type in the past environment should only be drawn when several indications exist based on the frequency of species and the employment of multiple proxies. The bird remains from Hoogwoud (Figure 2.16) for example, showed the presence of only aquatic birds. This, however, by no means signifies that a site was situated amidst only wetlands. Human selection can severely affect the formation of the bird remains assemblage, and in the case of Hoogwoud, the presence of habitat types other than wetlands were indeed only confirmed by other proxies (cf. Figure 2.17 and Figure 2.18).

Specific taphonomical processes can diversely affect wild animal remains, depending on the species. Salmonids (including salmon and trout species) for example, are rarely found in archaeological contexts, because of their poor preservation characteristics. Salmon and trout possess bones which consist mainly of fat, which increases their susceptibility to degradation (Beerenhout 2005, 49; Beerenhout 2010, 134). The major manner in which these remains can be preserved is after contact with fire, which removes the fat. However, although it can be assumed that when salmonids are available to people, they will be caught and consumed, and most likely come in contact with fire during the process,

this burning process renders the salmonid bones very brittle. This brittleness also increases their chance of being lost by taphonomic processes. Therefore, because preservation of salmonid bone is so rare in general, it is hard to draw any conclusions about their prevalence and abundance. Furthermore, since the preservation of salmonid bones most likely occurs through contact with fire, this also inherently means that the chance of procuring salmonid bones from natural contexts is highly unlikely. Adequately sampling at on-site locations may be one of the few chances in which such fish, and their habitat types, can be identified.

Bird bones are adversely affected as well, as they are hollow and therefore also prone to degradation via mechanical pressure, hindering subsequent identification to species level.

The low numbers of large wild mammal bones furthermore, might also to some extent be related to taphonomical processes. Although in general, all large mammal bones should presumably be similarly affected by taphonomical processes in the soil, pre-depositional processes may very well have been very different for domestic and wild animal species, which could mainly be based on human selection. One such example was obtained from an interview with a present-day huntress who also has experience in taking care of livestock (Mrs. Van Hoey-Smith). Wild animal bones were treated very differently than bones from domestic animals in the recent past and sometimes even in the present: hunting dogs are fed with wild animals bones, to sustain their alertness towards this smell (pers. comm. Mrs. Van Hoey-Smith). However, raw cattle and other domesticated animal bones are not given to the hunting dogs, since they might initiate attacks towards livestock. This practice inevitably results in the complete consumption of wild animal bones, whereas domestic animal bones are largely spared, thus resulting in an under-representation of wild animal bones preserved in the archaeozoological record. Moreover, the purpose of the hunt could also affect the reflection of wild animals in the bone assemblage. When large animals are hunted for meat or raw material and need to be transported back to the settlement, the carcass could be left behind at the hunting location, considerably lowering the transport weight. Therefore, low numbers of wild animal bones as opposed to the large numbers of bones from livestock could have resulted from treating both animal groups differently before deposition, and this would not reflect the original ratios.

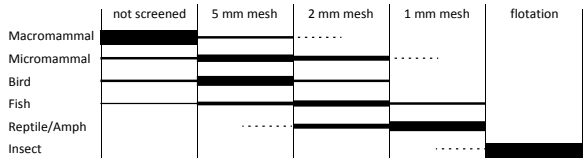

Figure 2.20. Overview of the sieving mesh sizes affecting the recovery of each of the animal groups mentioned (after: Meadow 1980, 69, Figure 2). Thicker bars reflect a higher chance of finding bones of an animal group related to mesh size. Amph: amphibians.

Small mammals finally, can occur at a settlement for several reasons, including natural occurrence and being transported to the settlement by man or animal. The occurrence of several species of small mammal from different habitats within one context for example, increases the likelihood of human (or animal) influence rather than natural occurrence (*e.g.* Lohof & Vaars 2005, 45). However, since small mammals are the prey of many larger animal species, their remains could have alternatively reached the settlement in the form of pellets (*e.g.* from owls; IJzereef 1981, 117) or by gutting a carnivorous animal. For example, a polecat has consumed several small mammals from different habitat types and is subsequently caught by humans and taken to the settlement. There, it is gutted, skinned and cleaned, and the discarded offal containing the stomach and intestinal content (and therefore the small mammals from different habitat types) ends up in the ditch within the settlement. Such a process may be recognised by identifying particular corrosion on the bones from stomach juices (cf. Payne & Munson 1985). When identified, the different small mammal species might thus be preserved in on-site contexts depending on the diet of a hunted carnivorous animal species, and may not always necessarily reflect all the different habitat types present on the settlement itself.

All animal groups have provided examples of the effects of pre-depositional and depositional

taphonomical processes, such as human selection in the past, but also species-specific preservation characteristics on the formation and composition of the archaeozoological record, as well as its interpretation. Therefore, continuous care should be exercised in future research towards landscape reconstruction based on animal remains. In conclusion, the most accurate analysis of available habitat types in the surroundings can be performed by combining different proxies and using the frequency of remains rather than numbers.

2.4.5.3 Indicators for the cultivated landscape

Fish
No clear indications for the cultivated landscape could be recognised among the fish species.

Birds
Some present-day birds display a clear preference for the presence of human-influenced vegetation, such as agricultural fields, fallow fields, and/or meadows. This habitat preference can be regarded as a sub-category within the habitat type grassland and similar preferences might have already existed in the Bronze Age. When such species are uncovered at settlements, and when they prefer such human-bound habitats, it can be assumed that they lived in relatively close proximity to the settlement, and can in a way be regarded as local habitat indicators. Crane and different species of goose and swan, which were all found in West Frisia, graze on the stubbles and remnants of crops on arable fields in autumn and winter (Birdlife International 2012). Skylark, quail, ruff, thrush, and swallow (also all found in West Frisia) profit from these fields all year long.

Especially quail and skylark show a strong preference for a specific height of grass/crop during their breeding seasons. Quail prefers vegetation no higher than one meter (Kwartel n.d.) and for skylark it is important to have areas of extensively used pasture, meadows or arable fields in order to breed successfully in the high vegetation (Willems 2008). Both species show a preference for the summer variety of crops because these provide appropriate shelter and food options at the right time. Winter varieties of crops are not preferred, as they are already too high and dense during the time the breeding season commences (Poulsen 1998; Koffijberg 2002; Willems 2008). The presence of these bird species can therefore provide possible indications for the cultivated landscape and can even provide information on the type of field used as well the type of crop. In the case of West Frisia, this means that both extensively used fields, including pasture, meadows, and arable fields, may have been present, as well as summer crops.

Small mammals
Two species of small mammal have adapted to human habitation in a specialised manner. Both the house mouse (*Mus musculus*) and harvest mouse (*Micromys minutus*) (both found in West Frisia, Table 2.8), can thrive within a settlement or even a house context, and can completely abandon their original habitat preferences. Such species can therefore be used as possible indicators of the cultivated landscape.

2.5 LANDSCAPE RECONSTRUCTION

The main components of the current model listed at the beginning of this chapter have all been challenged with the application of multiple proxies and an analysis based on the combined types of information they provide. A short summary (section 2.5.1) highlights the contribution of each of the used proxies and the approach of this thesis in general to the analyses of the data. The results of the analyses performed in this chapter are subsequently compared to each of the main components of the current model, after which it will become clear if and how they should be re-formulated into new main components (section 2.5.2). In turn, these new main components are combined into a new environmental model for West Frisia based on the integrated use of archaeobotanical and archaeozoological remains (section 2.5.3).

2.5.1. Contributions of proxies and approach to landscape reconstruction

The analysis of off-site pollen has provided information on the regional landscape including the presence or absence of indications for salt marsh, oligotrophic peat, and upland trees and herbs at

different locations within West Frisia. This type of analysis, which had not been performed in the past for West Frisia, provided a clearer image of the vegetation outside the settlements.

Among the macro botanical remains from the settlements there were indications for the regional landscape as well, represented by the presence or absence of remains of trees, peat, salt marsh, and upland vegetation. Fish remains, although not always included in landscape reconstructions, have provided a wealth of information on the aquatic landscape including the available water types in the surroundings of the settlements, as well as their salinity. Also, the observed fish species have provided indirect indications for the required presence of connecting waterways with the sea, based on migratory species. Remains of birds have provided mostly general, but also some detailed indications regarding the environment. A varied terrestrial landscape could be confirmed, as well as the presence of both freshwater and saltwater environments. The presence of trees especially, could be identified on a regional, but also a more local level based on home range size of different species.

Mammal remains finally, also provided evidence for both the regional and local landscape. Large mammals were used for the distinction between the presence of saline and freshwater conditions, as well as for a rough estimation of the size of the water bodies present in the surroundings of the settlement. Moreover, they were able to make the presence of trees in the settlements' surroundings very plausible. Small mammals provided very local information, probably only reflecting the habitats (in the near surroundings) of the settlements, and small and large mammals combined provided a more general and overall insight into the surrounding landscape.

The combination of both botanical and zoological remains used in this chapter has yielded a much more detailed picture than before of the variety of landscape and habitat types present in the surroundings of the settlements of West Frisia. This detail would not have been possible to such an extent if only one of the proxies were considered, or multiple proxies without integration of the individual results.

2.5.2 Assessing Previous Main Components

It is clear that the approach applied in this chapter has given new results regarding the landscape of West Frisia. In this section, to evaluate whether the previous main components are still appropriate to describe this landscape, the main components of the current model are compared to the new results of this chapter.

Main component 1 was formulated as follows:

(1) The seacoast to the west of West Frisia is closed around 1550 BC therefore making influx of marine water impossible after this time.

Based mainly on the fish remains and physical geographical information (van Zijverden forthcoming), but also on pollen remains, it has become clear that the seacoast to the west of West Frisia was connected to the hinterland until at least 1300-1100 BC, possibly even later. Since the new results do not match main component 1, a new main component 1 is formulated:

(N1) The seacoast to the west of West Frisia was at least open until 1300-1100 BC, and the inland influx of marine water was possible up to at least the settlement of Hoogwoud.

Main component 2 was formulated as follows:

(2) A purely freshwater environment existed around the settlements in eastern West Frisia throughout the Bronze Age.

The analyses of pollen remains, macro botanical remains, and animal remains have revealed that the settlements in the east of West Frisia were surrounded by a varied aquatic landscape, consisting of water bodies with varying (low) salinity levels. Most water bodies surrounding the eastern sites can be characterised as freshwater to slightly brackish, possibly due to their indirect connection with the North Sea via the Oer-IJ estuary and the large lakes to the east of West Frisia. Again, the new results and the current main components are not compatible and main component number 2 is therefore newly formulated:

(N2) An aquatic landscape with varying low salinity levels existed around the settlements in eastern West Frisia throughout the Bronze Age.

Main component 3 was formulated as follows:

(3) Wide-spread peat growth occurred in the Late Bronze Age, resulting in the abandonment of West Frisia.

Based on the pollen remains and the macro botanical remains, no evidence for the wide-spread growth of peat on settlements could be discerned, neither for the Middle Bronze Age, nor the Late Bronze Age. These results suggest that also main component number 3 should be reformulated:

(N3) No wide-spread peat growth occurred at the Late Bronze Age settlements, so this phenomenon cannot be regarded as a reason for the alleged abandonment of West Frisia during this time.

Main component 4 was formulated as follows:

(4) The terrestrial landscape of Bronze Age West Frisia is characterized by treeless, open areas.

Species observed among the pollen remains, macro botanical remains as well as animal remains show clear preferences for the presence of shrubs and trees in the surroundings of the Bronze Age settlements. Since this hardly reflects a treeless landscape, main component number 4 is also reformulated:

(N4) The terrestrial landscape of Bronze Age West Frisia can be characterised as a mosaic of habitat types including grassland, shrub land, trees, and wetlands.

All the previous main components are clearly no longer accurate to describe the West Frisian situation regarding the landscape. Therefore, the new main components, as well as the other new results are combined into a new model below.

2.5.3 New model for the Bronze Age West Frisian landscape

The new model for the West Frisian landscape presented here is mostly based on the research of Van Zijverden (forthcoming), which covers the Early, Middle, and Late Bronze Age. Where applicable, additions to his model are made based on the results of the analyses of organic remains from this chapter.

Aquatic landscape

In the Early Bronze Age, the Bergen inlet was open and saltwater influxes could reach as far inland as Emmeloord (van Zijverden 2002). Since West Frisia is situated between the North Sea and Emmeloord, the eastern sites of West Frisia thus also experienced these influxes (van Zijverden forthcoming, Chapter 3). The Early Bronze Age site Schagen was located near the seacoast along a large water way, evidenced by the many marine indicators found here (Vos 2015). Based on geology and ecology, the site of Schagen was most likely located in an intertidal habitat, with smaller, more freshwater bodies present in the surroundings as well.

Insight into the Early Bronze Age landscape in the eastern part of West Frisia was obtained by analysing multiple proxies on an off-site location, the site Noorderboekert (van Zijverden forthcoming). The Early Bronze Age landscape (*i.e.* from 2100-1600 BC) could be reconstructed y analysing samples deriving from a natural flood basin area. The investigated proxies include pollen, botanical macro remains, ostracods, diatoms, forams, and molluscs. The general landscape type in this part of West Frisia can be regarded as a large area of flood basins and tidal creeks with varying salinity levels ranging from brackish to saline (Figure 2.21). Throughout the Early Bronze Age, the aquatic landscape was very dynamic, with both water depth and flow speed varying enormously. The environment at the start of the Early Bronze Age is characterized by presence of a deep tidal channel transporting marine organisms, which changes into a marsh dominated by stagnant and fresher water conditions. However, this local presence of fresh(er) water is periodically, but irregularly influenced by saltwater influxes, which indicates the possible occurrence of storm surges

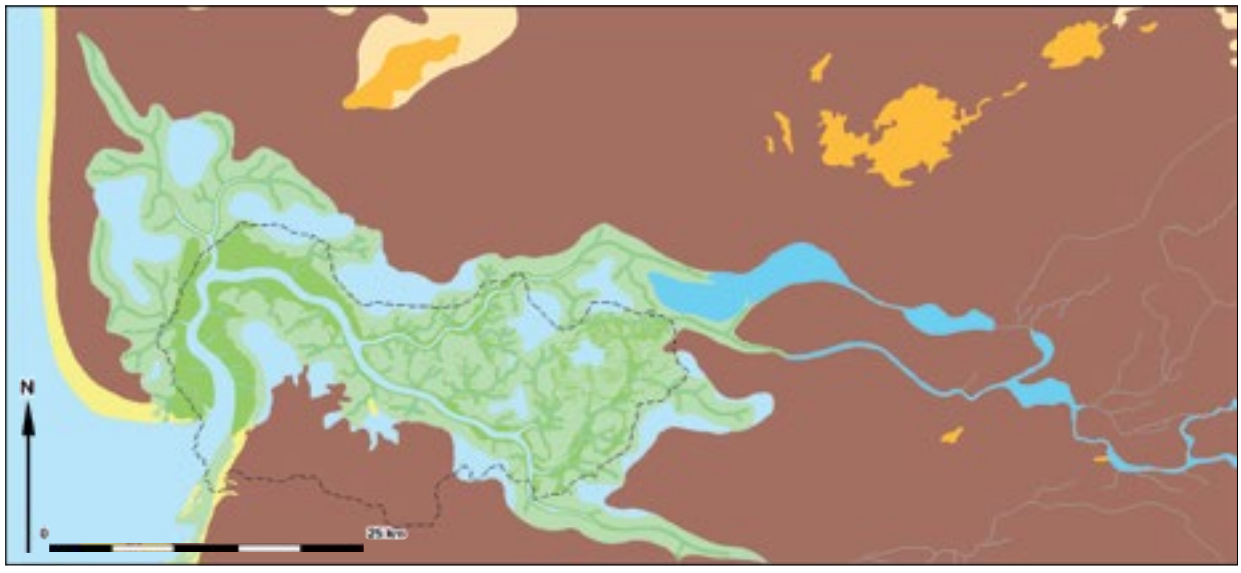

Figure 2.21. The Early Bronze Age landscape of West Frisia (from: van Zijverden forthcoming) For the legend of the underlying map, see Figure 2.1b.

Figure 2.22. The Middle Bronze Age landscape of West Frisia (from: van Zijverden forthcoming). For the legend of the underlying map, see Figure 2.1b.

Figure 2.23. The Late Bronze Age landscape of West Frisia (from: van Zijverden forthcoming). For the legend of the underlying map, see Figure 2.1b.

and/or spring tides during this time. Near the end of the Early Bronze Age, water flow again increases, reverting the landscape back to being dominated by flood basins and tidal creeks, although the water is no longer saline (van Zijverden forthcoming).

The Middle Bronze Age is characterized by a decreased size of the Bergen inlet, with saltwater influxes still reaching as far as Hoogwoud. In the east, large lakes are fed by rivers from the east of the Netherlands and via the northern branch of the river Rhine discharging in the Oer-IJ estuary (Figure 2.22). Hoogwoud can be regarded as being dominated by an intertidal habitat, with the additional presence of water bodies with less saline conditions in the area. The eastern sites of Medemblik, Enkhuizen, Westwoud, and Bovenkarspel can be characterised by a combination of water types present in the surroundings, mostly consisting of stagnant to slow-flowing water and open water. The water will have been fresh to slightly brackish. In addition, there appears to be an absence of actual fast-flowing water types (*i.e.* rivers) within the eastern part of West Frisia.

In the Late Bronze Age, the Bergen inlet is probably closed entirely, but possibly, a residual opening was still present. The main inflow of saltwater now only occurs via the opening of the Oer-IJ estuary, which is also starting to decrease in size, leaving less room for the passage of sea water into the hinterland. This phenomenon, in combination with the fact that the large lakes in the east are still being fed with fresh water from rivers further east, means that the eastern large lakes are expanding, and that the overall salinity level of the lakes decreases. Still, several different types of water bodies will have remained present around the settlements (Figure 2.23).

Terrestrial landscape

The Early Bronze Age terrestrial landscape in the west of West Frisia was an intertidal landscape (Figure 2.21). The uncovered terrestrial animal species in Schagen reflect a varied landscape, consisting of a combination of grassland, shrubs, and trees. The eastern part of West Frisia consists of creek ridges amidst large bodies of water (Figure 2.21; Knippenberg in prep.). Since large fluctuations in water table and salt content occur, only marsh dominated by reed vegetation, and willow shrubs can survive. The usual wetland vegetation types, including alder carr and sedges, do not develop here. In the Middle Bronze Age, the landscape surrounding the settlements throughout West Frisia can be viewed as a mosaic of different landscape types,

including grassland, shrub land, trees, wetlands in the east, and, more towards Hoogwoud in the west, saltwater areas (Figure 2.22). The vegetation in the eastern part of West Frisia during this time more particularly consisted of alder carrs in wetlands, ash-elm forests in drier areas, and moderately nutrient-rich grassland in the driest areas, probably caused by grazing of livestock.

The Late Bronze Age is characterised by an increase of the ground water table by as much as one metre (van Zijverden forthcoming). In combination with an increase in surface water fluctuation, this results in a change in wet vegetation types, which now consist of reed vegetation and soft willow shrub along shallow lake shores. The habitat types from the Middle Bronze Age still exist in the Late Bronze Age, but are now more condensed into smaller areas with remaining suitable soils (Figure 2.23). This condensed state of vegetation types and shortage of suitable land will ultimately have restricted the exploitation, habitation, and migration by people and animals living in West Frisia at this time, although some areas remained habitable until the Iron Age.