Deeply Set Roots: an Archaeobotanical Perspective on the Origins of Crop Husbandry in the Western Balkans

Anne de Labroue de Vareilles Sommières

Thesis submitted in fulfilment of the Degree of Doctor of Philosophy
Institute of Archaeology, University College London
September 2017

A personal rendition of *Auguries of Innocence*, by William Blake

To see a World in a Grain of Wheat
And a Field in a Wild Flower,
Write Prehistory through its Crops and Meat,
And a Thesis in an Hour!

A sampled site without an Age
Puts all Heaven in a Rage.
A flot with no descriptions
Shudders Hell thro' all its regions.
Wheat farming in the Iron Gates
Predicts the ruin of the States.
Millet, Spelt or the New Type
Cause the Academics to Fight.
Each Student outcry: It's not Fair!
A fibre from the Brain does tear.

A Graph that's shown with Bad intent
Beats all the Lies you can invent.
It is right it should be so;
Stats were made for Joy and Woe;
And when this we rightly know
Thro' Data we safely go.

Every Night and every Morn
Few then many words were born.
Every Morn and every Night
Chapters finished in Delight.
Chapters finished in Delight,
And a Thesis came in Sight.

(original phrases are shown in italics)

I, Anne de Labroue de Vareilles Sommières, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

ABSTRACT

This doctoral thesis explores the origins and development of Neolithic crop agriculture in the western Balkans from *c.*6100 to 4500 cal. BC, through archaeobotanical data. The western Balkans is a geographical area comprising of Montenegro, Croatia, Bosnia and Herzegovina, Serbia and the Former Yugoslavian Republic of Macedonia. The western Balkans is the first area in the westward spread of agriculture into Europe where different maritime and inland routes can be observed to progress simultaneously whilst retaining distinctive cultural signatures. The aim of this thesis is to identify and describe the crop packages, gathered edible plants and cultivation practices between the two streams of neolithisation, and to place them within their wider geographical and chronological contexts. As such, archaeobotanical records from Adriatic Italy, Hungary, Romania, Bulgaria and Greece were also used. Data for this thesis is thus composed of samples from ten sites analysed by the author, in addition to a dataset of 244 archaeobotanical records from published and unpublished Neolithic sites. The ten sites are analysed individually before being added to the larger dataset, allowing for site-specific interpretations to be made. This thesis demonstrates that the suite of crops cultivated by the first farmers to reach Europe was not as restricted as was previously suggested by other meta-analysis approaches. Through statistical methods, spatial and diachronic differences within the crop packages are illustrated, and ecological characteristics of the possible weed flora are used to define past agricultural systems. Both environmental and cultural explanatory frameworks are sought to explain the patterns in agricultural practices, which appear to have been variably influenced by both parameters. Although domesticated fauna are not the focus of this thesis, information on animal husbandry regimes is included wherever possible, with a view to present a more accurate image of the agricultural foundations that defined the Neolithic in the western Balkans.

CONTENTS

List of Figures (figures are numbered by chapter)

List of Tables (tables are numbered by chapter)

Acknowledgements

My supervisors Marc Vander Linden, Dorian Fuller and Sue Colledge, each with their own level of expertise, have been a fundamental source of inspiration and encouragement throughout. I would particularly like to thank Marc for his patient and tireless guidance, not only in shaping me back into academia, but also in teaching me how to manage and run an excavation. I am very grateful to Sue and Dorian for stimulating discussions on archaeobotany, their useful comments on my work and for sharing unpublished data and articles.

I would like to thank Ivana Pantović, Marcel Burić, Josip Burmaz, Ivana Pandžić, Bojan Vujinović, Dejan Gazivoda and Nikola Borovinić who welcomed me into their projects and made archaeobotanical samples available. Dragana Filipović, Kelly Reed and Đurđa Obradović were always happy to share data and information, answering my numerous questions on the archaeology in the western Balkans. My thanks also go to Jane Gaastra, Ivana Jovanović, Nelis Drost, Gary Marriner, David Orton and Sebastien Manem, as my EUROFARM colleagues, for their friendship and mental support, both in the field and at home. And I think of Dijana Koljić and Leon Veal who assisted me through long hours of flotation under sun, sleet and snow.

My friends in Room 306 have been my other 'team'. They have given me aid and advice, even during the endless days stuck at home in my office, through the informative and often hilarious conversations on our 'Ultimate Sorters' WhatsApp group. I would especially like to thank Chris Stevens and Charlene Murphy for their corrections and comments on my work, and for their time generously given to discussions and help during seed identifications.

Lastly, my sincere thanks go to my husband Chris, my parents and sisters, and my friends Catherine, Sarah and Maria, for their time, love and encouragement. In particular, their help with childcare has been essential in enabling me to work long hours and to go on fieldwork. My admiration and love go to Matilda and Luke for their patience and (mostly) cheerful dispositions!

This research project would not have been possible without the unfailing support of my supervisors, colleagues, friends and family who have been there for me along the way. I will forever be grateful to them for giving me the opportunity to write a doctoral thesis, and to start an academic career in a field that is both exciting and fascinating.

CHAPTER 1

Introduction

This thesis uses archaeobotanical data to describe the origins and developments of arable agriculture during the Neolithic in the western Balkans (*c*.6100-4500 cal. BC). The research stems from the ERC funded project entitled *Transmission of innovations: comparison and modelling of early farming and associated technologies in Europe* (EUROFARM), directed by Dr M. Vander Linden (University College London). The aim of EUROFARM is to explore the first inland and coastal spread of farming in the western Balkans through four main technological innovations: farming practices, landscape use, pottery and lithics (Vander Linden *et al.* 2013). The western Balkans is composed of the Former Yugoslavian Republic of Macedonia (hereafter FYROM), Montenegro, Croatia, Serbia and Bosnia and Herzegovina (hereafter BiH). It is a group of countries that connect Greece and Bulgaria to the rest of Europe, and is a key geographical area where both inland and maritime routes of neolithisation co-developed within very different environmental settings, and potentially coalesced. By exploring what crop packages were used within the two routes, and assessing adaptational shifts in the use of edible plants, this thesis aims to bridge the gap between the first westward migration of farmers out of the Near East and the Early Neolithic communities of central Europe and the Mediterranean coast.

Archaeobotanical samples were retrieved from ten sites across Serbia, Croatia, BiH and Romania, and further records of plant macro-remains were obtained from 244 sites. These include Neolithic sites from Bulgaria, Greece, Adriatic Italy, Hungary and eastern and southern Romania, not only to contextualise the research area but also to include all sites attributed to the Early Neolithic coastal and inland cultural entities characterised by Impressed Ware and Starčevo-Körös-Criş (hereafter SKC) respectively.

Plant macro-remains (excluding charcoal) are used to describe, compare and contrast crop cultivation and the use of wild edible plants between the two streams of neolithisation. Within this overarching theme, further questions pertinent to the Early Neolithic (*c*.6100-5400 cal. BC) and the Middle/Late Neolithic (*c*.5400-4500 cal. BC) are addressed. Plant remains from the Early Neolithic are used to explore the origins of the two crop packages, and their development into that of the Cardial and *Linear-Bandkeramik* (hereafter LBK) groups. By 5400 cal. BC the cultural landscape of the research area began to diversify and a greater range of geographical and ecological zones were occupied. Thus, the Middle/Late Neolithic plant remains are used to describe developments in the plant diet as well as cultivation regimes, and evaluate the effects of environmental and cultural conditions at both regional and local scales.

The following nine hypotheses concerning arable farming and the consumption of wild plants are tested:

1. that differences in the quantity of charred crop remains between the Early and Middle/Late Neolithic do not represent a shift in the importance of cultivation (contra, for example, Greenfield *et al*. 2014), but rather differing levels of preservation and archaeological interests;
2. that during the initial phase, differences between the two streams, firstly seen in the pottery, are also evident in the crop packages (e.g. Bocquet-Appel *et al*. 2009; Forenbaher *et al*. 2013; Vander Linden 2011);
3. that during the initial phase, there was a drop in diversity in the crop packages of both streams, compared to earlier packages from Greece and Bulgaria (*cf*. Bogaard *et al*. 2007a: 434-36; Bogaard & Halstead 2015: 391; Colledge *et al*. 2005: 150; Coward *et al*. 2008);
4. that in the subsequent phase there was both an increase in the range of cultivated crops, and in the diversity of exploitation practices (of both crops and wild edible plants) within the two streams of neolithisation;
5. that adaptations to new environments are visible in the use of cultivated and wild plants, but that the cultivation of particular species was not purely dictated by environmental/climatic conditions (*cf*. Colledge *et al*. 2004; Coward *et al*. 2008; Stevens *et al*. 2016);
6. that adaptations to increasingly northerly latitudes can be explored through reconstructed climatic parameters and the temperature thresholds of modern crop varieties;
7. that adaptations to more northerly latitudes included a shift from autumn- to spring-sowing of cereal crops;
8. that, as has been demonstrated for sites in Greece, Bulgaria and central Europe, farmers practised an intensive form of cultivation, dedicating high inputs of time and energy on creating fertile, weed-free and watered conditions (Bogaard 2002a,b, 2004b, 2005; Bogaard & Halstead 2014; Halstead 1987, 1989; Marinova 2006);
9. that fixed-plot as opposed to shifting cultivation was prevalent (*contra*, for example, Whittle 1996: 160-62, 1997).

Despite an early interest in plant remains from Neolithic sites in the research area (e.g. Evett & Renfrew 1971; Hopf 1967, 1974; Renfrew 1974, 1976, 1979; van Zeist 1975), the value of archaeobotanical data to explicate Neolithic lifestyles is, though increasingly recognised, still in its infancy (Filipović & Obradović 2013; Reed 2015, 2016). Initial attempts to describe the first agricultural communities seldom included archaeobotanical data. Most famously, Gordon Childe (1929, 1957) described how an expanding population of Neolithic farmers spread across Europe, and in particular along the Danube, replacing the 'simple' hunter-gatherers with a 'civilised', complex and agriculturally dependant, sedentary civilisation. Incoming farmers were argued to have spread quickly relying on slash-and-burn agriculture to cultivate the virgin forests of Europe (Childe 1929: 45-46; Clark 1952: 92-98). Farmers were also assumed to have cultivated the fertile river floodplains, with very little effort, presumably sowing their crops in the spring after the winter floods (Sherratt 1980: 315; Bogucki 1996: 244). More recent research on individual sites has sought to describe cultivation practices through the ecological requirements of wild/weed seed assemblages. Nevertheless, most of these assemblages are very small, and only one site has produced robust results (the Hungarian site Ecsegfalva: Bogaard *et al.* 2007a, 2008). This research project not only presents new findings from recently excavated Neolithic sites, but also pools all existing records of plant macro-remains, enabling the data to be examined from a new perspective and at different scales.

The research area, whose environmental and climatic conditions during the Holocene are defined in **Chapter 2**, is comprised of several ecological and climatic zones. Some cultural groups inhabited more than one zone and some zones were home to more than one cultural group. The defining cultural and economic traits of the various Neolithic groups are presented in **Chapter 3**, which also reviews the mode and tempo of the coastal and inland routes, as well as possible encounters with Late Mesolithic populations. Exploring the plant diet and arable farming strategies *vis a vis* cultural and environmental parameters has illustrated the interplay between culture and nature, and resulted in more nuanced explanations for the cultivation of particular crops and the use of wild resources (*cf*. Colledge *et al*. 2005; Fuller & Lucas 2017).

The archaeobotanical records used in this thesis are presented by country in **Chapter 4**, where the current state of archaeobotanical research for the Neolithic is outlined. Before the data can be analysed to extract new interpretations, the pre- and post-depositional factors that shape archaeobotanical assemblages must be considered. **Chapter 5** explores how archaeobotanical assemblages are formed, recovered, analysed and interpreted. Emphasis is placed upon the theoretical framework and taphonomical considerations relevant to the analyses of samples and published data. The methodology employed, including the use statistical techniques, is defined in **Chapter 6**. Results from the samples I sorted are presented and interpreted in **Chapter 7**, where questions relating to crop processing and the functions of features/structures are addressed.

Additionally, grain measurements are plotted against other known sizes to explore the possible evolution of landraces. The newly acquired data are added to other published and unpublished archaeobotanical records in **Chapter 8**, where trends in the gathering and cultivation of plant taxa during the Neolithic are illustrated. The Early Neolithic data is split between the two coastal and inland areas, demonstrating the need to recognise these two streams when considering how crops first spread into Europe. For the Middle/Late Neolithic common trends and diversity in farming practices across geographical, ecological and cultural boundaries are demonstrated. In order to cover the geographical and temporal extent of the project, and to search for trends pertinent to different groups rather than individual sites, records of plant macro-remains were reduced to a format of presence/absence. Such an approach was the only way to amalgamate and compare records written over seven decades in five different languages and under shifting archaeological traditions.

This thesis is the first to present a thorough review and analysis of Neolithic grains, seeds, fruits and nuts from the western Balkans, Adriatic Italy and Hungary. It brings to light the arable economies of the first farmers to cross into Europe by two very different routes, and thereby fills a gap in our understanding of how farming initially spread and developed. Reasons for the preference of certain crops over others are explored, and the (re)discovery of taxa such as spelt, 'new' glume wheat, rye and opium poppy, offer new perspectives on their somewhat enigmatic history of domestication and cultivation. Evidence for the continued importance of wild plant foods is evaluated, and comparisons are made between geographical, environmental and cultural zones. The ecology of wild/weed seeds is used to extrapolate the conditions and levels of intensity under which crops were cultivated, and efforts are made to combine results with information on animal husbandry regimes in order to present a holistic view of the agricultural economy.

CHAPTER 2

Geographical and Environmental Setting

The research area encompasses the Balkan peninsula, Hungary, western Romania and eastern Italy (Figure 2.1). Its northern extent covers the Pannonian Basin and is bordered by the Alps (the most northerly site lies at N 48.4, E 21.3 in north-eastern Hungary). In the West the boundary is stretched to include Adriatic Italy, from Apulia to the Po Plain (the most westerly site lies at N 45.22, E 10.25 in the Po Plain). The research area therefore consists of a vast and varied topographical area, offering a range of ecological and geographical zones. This chapter begins by describing the geology and physical geography of the study area. Modern soil distributions are also described, and their potential suitability for cultivation. Section 2.3 focuses on the palaeoclimate and palaeovegetation of the area during the Early and Middle Holocene (*c*.11,700-5700 cal. BP). After available proxies for regional vegetation and climatic reconstructions are discussed, broad-scale parameters for temperature and precipitation are obtained from a recent article (Mauri *et al*. 2015). The chapter concludes with a presentation of the bioregions used to define broad ecological conditions across the study area.

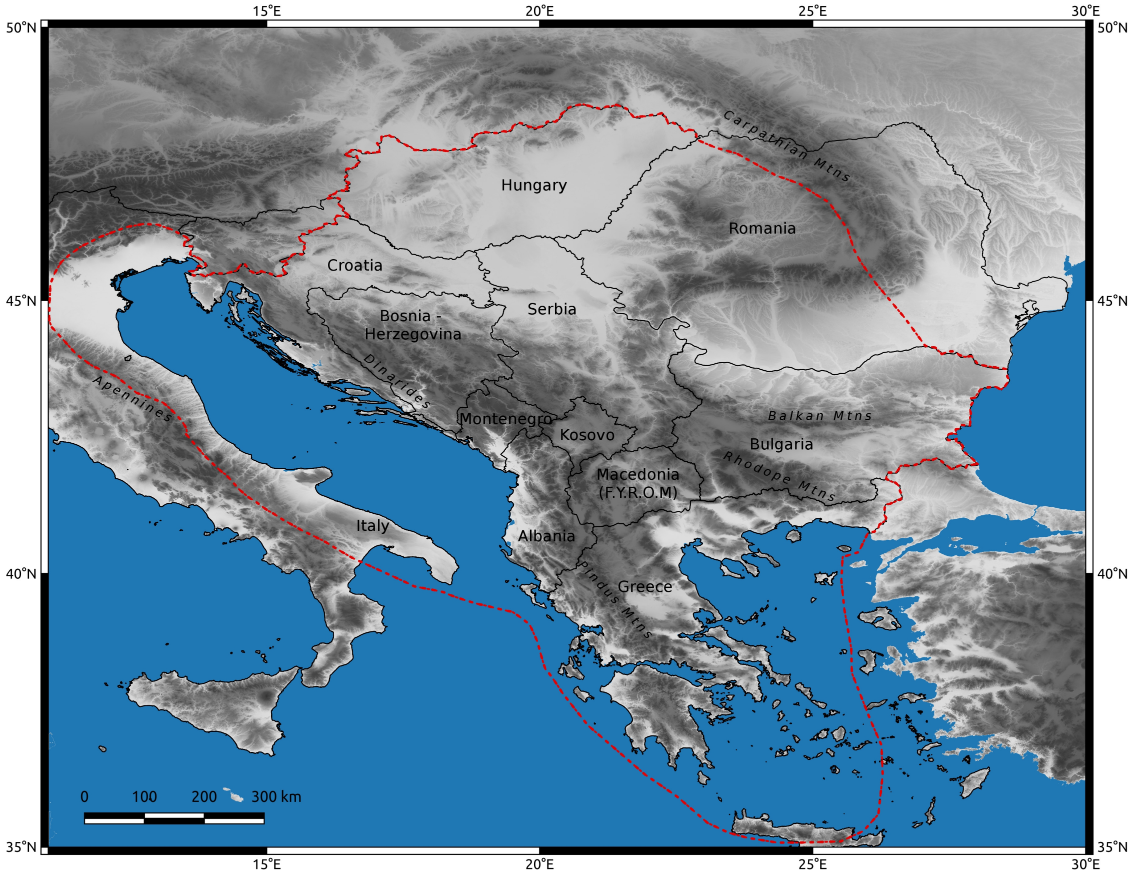


Figure 2.1: The research area (outlined in red) with its major political boundaries and mountain ranges.

2.1 Geology and physical geography

The Balkan Peninsula is composed of various tectonic zones (Gealey 1988; Robertson *et al*. 2009: fig.2), consisting of five main mountain ranges and several major river systems. About 60% of the land rises to 1000m or more above sea level (Willis 1994: 770). It has an extensive coastline, that at the height of the Last Glacial Maximum (hereafter LGM) would have been about 100 metres below current levels (Brückner *et al.* 2010: 162-65; Lambeck *et al.* 2004). At the onset of the sixth millennium BC Adriatic sea levels were still about *c*.16 to 20 metres lower than today's, only reaching current coastlines during the Roman period (Lambeck *et al*. 2004: 1592, Fig.12; see also Zecchin *et al*. 2015 on the possible uneven rates in sea level rise). Black Sea levels also rose during the Early Holocene, though timing, speed and flooding effects upon local human populations are still heavily debated (e.g. Brückner *et al*. 2010; Peev 2009; Yanko-Hombach *et al*. 2007).

In the South-East corner of the Balkan Peninsula lie the Rhodope mountains. They are formed of marbles, schists and gneiss, and stretch from the Thracian plain into southern Serbia. These mountains separate Greece from Bulgaria, and border the high plateaux of the FYROM. The Thracian plain, or lowlands of Bulgaria through which runs the Maritza river, is flanked on its northern side by the Balkan mountains, or Stara Planina. These and the Rhodopes converge north of Sofia creating a mountainous border between the Serbian, Bulgarian and Romanian plains. To the West of the mountains, in Serbia, lies the Morava Valley. The latter is part of the Morava-Vardar corridor: a natural passage of extensive alluvial plains that connects the eastern Mediterranean with the Danube Basin further North. The Carpathian mountains begin in Slovakia and arch across Romania encircling its western zone into the Pannonian Basin (Jordan-Bychkov & Bychkova-Jordan 2001: 34). They are severed from the Balkan mountains by the Danube Gorges, which create a natural border between Serbia and Romania. The Danube Gorges, or Iron Gates is a 130km long pass through the Alpine ranges where about 30 Palaeolithic and Mesolithic sites have been discovered (Bonsall *et al*. 1997: 51-52; Chapter 3.2.4). It separates the Pannonian Plain to the West from the Wallachian plain to the East.

The northern part of the research area contains most of the lowland territories of the northern Balkans. It is known as the Pannonian Plain and encompasses Slavonia (northern territory of Croatia), Serbia north of the Sava and Danube rivers, western Romania and Hungary (Figure 2.2). It is composed of a flat landscape no higher than 100m above sea level, dissected by the Sava, Danube, Tisza and their tributaries (Bridges 1990: 226). Though today rivers are canalised, the lack of gradient would have resulted in large meandering rivers and high water-tables.

Geoarchaeological investigations in Hungary and northern BiH describe the plain during the Early Holocene as a hydrologically active and extensively flat landscape of braided river systems, oxbow lakes, bogs, gravel islands and raised levees (Magyari *et al*. 2010; Magyari *et al*. 2012: 12-15; Marriner *et al*. 2011; Marriner *et al*. 2015; Sümegi *et al*. 2002; Sümegi & Molnár 2007: 67-69).

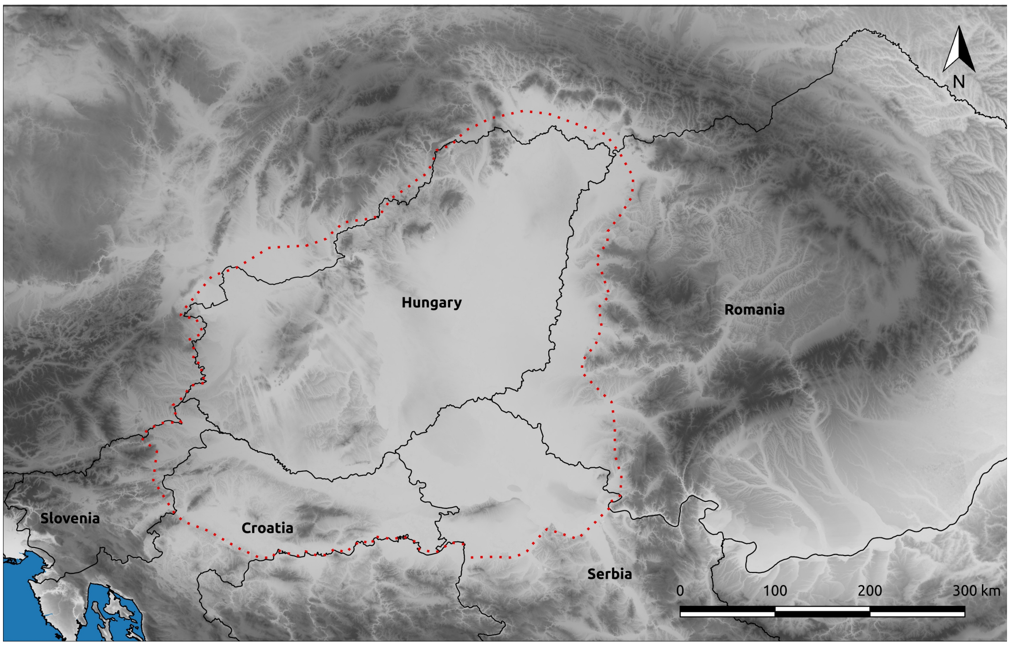


Figure 2.2: The extent of the Pannonian Plain (outlined in red).

The western side of the Peninsula is lined by the Pindus Mountains across Greece and Albania, and by the Dinaric Alps, or Dinarides from Albania to the Croatian coastline; "...the Dinarides and Pindus tend to rise very steeply from the coastal strip, and the boundary between the northern Dinarides and the Pannonian Plain is clearly defined." (Reed *et al*. 2004: 14). The Dinarides expand eastwards into much of central BiH where they are known as the Bosnian Mountains. Together with southern and central Italy (covering the Apulia and Marche regions), the Adriatic zone of the Balkan Peninsula is rich in limestone, being formed on a carbonate platform (Bridges 1990: 234; Robertson *et al*. 2009: 4). Dalmatia is considered a 'high karst zone' where soils are generally thin, springs are scarce and limestone outcrops are frequent (Bridges 1990: 234; Reed *et al*. 2004: 14). Only the Ravni Kotari region (from Zadar to Split) offers a fertile plain with abundant fresh water resources between the Adriatic and Dinaric Alps some 40km inland (Korona *et al*. 2009: 222).

The Apennines run down the centre of Italy, separating the broad Adriatic coastal plain from the western side of Italy (Figure 2.1). Southern Italy, here equated to Apulia, stretches from the tip of the 'heel' to the northern side of the Gargano Promontory (Figure 2.3). The 'heel' is covered in the low Salento hills interspersed with flat, wide valleys (Fiorentino *et al*. 2013: 1299). Between the hills and the Plateau of the Murge lies the small Brindisi plain, about 150m above sea level and which contains many streams (Fiorentino *et al*. 2013: 1299). The Murge Plateau is the largest section of Apulia; it is a wide calcareous ridge that, in certain areas, sits at over 600m above sea level, and is characterised by a series of terraces dissected by short karst canyons from which freshwater springs (Caldara *et al*. 2011: 183; Fiorentino *et al*. 2013: 1299). Between c.5900-4400 BC the Plateau also hosted small coastal lakes and fen-like fresh water marshes, offering resources from both wet and dry biomes (Caldara *et al*. 2011: 185). Between the Murge Plateau and the Gargano Promontory lies the Tavoliere Plain: a large alluvial plain that slopes gently towards the Adriatic. During the sixth millennium BC, when sea-levels were lower, rivers of the Tavoliere Plain drained into a large coastal lagoon with predictable marine resources (Caldara *et al*. 2011: 188). The Gargano at the northern tip of Apulia is a mountainous headland of deep valleys and caves that protrudes into the Adriatic.

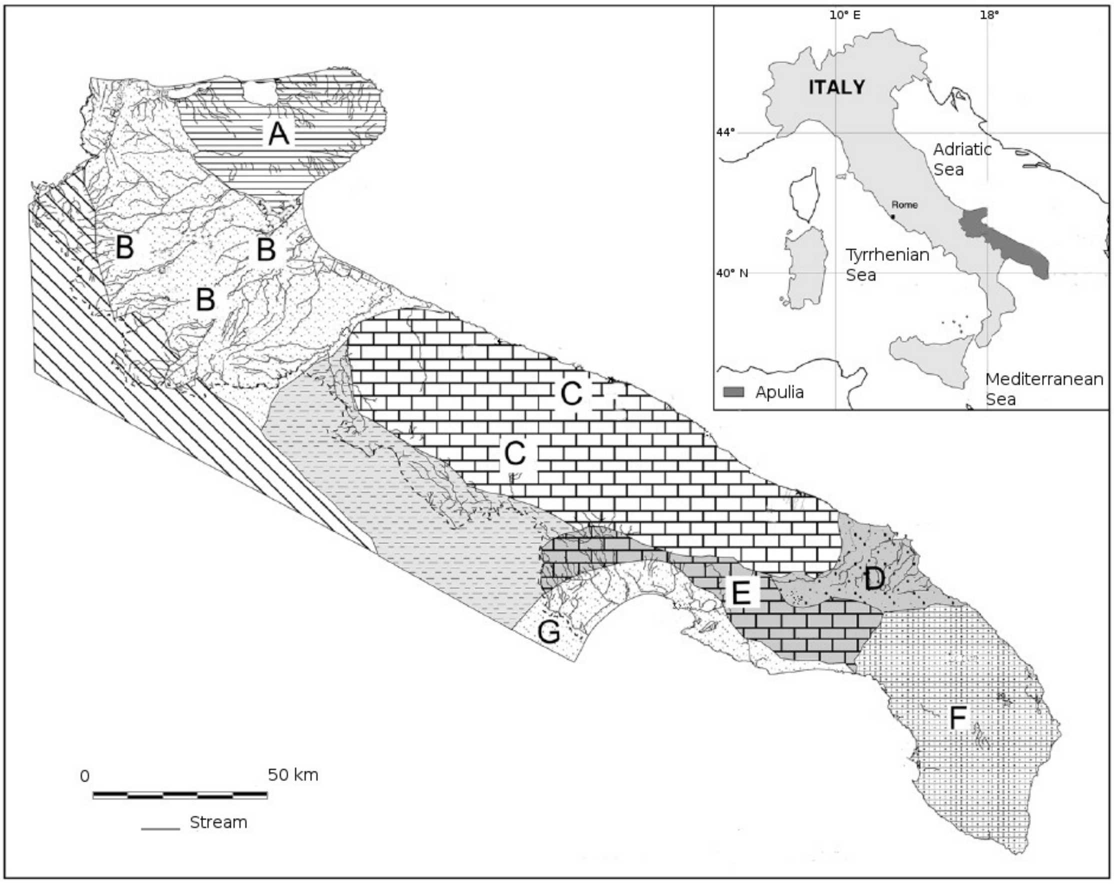


Figure 2.3: Geological map of Apulia (modified from Fiorentino *et al*. 2013: Fig.1). A- Gargano Promontory; B-Tavoliere Plain; C & E- Murge Plateau; D-Brindisi Plain; F- Salento Hills.

The Adriatic coast of central Italy covers three modern regions: Molise, Abruzzo and Marche. The first two are more mountainous, whereas Marche has a wider coastal plain of clay and sandstones deposited over a micritic and marly limestone bedrock (Coltorti 1997: 313). By the Early Holocene the plain was mostly covered in fluvial deposits that were cut by low-energy meandering rivers (Coltorti 1997: 317, 322; Coltorti & Farabollini 2008: 41). Large sandy bays formed between the receding coastal cliffs where rivers met the transgressive sea (Coltorti 1997: 324; Coltorti & Farabollini 2008: 41).

The eastern side of northern Italy consists of the Po plain. It lies on the same limestone platform as southern and central Italy but, being a natural trough, it has accumulated rich colluvial and alluvial soils from the bordering Alps and Apennines (Bridges 1990: 240; Campo *et al*. 2016: 266; Jordan-Bychkov & Bychkova-Jordan 2001: 41). The Po river is primarily fed by snowmelt in the spring and runoff in the autumn, and is the main contributor of fresh water into the Adriatic (Combourieu-Nebout *et al*. 2013: 2025). At the foothills of the Alps large lakes created by the deposition of moraines during the LGM would have provided fresh water and a rich ecosystem within a sub-alpine ecozone (Bychkova-Jordan 2001: 41). Between the lakes and the fertile coastal plain lies a rocky outwash area where the bedrock protrudes above the Po-Veneto plain, resulting in the elevation of the water-table and an east-west line of natural springs known as the *fontanilii* (Bychkova-Jordan 2001: 41). Due to rising sea levels and global warming after the LGM, Late Pleistocene fluvial sands were covered by mud-dominated Holocene deposits (Campo *et al*. 2016: 270-72). During the sixth and fifth millennium BC the plain and its surroundings would have been the most ecologically diverse of the Adriatic regions, hosting various environments: alpine and sub-alpine, low-energy systems of meandering rivers, more hydrologically active zones of braided-river systems, fresh water swamps and a transgressive coastline (Campo *et al*. 2016: 267-70).

2.2 Soils

Soils are formed through the physical and chemical weathering of the geological substrate, or bedrock. They are composed of inorganic (sand, silt and clay) and organic materials (mainly carbon, hydrogen and oxygen compounds from decaying organisms). Soils are classified according to the proportion of these materials, the type of bedrock they overlie and their moisture content. They are active and host dynamic ecosystems that will change or develop under topographical, hydrological, ecological and anthropogenic influences (French 2003: 35-43; Limbrey 1975).

Modern soil maps indicate that the Balkan Peninsula can be broadly divided into the littoral and inland zones (FAO & UNESCO 1981: 27-72). Cambisols (brown soils) and chernozems (heavy, fertile soils) dominate inland, as well as in northern Italy and at the very tip of the Italian 'heel'. The littoral zones of the Balkan Peninsula and Apulia are interspersed by lithosols in which bare rock outcrops are frequent, and stony chromic luvisols, or *terra rossa*. Calcaric regosols are found along the middle section of the Italian Adriatic coastline. Overall the research area currently contains

> "...a highly diversified variety of soils, offering considerable possibilities for suitable agricultural use. By and large, farming is impossible only in the mountainous regions. In some areas, salinity or the dry climate, or both, also impose strict limitations. On balance, it can certainly be said that, all in all, Europe is one of the most privileged regions of the world from the standpoint of the agricultural potential of its soils" (FAO & UNESCO 1981: *viii*).

Although general soil classifications may be useful for locating settlements, natural phenomena and anthropogenic activities have greatly altered both chemical and physical conditions of soils since farming began (e.g. Jarman *et al*. 1982: 132; Kalis *et al*. 2003; Marinova *et al*. 2012). The structure and fertility of soils cultivated during the Neolithic should therefore be investigated through geoarchaeology and environmental proxies (Chapter 3.3.2).

2.3 Climate and vegetation

2.3.1 Regional scales

The Neolithic expansion through the Balkans and along the Mediterranean occurred during the start of the Middle Holocene (i.e. around 8.2ka BP according to the tripartite division of the Holocene by Walker and colleagues (2012)). By then temperatures and available humidity had increased since the LGM, enabling woodland to expand over Europe. Pollen records from Bulgaria, Greece and lakes on both sides of the Adriatic all indicate a high presence of deciduous oak (*Quercus robur* Type), with a prevalence of birch (*Betula*) at higher altitudes (Connor *et al*. 2013: 208; Favaretto *et al*. 2008: 97; Willis 1994: 778). A rise in elm (*Ulmus)* and birch dominated woodland was seen in Slovenia, and in Hungary and Romania, where it was apparently colder, conifers, birch and alder (*Alnus*) prevailed (Eastwood 2004: 38; Feurdean *et al.* 2014: 220; Willis 1994: 778). In Vojvodina (northern territory of Serbia), abundant pine (*Pinus*) and beach (*Fagus*) pollen indicate colder environmental conditions similar to those of western Romania (Filipović *et al*. 2017: 18). Mixed temperate deciduous forests spread across the Pannonian plain, with a more open distribution in the lowlands (Feurdean *et al.* 2014: 218). Other tree species within the mixed woodlands included those indicative of rising levels of precipitation (*Alnus*, *Salix* and *Fagus*) and average temperatures (*Acer,* *Carpinus, Tilia, Corylus, Ulmus*) (Favaretto *et al.* 2008: 98). The latter four species are indicative of cool temperate summers and tolerate a minimum (winter) temperature range of -15°C to +10°C (Prentice *et al*. 1996: 189). During the Early and Middle Holocene woodland phases were interrupted by peaks of juniper (*Juniperus*), wormwoods (*Artemisia), Ephedra* and Chenopodiaceae pollen, suggestive of cooler and drier climatic oscillations, such as the so-called Pre-Boreal oscillation, or the 11.4ka event (Favaretto *et al*. 2008: 97-99). Early Holocene sediments and environmental proxies from the Čepić plain in Istria (Balbo *et al*. 2006), Edera cave north of Istria (Voytek 2011: 196), Lake Maliq in Albania (Bordon *et al.* 2009: 27) and Lake Sedmo in Bulgaria (Bozilova & Tonkov 2000: 323) confirm that mixed temperate deciduous woodlands spread throughout the Balkans (Eastwood 2004: 38; Willis 1994: 774-80). These mixed deciduous woodlands, particularly prevalent inland, would have required annual precipitation levels of 800-1200mm, with minor seasonal contrasts (Rossignol-Strick 1999: 525). Along the coast there is evidence from Lake Vrana on the Ilse of Cres (Croatia) to suggest an overall rise in temperature and increased seasonality (Schmidt *et al*. 2000: 125). Increased differences between warm/wet winters and hot/dry summers is also evident from pollen sampled at Lake Accesa (Italy) and Lake Tenaghi-Philippon (Greece) (Peyron *et al.* 2011: 136-40). In the Adriatic, Ionian and Aegean seas warm conditions similar to those of today were evident from *c*.9000 BP, but with higher overall precipitation (Peyron *et al*. 2011: 136-40; Rossignol-Strick 1999: 525-28; Connor *et al*. 2013: 208). Evidence from Lake Maliq confirms that modern littoral climatic parameters were reached by the Middle Holocene (see below) (Bordon *et al.* 2009: 27).

The 8.2ka BP is the most pronounced cooling episode during the first half of the Holocene in the northern hemisphere, and its effects are clearly recorded in Greenland ice cores (Alley & Ágústsdóttir 2005; Walker *et al*. 2012: 651). It lasted *c*.300 years and resulted in an overall colder climate (in the northern hemisphere) with more accentuated seasonal variations and more extreme, locally variable hydrological systems (Alley & Ágústsdóttir 2005; Berger & Guilaine 2009; Magny *et al*. 2003; Weninger *et al.* 2006). Magny and colleagues (2003) describe a zonation of hydrological regimes over Europe, with increased aridity south of the Valencia-Napoli-Athens line (see also Berger & Guilaine 2009). Most of the research area falls within the 'fresh and humid' zone where rainfall was intensified, causing sudden and intensive floods (Berger & Guilaine 2009: 38-40). In northern Italy unusually high levels are recorded for Lake Ledro whose records suggest most of the rain fell in the winter (Magny *et al*. 2012: 393-95). High precipitation would have magnified the discharge of the Po river, which may explain the decrease in salinity recorded for the Adriatic sea during that period (Zanchetta *et al*. 2013: 2). Greece, where farming was already practised

(Chapter 3.3), was in another hydrological zone of more extreme seasonal variation (Berger & Guilaine 2009: 40). Evidence from Lake Tenaghi-Philippon suggests a reduction in the annual level of precipitation by 100-150mm/yr, and a reversal of seasons, with colder, drier winters and milder, wetter summers (Peyron *et al*. 2011: 141). Colder and drier conditions, particularly in winter time, is also attested by evidence from Lake Maliq (Bordon *et al*. 2009: 27). Oak was replaced by pine in the western Balkans and wormwoods in Greece, both more tolerant of cold and dry conditions (Berger & Guilaine 2009: 38). The sub-alpine regions of Italy witnessed a significant increase in spruces (*Picea*) and a rise in the number of fir trees (*Abies*) (Magny *et al*. 2012: 393). A further two periods of intensified rainfall during the Holocene are noted for the Adriatic: around 7.7ka BP, combined with lower summer and winter temperatures, and at 7ka BP though this signal appears localised to the central Italian coast (Combourieu-Nebout *et al.* 2013: 2036-37). Indeed Apulia suffers a dry phase around the same time, which has been associated with a sharp population decrease towards the end of the Middle Neolithic (Caldara *et al*. 2011: 188; Fiorentino *et al*. 2013: 1310).

After the 8.2ka cooling event the climate continued to warm up. Along the coast conditions appear to have grown progressively drier, reaching present-day Mediterranean conditions of hot arid summers by *c*.5000 cal. BP (Balbo *et al*. 2006: 119; Peyron *et al*. 2011: 142). Pollen records from Greece and Italy indicate that aridification began *c*.7800 cal. BP, characterised by drier winters and slightly wetter summers in comparison to present day levels (Peyron *et al*. 2011: 142; Wu *et al*. 2007: 218). Compared to modern parameters, winter temperatures in the eastern Mediterranean are thought to have been lower by 2-4°C in the winter, and by 1-3°C in the summer (Wu *et al*. 2007: 218; Mauri *et al*. 2015: Fig.4 & 5). More precisely, pistachio (*Pistacia)* pollen from Greece and the Dalmatian coastline suggest that winter temperatures did not fall below 5°C (Eastwood 2004: 38; Prentice *et al*. 1996: 189). The presence of deciduous oak reduces along the coast and, similarly to the inland signal, is first replaced by hazel and then hornbeam (Willis 1994: 780-82). Pollen from the Malo and Veliko craters on the island of Mljet (Croatia) indicate that the deciduous oak forests of the Early Holocene developed into an open woodland dominated by juniper (*Juniperus*) and *Phillyrea* (Jahns & Bogaard 1998: 225-7). Around *c*.6500 BP open forests of the Mediterranean evergreen oak (*Q. ilex*), that currently dominate the Dalmatian coastline, replaced the *Juniperus-Phillyrea* vegetation (Jahns & Bogaard 1998: 227-29; Willis 1994: 782).

Mild and wet conditions are attested inland by pollen records from Lake Vrana, Lake Sedmo and other locations within Bulgaria: deciduous forests migrated further up the mountain ranges in Istria and the Dinarids (Schmidt *et al*. 2000: 126), and across Bulgaria birch, pine and fir trees reach a maximum altitude at *c*.5000 BP (Bozilova & Tonkov 2000: 323; Connor *et al*. 2013: 209-10; Marinova *et al*. 2012: 420). The composition of woodlands changed with an overall increase in hazel (*Corylus*) across the entire Balkans between *c*.8000-7000 BP, followed by a marked increase in hornbeam varieties (*Carpinus*) (Connor *et al*. 2013: 209-10; Filipović *et al.* 2017: 19; Willis 1994: 780-82).

Palaeoenvironmental data from the Pannonian plain has provided evidence for four climatic zones within the Basin from the Pleistocene to the present day: a cool and relatively wet oceanic climate to the west; a sub-Mediterranean climate to the south, with warmer winters and wetter springs and autumns; a central continental climate, extending east of the Basin, and a submontane climate within the surrounding mountain ranges (Rudner & Sümegi 2001; Sümegi 2004, 2007; Sümegi & Kertész 1998; Sümegi *et al.* 2002). The effect of the four overlapping climatic zones is further complicated by topographical and hydrological conditions. As a result of geological shifts during the Quaternary Period, loess covered Pleistocene alluvial zones in river valleys became isolated, forming island-like, meadow-covered, dry surfaces within wet, marshy floodplains; "the development of both vegetation and soils followed this mosaic pattern characteristic of the landscape" (Sümegi 2007: 49). Thus, by the Middle Holocene a mosaic-like pattern of alternating environmental conditions could be found in the Great Hungarian plain, and particularly within the Carpathian Basin (Raczky *et al*. 2010: 148-50; Sümegi *et al.* 2002: 175; Sümegi 2004: 122, 2007: 49). Adaptations to such conditions, so different to those under which farming originally developed, may have resulted in one of several pauses during the expansion of farming into Europe (Chapter 3.1). Pollen data from the Sarló-hát meander, NE Hungary suggest a pattern of hazel-oak-elm woodland alternating with continental steppe vegetation (Magyari *et al*. 2012: 8). The herbaceous pollen is dominated by grasses, wormwoods and chenopods (Chenopodiaceae), whilst gallery forests rich in willow (*Salix*), ash (*Fraxinus*) and deciduous oak were prevalent along the water-ways (Magyari *et al*. 2012: 8). In the Danube-Tisza interfluve a similar vegetation has been described, with the addition of lime (*Linden*), ash and alder but without hazel (Sümegi *et al*. 2013).

2.3.2 European scale

The most comprehensive pollen based climatic reconstruction for the whole research area is the recent article by Mauri and colleagues (2015). Based on the work published by Davis and colleagues (2003), the authors present a new gridded climatic reconstruction for Europe for the last 12,000 years, obtained from 879 pollen sites.

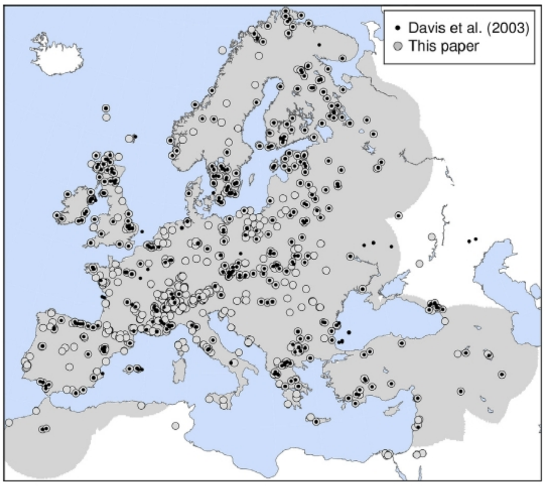


Figure 2.4: Spatial distribution of pollen samples (Mauri *et al*. 2015: Fig.1). The temporal distribution of samples is not given.

Pollen data was subject to rigorous selection criteria, and Plant Functional Types, as defined by Peyron and colleagues (1998), were used to reconstruct palaeoclimate values from individual samples (Mauri *et al*. 2015: 110-11). Taxon presence and relative abundance were used to extrapolate temperature, precipitation and growing degree days above 5°C (GDD5), relative to a late pre-industrial baseline (1850 AD). Using such a baseline is argued to be more appropriate given the recent level of climate warming (Mauri *et al*. 2015: 112; Davis *et al*. 2003: 1706). The climatic reconstructions are presented in the form of a series of gridded data with coarse geographical resolution (each tile covering a degree of latitude and longitude), spanning each millennium for the entire duration of the Holocene. The climatic parameters were interpolated over a 500km limit to cover areas with no data points, including Serbia and BiH (Figure 2.4). Local results will therefore reflect the interpolation technique, which at present offers the most accurate readings. The authors note that winter precipitation levels were the most difficult parameter to reconstruct at the European scale, and that sub-millenial scale events are not clearly represented. The 8ka map may therefore be biased by the 8.2ka event. (see Mauri *et al*. 2015: 111-12, see pg.110-114 and Davis *et al*. 2003: 1702-06 for further details on the methodology). Figures 2.5a and b are adapted from Mauri and colleagues' (2015) article and illustrate summer and winter temperature and precipitation values for the Early and Middle Holocene. Whilst the overall trend is one of decreasing temperature and increasing precipitation over the western Balkans between 9000 and 6000 cal. BP, comparisons within the research area are difficult as the pre-industrial baseline is neither uniform nor published.

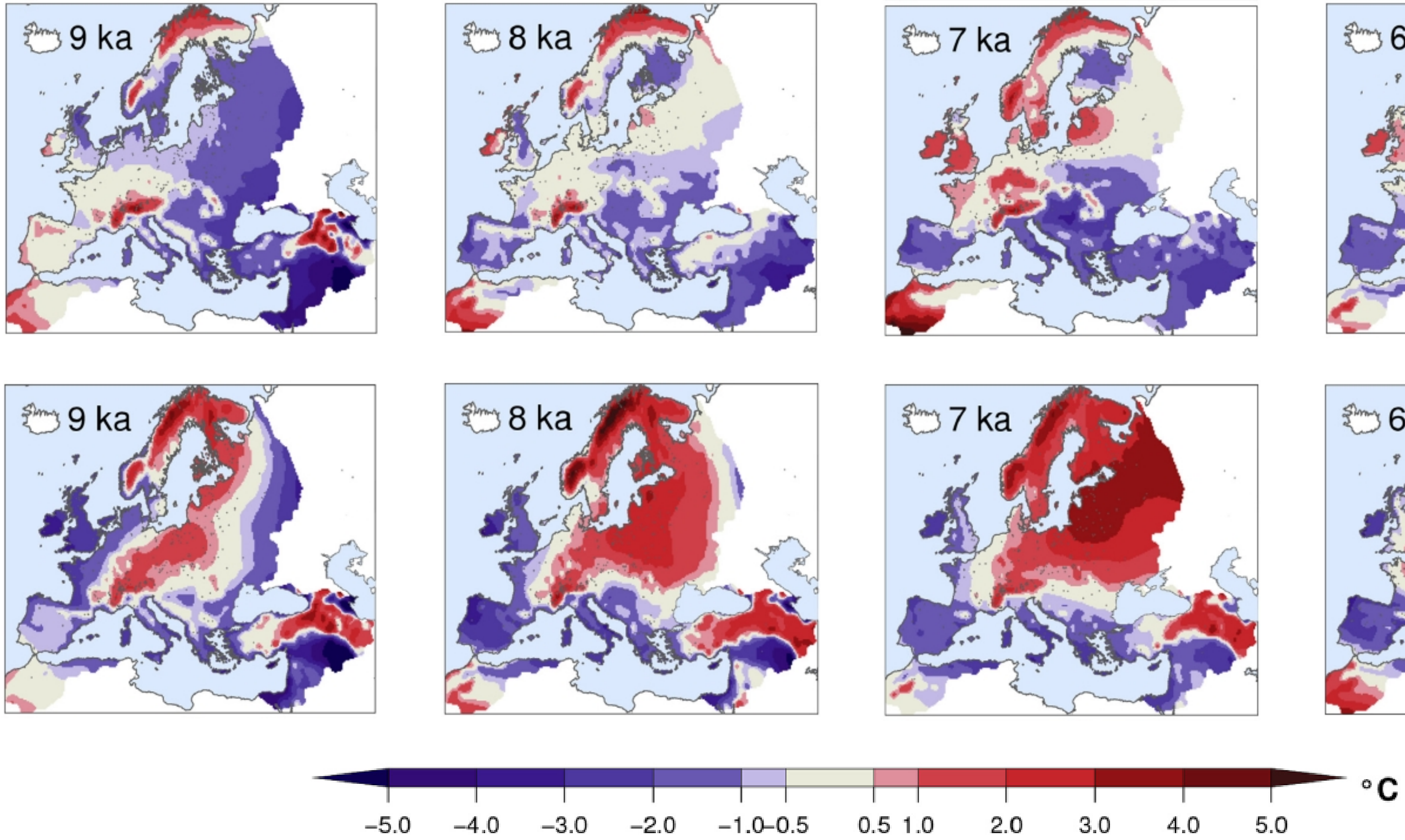


Figure 2.5a: Reconstructed summer (top) and winter temperature anomalies relative to pre-industrial values (1850 AD), from 9000 to 6000 BP. (Modified from Mauri *et al*. 2015: Fig.4&5).

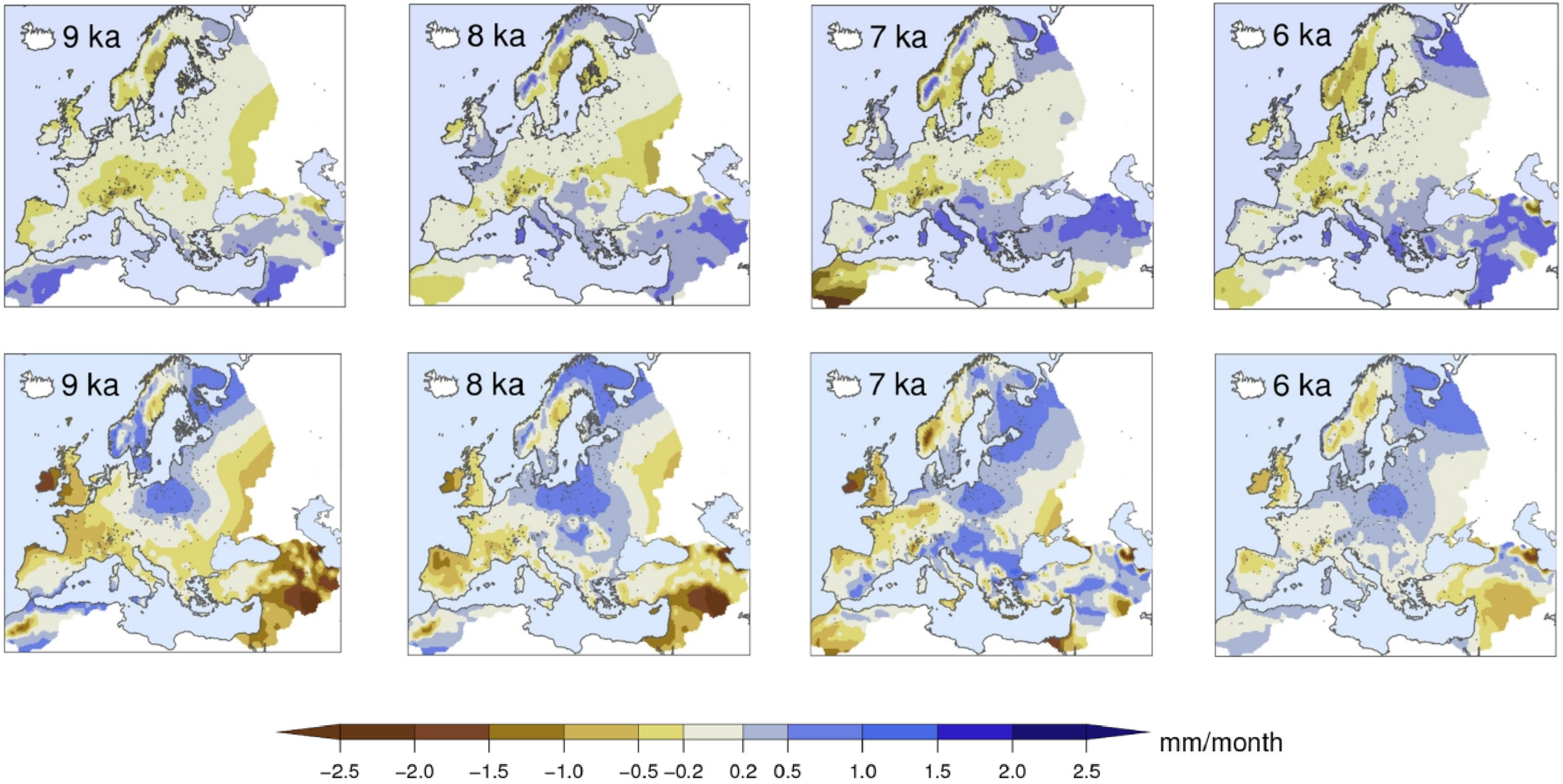


Figure 2.5b: Reconstructed summer (top) and winter precipitation anomalies relative to pre-industrial values (1850 AD), from 9000 to 6000 BP.
(Modified from Mauri *et al*. 2015: Fig.6&7)

2.4 Bioregions

Bioregions are land areas defined by geography and ecology. As such they unite areas of similar climatic conditions and ecological characteristics. The bioregions used in this thesis are those defined by the Bern Convention for the Conservation of European Wildlife and Natural Habitats (European Environment Agency, 2016), (Figure 2.6). Although ecological conditions have changed significantly since the Early Holocene, mainly due to anthropogenic effects, the broad geographical determinants that define bioregions (such as altitude, latitude, effects of oceanic drift and mountain ranges) have not. Consequently, modern bioregions probably have comparable boundaries to those of the Early Holocene, even though their detailed ecological characteristics would have differed.

Figure 2.6: The bioregions in the research area. The red and yellow zones on the right side of the map are the Steppic and Black Sea bioregions respectively. The former falls outside of the research area and no Neolithic sites were discovered in the latter.

CHAPTER 3

Chronology and Cultural Frameworks

This chapter describes the chronological and cultural frameworks within which crop agriculture developed in the western Balkans. It is organised into four sections: section 3.1 explores the routes and the rates of neolithisation into the Balkans; section 3.2 reviews the evidence for Neolithic encounters with local Late Mesolithic populations, and what effect such confrontations may have had, and section 3.3 broadly illustrates the various spatial and diachronic cultural attributions, settlement patterns and uses of animals. Finally, the whole is summarised in section 3.4.

3.1 Modes and rates of neolithisation

The first half of the 20th century AD saw an interest in the mode and tempo of the neolithisation of Europe from its Near Eastern origins. It was argued that incoming farmers spread quickly along the Danube, relying on slash-and-burn agriculture to cultivate the virgin forests of Europe (e.g. Childe 1929; Clark 1952). Based on the then available radiocarbon dates Ammerman and Cavalli-Sforza suggested a hypothetical advance of farming across Europe at an estimated rate of 1.08km/year (1971: 684). Despite the authors' acknowledgements that the Wave of Advance took no account of geographical and socio-cultural barriers, some researchers were keen to co-opt it as conclusive evidence for a fast, diffusionist view of the neolithisation of Europe (e.g. recently Robb & Miracle 2007). In 1982 a coastal spread, different in mode and tempo to the Wave of Advance, was described by Arnaud in his 'leap-frog' colonisation model (cited in Zilhão 1993: 37). This model has been successfully used to describe the spread of farming along both the western Mediterranean and Adriatic coasts, where radiocarbon dates and cultural entities followed a different course to those inland (Forenbaher & Miracle 2005; Forenbaher *et al.* 2013; Legge & Moore 2011; Zilhão 1993). In 1995 van Andels and Runnels argued that the farming frontier was far more punctuated than was implied by the smooth Wave of Advance. Using the example of Neolithic settlement patterns in the Balkans (with an emphasis on Greece), the authors describe how farmers 'leapt' between areas with suitable soils and available water sources, namely river and lake floodplains (van Andels & Runnels 1995: 497). The neolithisation process has since been further discussed in combination with additional influences, all capable of accelerating or decelerating rates of migrations; such as climate change, availability of resources, population increase, water-ways and mountains (Bocquet-Appel 2005; Krauss *et al.* 2017; Shennan *et al.* 2013; Vander Linden 2011).

The more recent surge in radiocarbon dates has permitted increasingly precise descriptions of the rate of the European Neolithisation (e.g. Gkiasta *et al*. 2003; Pinhasi *et al*. 2005). Nevertheless, the radiocarbon record for the western Balkans is relatively sparse and patchy (Vander Linden *et al*. 2014a; Vander Linden *et al*. submitted), limiting the precision with which local trajectories have been described. Guilaine's (2001) *modèle arythmique* developed from a realisation that, unlike the Wave of Advance, neolithisation is not a chronologically uninterrupted process. The model thus focuses on the periods of stasis as key moments when archaeological cultures are established and re-defined before moving on again. Bocquet-Appel *et al*.'s (2009) geostatistical interpolation of 3027 AMS ^{14}C dates from 940 sites mirrors Guilaine's (2001) intuition in establishing centres of stasis from where the diffusion of early farming then resumed, and confirms the different rates of neolithisation between inland and coastal routes (Bocquet-Appel *et al*. 2009, 2012; Vander Linden 2011).

Seeking to find the best fit between the archaeological data and the mathematical predictions Fort *et al*. (2012) based their model on an initial expansion of the Neolithic during the Pre Pottery Neolithic B/C. They found that mountains smaller than 1750m should not be considered barriers and that sea travels between sites could be around 150km, predicting that farming reached the western Balkans about one thousand years after it had spread out of the Near East (Fort *et al*. 2012: 215-7). Recent projects all reinforce the importance of waterways and note a discrepancy between migrations along rivers and seas (Biagi *et al*. 2005; Bocquet-Appel *et al*. 2009, 2012; Davison *et al*. 2006; Fort *et al*. 2012; Henderson *et al*. 2014). The initial expansion along the Adriatic was slower and more sporadic than the inland spread, which rapidly reached the Pannonian Plain before experiencing a *c*.4/500 year period of stasis (Biagi *et al*. 2005: 45-8; Krauss 2016: 214; Vander Linden *et al*. submitted). Along the Croatian coast it took *c*.300 years for a farming lifestyle to spread 400km, and 1000 years to cover 700km of the Italian Adriatic coast (Biagi *et al*. 2005: 45). Once in the Mediterranean however, the rate of Neolithisation increased significantly in comparison to both the early Adriatic spread and that of the LBK phenomenon (Henderson *et al*. 2014: 1297-8; Zilhão 2001, 2003). Inland of the western Balkans 500km were covered in *c*.150 years following the Danube and its tributaries (Biagi *et al*. 2005: 45). The ever expanding front of the SKC is argued to have been halted by the Central European–Balkanic Agroecological Barrier (CEB AEB), beyond which the combination of climate and soils were unsuitable to productive societies whose economy was based upon Mediterranean-adapted plants and animals (Raczky *et al*. 2005; Sümegi & Kertész 1998; Sümegi 2007; see also Jarman *et al*. 1982: 168-180, 227-232). The CEB AEB was not a linear one but rather shaped by the mosaic-like distribution of ecological conditions (Chapter 2.3.1). Another pause of similar duration and possible causes is noted prior to the expansion of agriculture into the western Balkans (Krauss *et al*. 2017). A *c*.500 year period of stasis is seen in the Sub-Mediterranean-Aegean biogeographic region, comprising of the northern Aegean and the Vardar, Struma and Vesta valleys (Krauss et al. 2017: 6-7). The pause is argued to represent a necessary period of crop-adaptation during a time of Rapid Climate Change (RCC: 6550-6050 cal. BC), before farmers could continue their northerly migrations (Krauss *et al*. 2017). The resumed expansion coincides with the end of the 8.2Ka cooling event, after which a climate more favourable to the cultivation of Neolithic crops prevailed (Berger & Guilaine 2009; Krauss *et al*. 2017: 2; Pilaar Birch & Vander Linden 2018: 186; Chapter 2.3.1).

Beyond the modes of neolithisation (sea, land or rivers), the geographical provenances of the first Neolithic cultures in the western Balkans remain more problematic. Models of routes into Thrace suggest that the spread of farming came from north-western Anatolia, through Bulgaria and into the rest of south-east Europe (Demoule 1993; Özdoğan 2000, 2011; Thissen 2000a; 2000b), with a possible separate migration from Bulgaria to Romania following the Black Sea coast (Peev 2009). Contrary to Demoule (1993) and Thissen (2000b), Perlès (2005) argues for a separate migration to Greece, directly from the eastern Mediterranean. By comparing differences in material culture, Perlès (2005) suggests that the first farmers in Greece and the Aegean basin came along maritime routes from the Levant (see also Perlès 2001: 303-4; Perlès 2003: 107-9; Perlès 2010: 274-8). This hypothesis is corroborated by two large-scale archaeobotanical studies on the first spread of Neolithic crops into Europe, which both highlight the difference between the Bulgarian plant spectrum (crops and associated weeds) and those from Greece and Former Yugoslavia (Colledge *et al*. 2004; Coward *et al*. 2008; Chapter 4.2).

The distribution of Impressed Ware suggests that the first farmers in Greece continued their maritime route along the Adriatic (section 3.3). Based on a limited range of radiocarbon dates Chapman and Müller (1990) argued for a gradual, directional trend from western Greece to Istria. Fifteen years later and with additional dates, Forenbaher and Miracle (2005) suggested a staggered, two-phase model of colonisation. The initial, or 'pioneer', colonisation phase lasted around a century and consisted of exploratory visits by incoming farmers who created short-term camps along the coast, perhaps even as far north as on the island of Lošinj (at the site of Vela Spilja) (Forenbaher & Miracle 2005: 524, Forenbaher *et al*. 2013: 596). Farmers became established during the second phase and continued to spread along the coast as well as further inland, reaching Istria by *c*.5600 cal. BC (Forenbaher & Miracle 2005: 524). The staggered model is influenced by the authors' inclusion of Late Mesolithic hunter-gatherers and their inevitable interactions with farmers, despite the lack of well dated evidence for the presence of foragers (Forenbaher & Miracle 2005, 2006; see section 3.2).

3.2 A virgin landscape? Late Mesolithic presence across the Balkans and Adriatic Italy

Identifying and defining interactions between late foragers and early farmers in the Balkans and adjacent countries remains a problematic issue to this day. Most famously, Gordon Childe (1929, 1957) described how an expanding population of Neolithic farmers spread across Europe, and in particular along the Danube, replacing the 'simple' hunter-gatherers with a 'civilised', complex and agriculturally dependant sedentary civilisation. Within more recent socio-political views, perspectives changed and arguments grew for a more complex process of interaction between late foragers and early farmers, with varying levels of mental and technological adaptations by both groups (e.g. Barker 1985; Bogucki 1996; Cauvin 1994; Price 2000; Robb 2013; Whittle 1996, 2007; Zvelebil & Lillie 2000). Various authors have described how incoming farmers may have spread inland up to Transylvania and along the Adriatic coast, acculturating some foragers whilst gradually pushing others to marginal areas unsuitable for agriculture (e.g. Banffy 2008; Dennell 1992; Forenbaher & Miracle 2005; Mihailović 2007a; Tringham 2000). In reality, however, few Late Mesolithic sites have been discovered, and even fewer have provided us with indisputable radiocarbon dates from clearly defined stratigraphies (Bánffy *et al*. 2007; Bonsall *et al*. 2013; Forenbaher *et al*. 2013; Franco 2011; Gatsov & Nedelcheva 2016; Kozłowski 2016; Krauss 2016; Pilaar Birch & Vander Linden 2018). Nevertheless, there are a few rare sites where 'Mesolithic' and 'Neolithic' material culture appear mixed within the same archaeological horizon, suggesting some form of contact. The evidence for such contacts is examined by geographical region; starting with Greece and the Aegean Basin, following the coast to Montenegro, Croatia and Italy, and then turning inland to the Iron Gates and finally the Carpathian Basin.

3.2.1 Greece, Crete and the Aegean islands

These areas represent a zone where contacts between Late Mesolithic and Early Neolithic populations are tangible, though the nature of these interactions remains contentious. In the Aegean islands evidence for Neolithic traditions are found in some Mesolithic levels of the 9th millennium BC which suggest a more sedentary, 'Neolithic-like' existence: round stone houses, crouched burials under pavements and pigs (which, whether domesticated or not, were evidently imported onto the island) at Maroulas (Kythnos), and goats at Cyclope cave (Gioura) (Kozłowski 2016: 54-59). The locations of sites and of sources of raw materials suggest Mesolithic populations relied upon a well developed network of marine contacts, not only between islands but more broadly across the

Aegean (Broodbank 2006; Horejs *et al*. 2015; Kozłowski 2016; Perlès 2003; Reingruber 2011). Their mobile existence and sea-faring abilities may have led to contacts, new migrations or trade with more sedentary communities further East. Late Mesolithic sites are fewer and sparsely distributed, a phenomenon which is arguably real rather than the result of preservation or research biases; “Greece is a well-surveyed country, and many inner basins have been intensely field-walked. In several areas, including Thessaly, the natural sections along the rivers have also been systematically explored” (Perlès 2003: 101, see also Hansen 1999: 163). The possibility of coastal sites lost to sea-level rise remains problematic (Kozłowski 2016: 54), though one would expect Mesolithic groups to relocate further inland (Hansen 1999: 163). Of the handful of Late Mesolithic sites within continental Greece and the Aegean Basin, three have an undisputed a-ceramic or initial Neolithic horizon: Sidari, Franchthi cave level X, and Knossos Level X (Kozłowski 2016: 60; Perlès 2001: 86, though see Berger *et al*. 2014 for Sidari; Perlès *et al.* 2013 for Franchthi cave, and Douka *et al*. 2017; Evans 1994; Efstratiou 2005; Efstratiou *et al*. 2004 for Knossos). Level X at Franchthi lies above Late Mesolithic layers and separate to 'true' Neolithic (ceramic) levels found at the neighbouring site of Paralia (Kozłowski 2016: 60). The material culture is a mix of Mesolithic lithic industries, domesticated ovicaprids and infrequent finds of domesticated emmer (*Triticum dicoccum*), einkorn (*T. monoccocum*), two-row barley (*Hordeum vulgare* ssp. d*istichum*) and lentil (*Lens culinaris*) (Hansen 1999; Kozłowski 2016: 60; Renfrew 1979: 246; Valamoti & Kotsakis 2007: 80). At Sidari cereal grains have only been recovered from the later Impress Ware levels (Berger *et al*. 2014: 220). At Knossos a wider range of domesticates is evident, including pig, cow, ovicaprid, pea (*Pisum* sp.), lentil (*Lens* sp.) as well as hulled and naked barley (H. vulgare *sl.*), emmer, einkorn and free-threshing wheat (*T. aestivum sl.*) (Colledge 2016; Kozłowski 2016: 60; Renfrew 1979: 246; Valamoti & Kotsakis 2007: 80).

The initial Neolithic stratum at Sidari is synchronous with that of Franchthi, and is characterised by ceramics of incised, or monochrome traditions (Berger *et al*. 2014). As at Franchthi, the stone tools seem to show continuity with older traditions (Perlès 2001: 86). However, a more recent geoarchaeological assessment of the Sidari stratigraphy has demonstrated that admixture of Mesolithic and 'first' Neolithic artefacts can be explained through natural geomorphological processes, and the authors emphasize the need for the re-evaluation of post-depositional processes at sites where Mesolithic and Early Neolithic artefacts appear simultaneously (Berger *et al*. 2014). The initial phase of Knossos may be slightly older, at most 200 years, and its occupants are argued to have been migrants of farming traditions, well practised in agricultural techniques (Douka *et al*. 2017; Perlès 2001, 2003, 2010). Despite possible contacts between Mesolithic and first Neolithic groups, a hiatus in the stratigraphy between the 'initial' Neolithic and Impressed Ware levels is seen at all three sites, suggesting an absence of indigenous continuity into the 'true' Neolithic (Berger *et al*. 2014; Douka *et al*. 2017: 315; Hansen 1999, Kozłowski 2016: 60; Perlès *et al*. 2013: 1011).

3.2.2 Montenegro

The Late Mesolithic of Montenegro begins around the mid-7th millennium BC and ends during the first quarter of the 6th millennium BC (Mihailović 2007a: 21). Occupation levels have been discovered at four caves: Odmut, Crvena Stijena, Vruća Pećina and Medena Stijena (Mihailović 2007a; Mihailović & Dimitrijević 1999). Impressed Ware at Odmut and Crvena Stijena have been assigned to the Late Mesolithic horizon and interpreted to indicate contact between local foragers and sea-faring farmers leap-frogging along the Eastern Adriatic (Forenbaher & Miracle 2005: 517-19; Müller 1988: 114), though the stratigraphical integrity of the sites has been questioned (Mihailović 2007b). Recently, research on material from layer 1b at Odmut cave and excavations at Vruća Pećina have revealed unusual assemblages of Mesolithic tools (bone harpoons) with domesticated cows, pigs and ovicaprids (Cristiani & Borić 2016; Vander Linden pers. comm. 14/10/16). The mix of Mesolithic tools with a full range of domesticated animals, as well as wild ones, remains to be conclusively interpreted: either herders/farmers adopted a Mesolithic technology and also hunted, or foragers adopted a full suite of farm animals along with their required associated technologies. There is currently no other evidence for direct forager-farmer interactions in Montenegro, though this may partly reflect the current poor state of research (Franco 2011; Mihailović 2007b; Mihailović & Dimitrijevic 1999).

3.2.3 Western Croatia and eastern Italy

Following the eastern and western Adriatic coast we observe a similar paucity of Late Mesolithic sites (Pilaar Birch & Vander Linden 2018: Fig.3), although it is possible many were engulfed by the rapid Adriatic transgression (Lambeck *et al*. 2004). Nevertheless, known sites all show a hiatus between the youngest Mesolithic and oldest Neolithic dates (Biagi 2003; Biagi & Spataro 2001; Forenbaher & Miracle 2005; Forenbaher *et al*. 2013; Franco 2011). The suggestion that the first farmers travelled along the coast, “establishing contacts with indigenous hunter-gatherer groups in the hinterland” (Forenbaher & Miracle 2005: 524), is based on pot sherds and/or occasional domesticated animal remains in cave sites traditionally assigned to forager populations, and remains speculative. In Italy the hypothesis of a neolithisation of Late Mesolithic groups was questioned back in 1987 by D. Evett and J. Renfrew, who noted the absence of domesticated plants and animals in Mesolithic deposits (Evett & Renfrew 1987: 404). More recently, Franco's (2011) extensive research into the Italian Late Mesolithic has demonstrated that the hunter-gatherer tool sources and technologies are not evidenced at early Impressed Ware sites.

3.2.4 The Iron Gates

The Iron Gates or Danube Gorges, as described in Chapter 2.1, is the inland area with the highest concentration of late Mesolithic sites, some of whose excavations have revealed tantalising evidence for the interaction between local foragers and migrating farmers. *Spondylus* shells and discoid beads in Mesolithic burials at Vlassac and Schela Cladovei (Borić *et al*. 2014; Boroneant *et al*. 1999), plastered floors in trapezoidal buildings at Lepenski Vir (but see Bonsall 2008: 273 for a possible independent invention of lime plaster pyrotechnology), and domesticated animals (other than dog) at three sites, Icoana, Padina and Hajdučka Vodenica (Greenfield 2008), all point to regular interactions - possibly trade? - with neighbouring farmers. The absence of charred cereal grains is not altogether surprising. The only sites to have been extensively sieved and floated for plant macro-remains are Vlasac (though the contexts were mainly from graves) and Schela Cladovei, where the few plant remains recovered were all wild (Bonsall *et al.* 1997: 57-58; Borić *et al*. 2014: 13-15). Despite the absence of any cereal remains, and no isotopic signatures to suggest a cereal-based diet (see below), a recent claim has been made for the consumption of domesticated cereals by the Mesolithic inhabitants of Vlasac. Cristiani and colleagues (2016) claim to have identified cereal starch grains found embedded in the dental calculus of *c.*6600 cal. BC skeletons to the Triticeae tribe, and concluded that domesticated wheat and barley had been consumed. Their conclusion rests on the reassurance that wild members of the Triticeae, namely species of *Aegilops*, were not native to the area (Cristiani *et al.* 2016: 10301), despite the limited knowledge of past and present distributions of wild members of the Triticeae tribe within the central Balkans (indeed charred wild barley varieties have been identified at Neolithic sites in Serbia: Table 2.8, Appendix II). The "extraordinary state of preservation" of starch grains is surprising and explained to be a consequence of "inhalation or ingestion during processing rather than ingestion after cooking" (Cristiani *et al.* 2016: 10299). Starch grains transformed by temperature, mixing, grinding and mastication are usually badly preserved and unrecognisable (Wesolowski *et al.* 2010: 1332). If starch had been inhaled during the grinding of cereals one might also expect micro-remains of chaff, such as phytoliths, to be present in the dental calculus. Unfortunately, samples for starch and phytoliths were not taken from other locations, such as the grinding stones. Our understanding of post-depositional movement of starch grains and "how starch is transformed […], including within biofilms that become calculus, is still extremely limited." (Barton & Torrence 2015: 198; see also Crowthers *et al*. 2014). Cristiani and colleagues (2016: 10301) use the purported presence of

Cerealia pollen in human coprolites as supporting evidence for the consumption, and presumably cultivation (though they do not explicitly say so), of domesticated cereals. Cârciumaru (1973, 1978) recorded the presence of Cerealia pollen in coprolites from Vlasac and Icoana, though his claims have since been questioned as his identifications were based solely on the size of pollen grains (all those with diameters of 38.5µm or larger were noted as Cerealia). Differentiating between pollen from domesticated and wild grasses is notoriously difficult, and using size alone may be deceptive (e.g. Behre 2007; Wilkinson & Stevens 2008: 83-85). Additional problems include the lack of secure chronological contexts, or indeed direct radiocarbon dates; the overall quantity of 'large' pollen grains (no more than 1% of the total at Icoana), and the absence of such grains in the stratigraphic sequence that contained the coprolites (Filipović forthcoming; Kozłowski & Kozłowski 1986: 97).

A significant forager subsistence change during the initial phase of contact with farmers is unlikely (*cf*. Zvelebil & Rowley-Conwy 1986), especially when their surroundings appear to have provided enough food (Bailey 2000; Bonsall 2008; Borić *et al*. 2014; Boroneant *et al*. 1999). The Danube environment offered plentiful aquatic and terrestrial resources, suggesting that a change to farming (more labour intensive and possibly less predictable) would have been neither necessary nor desired (Bonsall *et al*. 1997, 2015). Isotopic signatures from human skeletons at Vlasac, Schela Cladovei and Lepenski Vir show a clear dominance of riverine fish in the Late Mesolithic diet (Bonsall *et al.* 1997: 72-79; Bonsall *et al*. 2015: 695-6). Only at Lepenski Vir does the signal change to indicate an increased terrestrial protein source during the transformation, or transitional period (Bonsall *et al.* 1997: 72-79; Bonsall *et al*. 2015: 695-6; Borić & Price 2013: 3300), which is in concordance with the noted increase in migrants (see below). Pottery is argued to have been found associated with trapezoidal buildings at Lepenski Vir, but these have been dated to *c*.5950–5700 BC (Bonsall 2008: 270), by which time the Neolithic was firmly established there and elsewhere in the Balkans. At Vlasac pottery discovered in the excavations of the 1970s has never been adequately dated (Borić *et al*. 2014: 10). Recent excavations, however, found that ceramics were never included in the Mesolithic burials, and that all pots recovered date to 6000 BC or later, “suggesting that even if during this [transformation] period ceramics were obtained through contacts with farming groups, similar to ornaments, [...], they were in no way abundant or common.” (Borić *et al*. 2014: 27). Strontium isotopes provide another line of evidence for human mobility and potential contacts. A recent study mapped the strontium isotope signature of Epipalaeolithic to Early/Middle Neolithic skeletons from sites along the Danube Gorges (Borić & Price 2013). It notes a temporal increase in the number of people, particularly from the transformation period of Lepenski Vir and Ajmana, who were born and grew up beyond the Danube Gorges (Borić & Price 2013: 3300-2). Mobility and long distance trade was clearly practised in the Late Mesolithic, as is evidenced by "marine gastropods *Columbella rustica* and *Cyclope neritea* which must have come from coastal regions more than 400 km away from the Danube Gorge" (Borić & Price 2013: 3298). Outliers are also recorded for the Epipalaeolithic (one individual) and Mesolithic periods (one individual) (Borić & Price 2013: Fig.2). Importantly, the strontium isotopes demonstrate mobility but do not in themselves indicate either the origins or the cultural affinities of migrants. Mesolithic traditions continue in the Iron Gates after 6000 BC, but with ever increasing components of Neolithic material culture (Bailey 2000; Bonsall 2008; Borić 2007, 2011). These include ceramics, domesticated animals, architecture and tool technologies, and indeed contemporary Neolithic sites are known in the vicinity of the Iron Gates (Borić 2007: Fig.3.3).

Notwithstanding the well preserved Mesolithic presence in the Iron Gates during the transformation period, these sites remain unique in an inland area, stretching from Slovenia to Bulgaria, which are otherwise almost completely devoid of Late Mesolithic occupation (Gatsov & Nedelcheva 2016; Pilaar Birch & Vander Linden 2018: 182-86). The lack of evidence could be partly explained by the increase in extreme weather during the 8.2ka BP event, leading to the destruction of sites (Berger & Guilaine 2009: 42-43), or by possible research biases (Pilaar Birch & Vander Linden 2018: 186). Whatever the arguments, interpretations of forager-farmer interactions in the Iron Gates should not be expanded to explain the neolithisation for the whole of the Balkans, but must remain the focus of one particular point in space and time.

3.2.5 Hungary

Mesolithic populations in Transdanubia, the Danube-Tisza interfluve and the Upper Tisza Basin have always been given a central role in the development of the earliest LBK, which is thought to have developed from the interactions between Late Mesolithic and Late Starčevo groups (Bánffy 2000, 2004b, 2008, 2013a; Bánffy & Oross 2010; Bánffy *et al.* 2007; Chapman 1994; 2003; Kozłowski & Nowak 2007; Krauss 2016; Sümegi 2004; Zvelebil *et al.* 2010). Nevertheless, scholars agree that direct evidence for a Mesolithic presence is extremely limited, particularly in Transdanubia, and that there is a lack of continuity between Late Mesolithic and Neolithic horizons (Bánffy 2004a: 21-25; Bánffy & Oross 2010: 255; Chapman 2003: 102; Eichmann *et al.* 2010: 223; Kozłowski & Nowak 2007: 81; Krauss 2016: 197, 200). Furthermore, the situation is not helped by the nature of Starčevo sites, which are smaller than those known further south and mainly consist of haphazardly distributed pits (Bánffy 2004b: 66; Eichmann *et al*. 2010: 227). The Starčevo site of

Alsónyék, with over 500 features and 25 graves, is an exception to this trend and is a clear example that large Starčevo villages did exist in Transdanubia (Oross *et al*. 2016: 94-100). The situation changes when 'transitional' or sites of the earliest LBK are included: two long houses were discovered at Szentgyörgyvölgy-Pityerdomb, where the pottery assemblage is a mix of Late Starčevo and earliest LBK ware (Bánffy 2004b: 58). The assignation of sites to Late Starčevo or earliest LBK remains problematic, demonstrating the similarities in material cultures (e.g. Bánffy 2008: 154). To the east of the Danube Körös sites are far more prolific, possibly as a result of longer archaeological interest in the Upper Tisza region (see Raczky 2012 for a comprehensive review of twentieth and twenty-first century Körös culture research history).

Sites assigned to the Mesolithic are scarce in the Carpathian Basin and, with the exception of the excavated site of Regöly (Eichmann *et al.* 2010: 233-228), consist of ground scatters of stone tools (Bánffy 2008: 153). These have often been inadequately published so that re-evaluation and dating of the finds has been difficult (Bánffy *et al*. 2007: 54-56; Krauss 2016: 197). The re-examination of finds and more recent surveys have located only a handful of Mesolithic sites, assigned on lithic typologies and the absence of pottery, but lack reliable phasing and radiocarbon dating (Bánffy *et al.* 2007: 54-56; Eichmann *et al.* 2010: 213-16; Krauss 2016: 197). Arguments for contacts between local foragers and incoming farmers have predominantly been based on the presence of so-called Mesolithic stone tool technologies found on Late Starčevo-Körös and Early Linear sites (Bánffy *et al*. 2007: 59; Eichmann *et al.* 2010: 211; Mateicuicová 2004: 99-101). However, Kozłowski and Nowak, based on the rich lithic assemblage from Méhtelek argue that the Körös lithics retain traditional features of the Balkan macro-blade tradition whilst also incorporating new tools, “relating most probably to the growing role of hunting in the north-east part of the Carpathian Basin” (2007: 92). These authors agree that the small presence of backed bladelets at some Early Linear sites do indicate contacts with foragers, but suggest that these interactions occurred north of the Basin towards Slovakia and the Ukraine where Mesolithic groups were more common (Kozłowski & Nowak 2007: 82-84; Dolukhanov 2008: 289-92; though see Valde-Nowak 2010 who questions the evidence for Late Mesolithic populations in Northern Slovakia and the Polish Carpathians). Another popular argument for a Mesolithic influence on the formation of the LBK is the SKC's occupation of 'Mesolithic-type' landscapes, and their apparent increased use of wild resources (Bánffy 2000, 2004b: 51-54, 2008: 154, 2013a,b,c; Bánffy & Oross 2010: 257; Bánffy *et al.* 2007: 59; Bánffy & Sümegi 2011; Chapman 2003: 95-97; Sümegi 2004). The SKC expansion paused for about 500 years in southern Hungary (e.g. Krauss 2016: 214; section 3.1). This period of stasis is seen as a time of adaptation to climatic and ecological conditions very different to those experienced further south. The involvement of Mesolithic peoples during this period of adaptation is both hypothetical and unnecessary, resulting in confused and often circular arguments.

> “The general appearance of the Pre-Neolithic population of the region is not known; nonetheless, the oldest Neolithic settlements in the Banat region are no longer comparable to those in the Balkan area. Thus, a Mesolithic tradition of settlement could indeed be evident here, a tradition that becomes all the more visible only through neolithisation” (Krauss 2016: 218).

To give another example, pollen evidence from the Little Balaton area suggests an increase in domesticated cereals which Bánffy has associated with 'transitional' sites on the shores of Lake Balaton (2008: 154). Pottery from these sites show varying degrees of SKC influence and imitations of cult baked clay objects, such as the head of an altar with a wheat grain eye from Kéthely (Bánffy 2008: 154). These “water bound settlements”, the rise in cereal pollen and the rudimentary imitations of Starčevo ceramics have led Bánffy to conclude that Late Mesolithic foragers were “living amidst their traditional biotope, making contacts with the newcomer Starčevo people, and adopting some of the latter group's major innovations.” (2008: 154). The latter argument, however, rests upon ambiguous evidence from poorly preserved sites and overlooks the adaptability of early farmers who settled in a diverse range of landscapes (McClure 2013: 59-61).

3.2.6 Discussion

Traces of Late Mesolithic foragers have been found within the Aegean Basin, Montenegro, by the rich fishing grounds along the Danube, in the forested lake-side of Lake Balaton and further east in the Alföld region. Hunter-fisher-gatherers do, at a limited number of sites mentioned above, appear to have come into contact with farmers, and may have indeed contributed to their knowledge of resources and terrain. There are no Early Neolithic defensive structures or skeletal pathologies to suggest that relations between locals and migrants were not amicable (e.g. Bonsall 2008: 276). Established contacts between farmers and foragers in specific areas may have facilitated a migration into new lands. Nevertheless, the more traditional views of an independent development, or local adoption of agriculture can no longer be substantiated in the western Balkans (*contra* Cârciumaru 1996; Chapman 1994; Dennell 1992: 91; Tringham 2000; Whittle 1996; Zvelebil 2001). Current evidence shows a very scarce presence of Late Mesolithic populations, suggesting that any interactions the latter may have had with farming groups remained a local phenomena, and insignificant to the general expansion of new migrants. Even the Mesolithic 'hot-spot' of the Iron Gates is calculated to have held no more than 15 to 20 people per site (Porčić & Nikolić 2016: 183), a population number unlikely to have had much of an influence over a rapidly expanding farming lifestyle (see section 3.1). Similarly, recent genetic evidence from mitochondrial DNA as well the whole genome points to very little, if any, intermarriage between Mesolithic and incoming Neolithic populations. Research on both mtDNA and whole-genome aDNA has traced the ancestors of European farmers to the Near East (via the Aegean and Anatolia), and document a very low level of admixture between Mesolithic and Early Neolithic populations (mtDNA: Gamba *et al*. 2014; Hervella *et al*. 2015; Hofmann *et al*. 2014; whole genome: Broushaki *et al*. 2016; Hofmanová *et al*. 2016; Lazaridis *et al.* 2016; Lipson *et al*. 2017; Mathieson *et al*. 2015). This is particularly true for Hungary where levels of admixture with local Mesolithic groups (identified from the whole genome) are seen to have been lower than in Germany and Spain (Lipson *et al*. 2017: 369-70). To date, only one individual from a Körös culture cemetery, at Tiszaszőlős-Domaháza (Hungary), has been found with a Mesolithic genetic signature (Gamba *et al*. 2014: 3). To conclude, Late Mesolithic presence appears to have been minimal to non-existent in the Balkans and adjacent areas at the dawn of the Neolithic. Farming was not a local development, as is seen in the Near East, but arrived from the South East and spread along the Adriatic coast, and inland through the western Balkans with no clear Mesolithic interruptions or admixtures. After the establishment of farming in the Aegean and southern Bulgaria during the seventh millennium BC, a pause in the neolithisation process is evident until after the 8.2ka climatic event. The expansion of farming then resumed, quite suddenly and intensively, adopting two main routes: along the Adriatic coast and inland following the main river channels. The inland spread was a little faster than that along the Adriatic, but once in Hungary another period of stasis, also related to climatic/environmental adaptations, is evident. During this period the SKC developed into a new cultural entity, the LBK, through which agriculture then continued to expand throughout Europe.

3.3 Neolithic cultures – description and chronology

The start of the sixth millennium BC marks the onset of the Neolithic in the western Balkans, during which two new streams of diffusion spread across the region. The coastal route along the Adriatic corresponds to the Impressed Ware, Danilo and Hvar cultures, with additional groups appearing in Italy during the later Neolithic. In the Danube catchment area the SKC complex represents the first expanse of Neolithic farmers, which then develops into various localised cultures during the Middle-Late Neolithic (Table 3.1). Variations in sites and material culture are found not only between but also within the coastal and inland streams. In this section the chronology and ceramic typologies are described for the western Balkans and Adriatic Italy (and very briefly for Hungary, Romania, Greece and Bulgaria), followed by a general overview of settlement patterns and the economic role of animals during the Neolithic of the western Balkans.

Period	**Date range (cal. BC)**	**Coastal cultural groupings**	**Inland cultural groupings**
Early Neolithic	*c*.6100-5500/5400	Impressed Ware (Croatia, Adriatic Italy and Greece)	Starčevo-Körös-Criş (SKC - along the Danube, Sava and Tisza) Earliest LBK (Transdanubia) Anzabegovo-Vršnik (FYROM) Karanovo I & II (Bulgaria)
Middle Neolithic	*c*.5500/5400-5000	Danilo (Croatia, South Adriatic Italy) Fiorano (North Adriatic Italy) Sesklo and others (Greece)	Early Vinča (A–B) (Serbia) Early Sopot (Slavonia, Vojvodina) Early Butmir and Kakanj (BiH) Lengyel and Tiszapolgár (Hungary) Anzabegovo-Vršnik (FYROM) Vinča-Turdaş (Romania) Karanovo III/IV (Bulgaria)
Late Neolithic	*c*.5000-4500/3500	Danilo-Hvar (Dalmatia, South Adriatic Italy) Danilo-Vlaška (Istria and Trieste Karst) Square-Mouthed Pottery (VBQ - North Adriatic Italy) mainly Dimini (Greece)	Late Vinča (C–D) (Serbia, Slavonia) Sopot (Slavonia, Vojvodina) Butmir (BiH and SE Croatia) Lengyel and Tiszapolgár (Hungary) Dudesti-Boian (Romania) Karanovo V/VI (Bulgaria)

Table 3.1: Simplified groupings of cultural phenomena by Neolithic phase. See text for further descriptions and references.

3.3.1 Pottery and chronology

The increased use of AMS radiocarbon dates in the last two decades has enabled the arrival, spread and diversification of the Neolithic to be recorded with greater precision. Traditional ceramic typologies have been refined, demonstrating that the linear attribution of ceramic style to archaeological culture is not as transparent as was commonly assumed. Nevertheless, changes in material culture do purport a rudimentary split of the Neolithic into three sub-phases: Early, Middle and Late.

3.3.1.1 The Early Neolithic

- Along the coast

The earliest Balkan farming traditions, dating back to *c.*6500 cal. BC, are located in Greece and characterised by monochrome and Impressed Wares (Perlès 2001: 98-111). The latter are found on coastal and inland sites, such as at Sidari, Corfu (Perlès 2003: 102) and at Mavropigi-Filotsairi in western Macedonia (Karamitrou-Mentessidi 2013), as well as in Albania (Bonsall *et al*. 2013: 145). Along the Croatian coast the earliest Neolithic sites Pokrovnik and Rašinovac date to *c.*6000 cal. BC (McClure *et al.* 2014: 1028), and are recognised by Impressed Wares (Forenbaher & Miracle 2005; Forenbaher *et al.* 2013; McClure *et al*. 2014). This facies is observed in both Italy and Croatia along the entire Adriatic coast and, slightly later, a little within its hinterland (Forenbaher & Miracle 2005; Forenbaher *et al.* 2013; McClure *et al*. 2014; Spataro 2002; Vander Linden *et al*. 2014a: 19-20). The Impressed Ware culture varied in style within its geographical expanse and various typological sequences have been proposed (e.g. McClure *et al*. 2014: 1022; Spataro 2002: 24-28). Perhaps the most popular sequence marks the division between an earlier A and later B style (Forenbaher *et al*. 2013: 598). Impressed A consists of ceramics heavily impressed by small objects, including the *Cardium* marine shell, whilst zigzag impressions characterize Impress B, which developed about half a century later (Forenbaher *et al.* 2013*:* 598; Cauwe *et al*. 2007: 99). Differences have also been noted between ceramic assemblages on open-air sites and those from caves and rock-shelters, likely to reflect differences in site use rather than cultural separations (McClure *et al.* 2014: 1035). Although the same ceramic traditions are seen on both sides of the Adriatic, raw materials were sourced locally and there is no evidence for the movement of pottery (McClure *et al.* 2014: 1035; Spataro 2002: 194-5, 2009: 69-70). Conversely, there is clear evidence for contacts through the obsidian and flint trade routes across the Adriatic (Forenbaher & Perhoc 2015: 66; Tykot 1996: 69 cited in Spataro 2002: 201).

- Inland

Inland the earliest Neolithic presence comes from the Šumadija region of central Serbia, where SKC sites have been dated to the late 7th millennium BC (Whittle *et al*. 2002: 66-73). This area is part of the Morava-Vardar corridor which seems to have been one of the main inland routes from the southern Balkans (Chapter 2.1). Indeed, at least 84 Early and later Neolithic sites are now known from the 2475km^2 area of the Middle Morava Valley alone (Perić *et al.* 2015: 34). The SKC complex expanded through Serbia and BiH relatively quickly, reaching Romania and Hungary in the early 6th millennium BC (Whittle *et al*. 2002: 93). Technically, the inland portion of the western Balkans falls within the Starčevo group (after the eponymous site near Belgrade) whilst Körös-Criş (the Hungarian and Romanian name for the same river) is used to denote populations further east and north/east (Cauwe *et al*. 2007: 89; Tringham 2000a: 24). The earliest ceramics, according to Manson's (1995) Starčevo phase I, spanning the end of the seventh and start of the sixth millennium BC, were mostly coarse and plain but occasionally painted black-on-red and white and decorated with incised, impressed and plastic decorations (Bailey 2000: 86-9; Cauwe *et al*. 2007: 89-93; Manson 1995: 65-9; Tringham 1971: 79-80). Unique to the Starčevo contexts were “'barbotine' decorated ware in which vessel surfaces were coated with a rough application of clay which was streaked with a finger or a stick so that ridges were raised.” (Bailey 2000: 87). In phase II, during the first half of the sixth millennium BC, the production of fine wares began to increase and 'barbotine' continued to be the preferred coating on coarse-ware (Bailey 2000: 87; Manson 1995: 65-9). During the second half of the sixth millennium BC, or phase III, plain white ceramics were no longer made, 'barbotine' was still used on coarse-ware and the production of fine wares continued to increase (Bailey 2000: 87; Manson 1995: 65-9). There was also an increase in pots with bi-conical shapes and high pedestals (Manson 1995: 65-9). Manson's (1995) analysis of Starčevo pottery demonstrated that potting technology was refined and standardized through time. He also noted a change from the use of organic (namely cereal chaff) to mineral tempers, and suggested the latter was an indication of sedentary communities increasingly reliant upon agriculture, as mineral tempered pots can better withstand the high temperatures required to cook starchy foods (Manson 1995: 72-4). In the Former Yugoslavian Republic of Macedonia (FYROM) the Early to Middle Neolithic is attributed to phases of the Anzabegovo-Vršnik culture which differs slightly in architecture and subsistence strategies (see below). However their pottery is comparable to that of the SKC (Biagi & Spataro 2005).

The SKC complex in Romania (Criş group) is first represented at Gura Baciului, Ocna Sibiului and Miercurea Sibiului dated to 6100-6000 cal. BC (Luca *et al*. 2011: 7). Further north, the SKC (Körös group) is recorded in the Great Hungarian Plain around 5800/5700 cal. BC (Kozłowski & Nowak 2007: 77; Whittle *et al*. 2002: 73-75). Their ceramics are decorated in a slightly different manner to those attributed to the Late Starčevo groups around lake Balaton in Transdanubia, whose arrival has been dated to 5600/5500 cal. BC (Bánffy 2004a: 299-309; Bánffy & Oross 2010: 255). Although variations in typology are present within the SKC, the ceramic technology remains the same (Spataro 2010: 97), suggesting a common cultural origin. Indeed, the SKC is considered part of the monochrome Neolithic period, as is the Karanovo I in Bulgaria (*c*.6200-5750 cal. BC) from which it is thought to originate (Boyadzhiev 2009; Thissen 2000a; see Krauss 2008 for a detailed description and chronology of the Karanovo). Once in Transdanubia, the Starčevo-Körös was instrumental in the development of the LBK. Late Starčevo or Spiraloid B phase includes linear motifs reminiscent of LBK pottery (Biagi & Spataro 2005: 37). As is mentioned in section 3.2, such typological characters also occur at transitional Starčevo/LBK sites, making it difficult to separate one cultural group from another (Bánffy 2008: 154).

3.3.1.2 The Middle/Late Neolithic

- Along the coast

Along the eastern Adriatic the Danilo culture developed from that of the Impressed Wares and is used to describe the Middle Neolithic groups along the coast (Forenbaher *et al*. 2013: 598-9; McClure *et al*. 2014: 1021). Danilo pottery was decorated with painted and impressed, often red circular and zig-zag patterns. The type-site Danilo-Bintij is dated to span 5300–4900 BC (McClure *et al*. 2014: 1029), and recent dates suggest that the Danilo complex "may have originated in Istria and the Trieste Karst around 5600 cal. BC, and that there it lasted almost until the end of the fifth millennium cal. BC" (Forenbaher *et al*. 2013: 601). Hvar style pottery is associated with the Late Neolithic in Dalmatia and is dated to *c*.4800/4900-4000 cal. BC (Forenbaher *et al*. 2013: 601; McClure *et al*. 2014: 1021). Hvar wares are thought to have been a natural continuation of the Danilo ones and incisions continued to be the most popular decorative technique (Spataro 2002: 31). Motifs, however, tend to be more geometric, and fine wares are painted red (McClure *et al*. 2014: 1022). In Istria and the Trieste Karst the Danilo-Vlaška variant develops from the Danilo complex and is used until *c*.4300 cal. BC (Forenbaher *et al*. 2013: 604). The Danilo culture is also found in Italy but its chronological sequence with Impressed Ware is less clear as both styles coincide for longer than in Dalmatia, until *c*.5200 cal. BC (McClure *et al*. 2014: 1035; Spataro 2002: 32).

- Inland

After the initial spread of farming along the Danube catchment area geographical variations in ceramic styles develop almost simultaneously within the western Balkans. Towards the middle of the 6th millennium BC, new pottery traditions develop inland, marking the Middle Neolithic (Orton 2012: 7; Vander Linden *et al.* 2014a: 19-21). Within Serbia and Romania the SKC, with possible outside influences (see below), developed into the Vinča culture (phases A-B), whilst so-called Kakanj and Butmir I wares are found in BiH (Orton 2012; Vander Linden *et al.* 2014a; Spataro 2014). The Sopot culture in Slavonia and eastern Vojvodina is first seen towards the end of the Middle Neolithic and continues into the 5th millennium BC (Obelić *et al.* 2004: 252-253). A final change in pottery traditions occurs towards the start of the 5th millennium, i.e. the Late Neolithic, with Butmir II and III cultures in BiH and Vinča C-D in Serbia and into south-eastern Hungary (Orton 2008: 10; Vander Linden *et al.* 2014a: 21).

Named after the eponymous tell site Vinča-Belo Brdo in the Vinča suburb of Belgrade, the Vinča culture used a different potting technology and new forms of decorations to the previous SKC. Pots were fired in reducing conditions which produced dark wares (Cauwe *et al.* 2007: 93-5). These had glossy surfaces with incised and/or fluted decorations (Cauwe *et al.* 2007: 93-5). The change in typology during the Vinča period has been used to divide the culture into several phases, most notably by Milojčić (1949) (phases A-D) and Garašanin (1973) (Vinča-Turdaş I & II, Vinča-Pločnik I, IIa & IIb) (cited in Cauwe *et al.* 2007: 93). Additional radiocarbon dates obtained in the last ten years, not only from the type-site but also from others within the Vinča cultural sphere, have been used to date the Vinča phenomenon to *c*.5400/5300-4500/4600 cal. BC (Borić 2009; Orton 2012; Whittle *et al*. 2016). The original typological phases A-D assigned by Milojčić (1949) have been retained, but are now thought to have spanned similar durations of *c*.200/300 years (Borić 2009: 234; Whittle *et al*. 2016: 8). The origins of the Vinča culture remain a debated topic, with some authors suggesting an indigenous development of the SKC culture, whilst others argue for an influence from new migrants (e.g. Cauwe *et al*. 2007: 93, Chapman 1981: 33-9; Leković 1990; Orton 2008: 8-16; Whittle *et al*. 2016: 35). A recent analysis of the chronological and spatial distribution of ceramic types indicates that Vinča A began in northern Serbia and southern Hungary (Whittle *et al*. 2016: 41). Conversely, aDNA research suggests an influx of new genes from Anatolia during the Middle Neolithic, with which new pottery styles and technologies may have been introduced (Hervella *et al*. 2015: 13). The Vinča phenomenon was at its most extensive during phase C, when it spanned from Uivar (western Romania) in the North and across southern Hungary, cutting through central BiH to the southern extent of northern FYROM (Orton 2012: 6; Whittle *et al*. 2016: 2, 42).

Butmir ceramics belong to the later Neolithic of central BiH. Hofmann's (2012) paper on the 2.4 tons of pottery from Okolište provide a detailed description, analysis and interpretation of the Butmir typology. The earliest forms were mostly coarse-ware decorated with appliqué and filet or barbotine, and some fine pots painted with red on grey linear motifs. These styles show a strong influence of both Kakanj and SKC wares. However, this initial phase was soon replaced by thicker and completely black burnished wares with geometrical design patterns. Although contacts with other geographical regions are still evident in the pottery, Butmir became a distinct and unique pottery style. Another development in the Butmir style is seen towards the end of the period: coarse-ware became thinner, fine-ware decreased in production and new vessel forms were adopted. The new linear, zoned-laminar and channelling decorations demonstrate a strong link with Sopot communities to the north, the Hvar culture to the west and Vinča groups to the east (Hofmann 2012: 193-4).

The Sopot culture developed in the Slavonian region of eastern Croatia, starting *c*.5000/5500 cal. BC and spanning into the Late Neolithic (Obelić *et al.* 2004: 252-3; Balen 1997: 18-19). Contrary to previous descriptions, Sopot was not a direct development of Vinča groups pushing Starčevo populations northwards, but instead preceded Vinča by about 160 years (Obelić *et al.* 2004: 254). Sopot ceramics have a high concentration of sand and are mostly dark monochrome with highly polished surfaces. Starčevo-like painted pottery and biconic fine-ware were also made, sometimes decorated with animal head appliqués. Other forms of decorations included incisions, impressions and Vinča traditions such as channelling and pressing. (Obeliç *et al*. 2004: 246; Marković 2012).

The Karanovo culture in Bulgaria is seen to change from the early periods of I and II through periods III/IV (5500-5000/4900 cal. BC) and V/VI (5000/4900-4200 cal. BC, considered as the Chalcolithic) (Krauss 2008). During the later Neolithic in Hungary the Sopot culture overlaps with that of the Lengyel in the West and North-West, whilst the Tisza cultures developed in the East and North-East (Hertelendi & Horváth 1992: 863-5). The same period is characterised by the Vinča-Turdaş and Dudesti-Boian cultures in Romania (Cârciumaru 1996).

3.3.2 Settlement patterns and economic animals

- *Settlement location, types and architecture*

The first farmers of former Yugoslavia have been described as settlers of fertile alluvial plains and light soils that would have been easy to cultivate without animal-drawn ards/ploughs (Barker 1975; Bogucki 1996: 245; Chapman 1981: 86-92). It has also been suggested that the development of large Late Neolithic settlements was a direct consequence of cultivating heavy but fertile chernozem soils, which “necessitated ard or plough technology” (Chapman 1981: 92). No evidence (artefactual, osteological or geoarchaeological) has been confirmed for the use of ards in the western Balkans prior to the Bronze Age (Borojević 2006: 127; Filipović *et al*. 2017: 20), though ethnographic records reveal that heavier soils can be worked with a variety of digging sticks (Kreuz & Schäfer 2011: 334). A recent study on the distribution of sites across modern soil types in the middle Morava Valley (Serbia) does indeed suggest that Starčevo sites are more frequently located upon (modern) light brown forest soils (Obradović & Bajčev 2016). Nevertheless, the surveys to locate sites across the valley were not systematic and, as the authors point out, the statistically significant correlation between Early Neolithic sites and brown forest soils may simply be confirming that more sites are *known* upon these soils (Obradović & Bajčev 2016: 66). Fifteen percent of sites were found on heavy clay-rich soils and skeletoid soils unsuitable for crop cultivation, and only 6% were located on alluvium (Obradović & Bajčev 2016: 67). Barker's (1975) hypothesis that sites on soils less suitable for cultivation were seasonal camps, perhaps for grazing, could not be tested due to the lack of site descriptions and precise radiocarbon dating (Obradović & Bajčev 2016: 72). Importantly, the study shows that several soils types could be found within a 5km radius of most sites, and that, *contra* Chapman (1981), no correlation could be found between Vinča sites and chernozem soils (though results may be affected by the small Vinča sample of 21 sites) (Obradović & Bajčev 2016: 69-70).

The pattern of SKC settlements on the Great Hungarian Plain reflects the ecological mosaic conditions (Chapter 2.3.1), showing an “indubitable preference for loess-covered, residual islands in the alluvium” (Raczky *et al*. 2005). Only these islands would have remained habitable during times of high water, for both humans and livestock, though excellent pastures would have been available on the floodplains in the summer (Raczky *et al*. 2005; Sümegi 2007). In the Kerka valley of western Transdanubia settlements have been found on soils that were apparently unsuitable for cultivation (Bánffy & Sümegi 2011: 235). In northern Serbia (Vojvodina), although the main soil coverage is an organically-rich chernozem, the landscape is patched with a “mosaic of soils of diverse physical structure and chemical content (e.g. chernozem, alluvial sediments, sands, loess, saline soils)” (Filipović *et al*. 2017: 14). Another example can be drawn from the Neolithic colonisation of the Gargano Promontory at the northern tip of Apulia, which coincides with the mining of chert (Fiorentino *et al*. 2013: 1298). Indeed, many soils can be cultivated, depending on agricultural tools and practices (such as water management and manuring), and the distribution of Early Neolithic sites on particular soils may be more coincidental than intentional (not to mention the uncertainty of equating modern soil types with prehistoric ones; Chapter 2.2). Critical variables such as relief, aspect and angle of slope, hydrography and vegetation cover must have also influenced the choice of arable field and settlement location (*cf*. Obradović & Bajčev 2016: 69). Other considerations may have included access to other resources such as fresh water, raw materials and wild foods, as well as developed technologies and the proximity to neighbours (Jarman *et al*. 1982: 39-40, 133).

Settlement types vary enormously throughout the Neolithic in the Balkans. The early periods are characterised by cave and open-air flat sites. The former are common along the Adriatic whilst the latter tend to follow the floodplains and lower terraces of major rivers (e.g. Forenbaher & Miracle 2005; van Andel & Runnels 1995). Sites were occupied to various degrees, from short-lived 'camps' to permanent settlements, and are commonly represented by clusters of pits, though the interpretation of the latter as semi-subterranean pit-buildings, or pit-huts, is now mostly dismissed (Bailey 2000: 57; Barker 2006: 352-56; Chapman 2008: 69-72; Orton 2008: 163-4; Tringham 2000a: 40-1; but see Greenfield *et al*. 2014: 27-28). Remains of buildings are rarer, as have been found at Divostin Ic (Orton 2012: 7) and at a dozen Körös sites (Oross *et al*. 2016: 99). Settlements at Anza and Vršnik (FYROM) were small but more permanent, with rectilinear architecture (Orton 2012: 7). With time settlements were abandoned, some grew larger but remained flat, whilst others, such as Okolište, built up into large tells supporting hundreds of residents and protected by encircling moats (Barker 2006: 356-57; Chapman 1981: 40-51; 2008: 75-8; Hofmann 2012: 181, 2013: 39-49, 2015; Orton 2012: 8). Architecture also changed and varied as the Neolithic developed (Chapman 1981: 60-8; Tripković 2003). Dwellings became more linear with increasing internal divisions as populations became more sedentary (Bailey 2000: 55-7; Cauwe *et al*. 2007: 95; Tringham 1971: 180-85; Tripković 2003: 450-55). Clay and straw or wattle daubed with clay were used as building materials (Cauwe *et al*. 2007: 95). Sometimes the clay was tempered with straw and chaff, as has been found in Sopot houses (Obelić *et al*. 2004: 247). Burnt house horizons are ubiquitous across the Balkans and much has been written on the intentionality and meaning of such practices (e.g. Porčić 2012; Stevanović 1997; Tringham 2000b: 121-6; 2005).

- *The economic role of animals*

Neolithic subsistence strategies in the Balkans relied on plants and animals domesticated in South West Asia (see Conolly *et al*. 2011 for animals, Zohary *et al*. 2012 for plants). Nevertheless, farmed animals were not strictly isolated from wild populations and gene flow between wild and domesticates was frequent, particularly in pigs (Larson *et al*. 2007; Larson & Fuller 2014). Differences between the two streams of neolithisation can be seen in the choices of domesticates (Bogaard & Halstead 2015). Overall, the Early period is characterised by a preferential use of ovicaprids along the Adriatic and the Pannonian Plain, and cattle within the Danube catchment area. This general pattern continues into the later Neolithic with an increased importance of cattle and pig on inland sites (Bartosiewicz 2005; Bonsall *et al*. 2013; Hoekman-Sites & Giblin 2012; McClure 2013; Manning *et al*. 2013a: 240-244; Orton 2008, 2012: 27-29; Orton *et al*. 2016). Our understanding of how herds were managed, i.e. their associations with particular sites and/or landscapes, and their degree of mobility within a transhumance or nomadic system, remains uncertain (Bartosiewicz 2005: 56; Bonsall *et al*. 2013: 153-6; Hoekman-Sites & Giblin 2012;

McClure 2013: 61-3; Manning *et al*. 2013a; Orton 2008: 292-304, 2012; Orton *et al*. 2016). Hunting and the consumption of wild animals increases through time, especially during the first half of the fifth millennium BC (Bartosiewicz 2005; Conolly *et al*. 2011; Hoekman-Sites & Giblin 2012; McClure 2013; Orton 2008, 2012; Orton *et al*. 2016). Nevertheless, region and site-specific observations demonstrate that the choice of farm animals and the balance between herding and hunting was far more intricate and diverse (see below).

Along the Adriatic low hunting and a dominance of ovicaprids is seen during the Early Neolithic, with a slightly higher emphasis on hunting in the cave than the open-air sites (Bogaard & Halstead 2015: 397; Bonsall *et al*. 2013; 152-8; Maning *et al*. 2013: 239; McClure 2013: 61-2; Orton *et al*. 2016: 6). Although ovicaprids remained dominant, the use of cattle and pig increases during the later Neolithic (Legge & Moore 2011: 182-88; Orton *et al*. 2016: 9). Hunting also increases, though the overall picture may be partially biased by cave sites in the Trieste Karst where up to 50% of the faunal remains are from wild animals (Orton *et al*. 2016: 9). Exceptions exists, such as at the open-air site of Smilčić (northern Dalmatia) which has an abundance of cattle and so an 'inland', or perhaps simply 'open-air', signature (McClure 2013: 62; Orton *et al*. 2016: 9).

Greater variation in the use of animals is seen along the inland route of Neolithisation. Similarly to sites along the Adriatic, those on the high altitude plateaux of FYROM preferred ovicaprids, though a slight rise in pig and particularly cattle is seen in the Middle Neolithic (there is no evidence for the Late Neolithic) (McClure 2013: 62; Orton 2012: 25-6; Orton *et al*. 2016: 11). Within Serbia and BiH the earliest sites show variation in the composition of domestic taxa, though cattle very quickly become the preferred species (Maning *et al*. 2013: 239; McClure 2013: 62; Orton 2012: 25; Orton *et al*. 2016: 6). This pattern is in slight contrast to that of the Pannonian Plain, where the preference for ovicaprids endures for longer (Bartosiewicz 2005: 60; Hoekman-Sites & Giblin 2012: 516; Orton *et al*. 2016: 18). During the Middle Neolithic contributions from hunting are variable between inland sites but generally tend to decrease (Bartosiewicz 2005: 60; Maning *et al*. 2013: 239; McClure 2013: 62; Orton 2012: 25; Orton *et al*. 2016: 6). Overall, the inland signal (excluding FYROM) sees a reduction in the variability of domestic fauna with a cattle-focused later Neolithic. The surge in hunting towards the very end of the Neolithic is only seen at specific sites in the Kolubara valley (western Serbia), within the Iron Gates and in the southern Pannonian Plain, and as such “appears to be a specific regional phenomenon coterminous neither with cultural nor topographical groupings” (Orton *et al*. 2016: 10).

3.4 Summary

Farming was introduced to the western Balkans at the turn of the seventh and sixth millennia BC. The Neolithic package which defined the first farming communities included domesticated plants and animals, pottery and sedentary to semi-sedentary lifestyles. The initial expansion was defined by two routes: a coastal one originating from Greece, defined by the Impressed Ware culture, and an inland spread by the SKC culture following the river channels from Bulgaria, possibly inland Greece and the FYROM. Farmers spread at different rates, reaching the Pannonian Plain by *c*.5800 cal. BC, Istria by *c*.5600 cal. BC and the Po Plain by *c*.5400 cal. BC. The rates of advance and retardation are recognised to be dependent upon geographical, ecological and socio-cultural conditions, not all of which can be measured let alone predicted. Whether the slower coastal and more rapid inland spreads were associated with different agricultural regimes, practised in very different ecological settings, remains to be clarified. These questions are further addressed in the final chapters of this thesis.

The putative presence of Late Mesolithic populations did little to hinder the newcomers. Though foragers were present in particular areas, such as the Danube Gorges, the Aegean Basin, Montenegro and possibly the Carpathian Basin, the archaeological and genetic evidence does not indicate that either lifestyle was particularly influential or dominant over the other. The first farmers did supplement their diets by hunting, but the overall pattern is one of a decrease in hunting before a renewed increase in the final Neolithic, over a thousand years after the initial spread of farming. Settlers along the Adriatic and on the high plateau of the FYROM mostly kept ovicaprids. The same can be said for other inland sites, though preference of ovicaprids to cattle varied between sites and regions. Whilst ovicaprids may be seen as an adaptation to drier, harsher environments along the Adriatic, the same cannot be said for the delayed persistence of ovicaprid herding on the Pannonian Plain. By the end of the Early Neolithic, an increase in pig and a clearly cattle-focused economy is first witnessed within Serbia and BiH, and only slightly later on the Pannonian Plain.

During the Middle and Late Neolithic there is evidence for increasing sedentism and changing social complexities within and between varying site types (Bailey 2000; Chapman 2008; Tringham 1971, 2000). The second half of the sixth millennium saw regional diversifications of ceramic cultures, and the development of densely populated tells alongside both small and large flat sites. Settlements were established beyond the initial river valleys showing a nuanced understanding of, and adaptation to, diverse landscapes (e.g. McClure 2013). The rise in hunting towards the end of the Neolithic is often linked with the collapse of larger tell sites into smaller settlements. However, the increased rise in hunting is more localised than was previously thought (Orton *et al*. 2016: 10), and whilst the abandonment of tell sites certainly indicates a change in the socio-political system, it does not necessarily signify a population bust (Vander Linden *et al*. submitted).

CHAPTER 4

Archaeobotanical Research in the Study Area

More than three decades ago, Dame J. Renfrew published a review of the archaeobotanical data from Greece and former Yugoslavia (Renfrew 1979). The article was the first of its kind to include current thoughts on the appearance of agriculture in SE Europe based upon local archaeobotanical finds, which she included in the form of presence/absence of taxa per site. The late M. Hopf, W. van Zeist and R. Dennell, along with J. Renfrew, all worked on plant macro-remains from Neolithic sites in the Balkans and Bulgaria, keen to understand how agriculture developed and spread through former Yugoslavia. Archaeological projects were interrupted by political conflicts in the late 1980s and 1990s. Old interests were slow to resume and systematic sampling for plant remains during excavations remains uncommon in the western Balkans. Fortunately, a renewed interest in using archaeobotanical data to understand Neolithic lifeways, and to explore the diffusion of crops from their Near Eastern origins, through the Balkans and into Europe has led to increased sampling during larger excavation projects.

This chapter is divided into two sections: section 4.1 presents a critical review of the archaeobotanical research undertaken at Neolithic sites in the study area, with particular emphasis on Adriatic Italy, the western Balkans and Hungary. It provides an overview of the range of crops and wild plants identified from an area, focusing on regional reviews (where these exist) rather than individual site reports/publications. The section is organised by country (modern geographical boundaries) and phase (Early and Middle/Late Neolithic). Italy is further divided into its southern and northern parts, and Croatia into its coastal and inland regions. Section 4.2 describes and discusses recent studies that have used the archaeobotanical data in large-scale analyses aimed at exploring the first spread of crops into Europe. Descriptions of agricultural regimes are critically assessed, raising questions which are more fully addressed in Chapters 8 and 9.

4.1 Archaeobotanical research on Neolithic sites in the study area

4.1.1 Italy

The first review of Neolithic archaeobotanical research in Italy was published in 1971 (Evett & Renfrew 1971). It presents cereal impressions identified by J. Renfrew from 22 sites, ten of which had casts of grains whilst the remainder only had evidence for marks of straw (Evett & Renfrew 1971: 406, 408-09). The authors, although acknowledging that the assemblages could only be a poor representation of Neolithic agriculture, suggested that emmer (*Triticum dicoccum*), einkorn (*T. monococcum*) and barley (*Hordeum* sp.) were introduced into southern Italy as a package, with a slightly later introduction of free-threshing wheat (*T. aestivum sensu lato*) (Evett & Renfrew 1971: 405-07). Their findings also suggested that einkorn was restricted to the south whilst emmer and barley seemed ubiquitous (Evett & Renfrew 1971: 405-07). In 1987 Follieri's review of the first agricultural communities in Italy included a few additional archaeobotanical findings, though none that enabled her to further develop Evett and Renfrew's original work. The same conclusion was drawn by Costantini and Stancanelli in 1994, despite the inclusion of many new sites in their review of southern and central Italy. They stated that, 25 years after Evett and Renfrew's pioneering article (1971), the practice and development of Neolithic agriculture was still poorly understood, and explained this lacuna by the lack of adequate interest in, and sampling for, archaeobotanical remains (Costantini & Stancanelli 1994: 231-32). The inadequate number and type of samples for plant remains is still listed as a major limiting factor in more recent descriptions of Neolithic agricultural practices (Costantini 2002; Fiorentino *et al*. 2013; Mercuri *et al*. 2015; Rottoli 2006; Rottoli & Castiglioni 2009; Rottoli & Pessina 2007).

For southern and central Italy the cereal package described by Evett and Renfrew (1971) has been confirmed (though einkorn is no longer restricted to the south), with the possible addition of spelt (*T. spelta*) although identifications were only based on grains (Rottoli & Pessina 2007: 146). Although rarely recovered, a broad range of pulses are represented (Table 4.1a). Flax (*Linum usitatissimum*) and opium poppy (*Papaver somniferum*) have only been found at the waterlogged site of La Marmotta, near Rome, where the abundant (quantity unknown) opium poppy seeds “exhibit characteristics that are half-way between the wild and domesticated forms” (Rottoli & Pessina 2007: 147). This crop 'package' continued into the Late Neolithic, with a notable increase in the use of free-threshing wheat (Costantini 2002; Rottoli & Pessina 2007: 149). The range of gathered fruits/nuts includes berries (*Rubus* sp.), wild grape (*Vitis sylvestris*), olive (*Olea europaea*), fig (Ficus carica), elder (*Sambucus* sp.) and plum (*Prunus domestica*), with the last three only found at San Marco Gubbio (site 205, Table 8.3) (Costantini & Stancanelli 1994: Tables 20&21;

Fiorentino *et al*. 2013: Table 3). The range of 'weed' seeds remained low, with only four identified to species. In an attempt to correlate climatic and archaeobotanical data from Apulia, Fiorentino and colleagues (2013) found that changes in the importance of cereal types were associated with changes in climatic trends. Although the quality, quantity and chronological resolution between the two sets of data were not easily matched, the authors suggest that the increase in barley and decrease in emmer evidenced between 5000–4300 cal. BC (not discussed by other authors mentioned above) correlates with a drier period, and conclude that the development of farming in Apulia was “significantly correlated to 'minor' Holocene climate oscillations” (Fiorentino *et al*. 2013: 1313). However, their data does not support their statement as variations in the proportions of wheat and barley are extremely slight, with wheat always constituting over 50% of the ratio in the phases they define (Fiorentino *et al*. 2013: Fig.7).

Archaeobotanically, the first farmers to settle in northern Italy are best represented by two heavily sampled sites: Sammardenchia and Lugo di Romagna (sites 219 and 215 respectively, Table 8.3) (Rottoli 2006; Rottoli & Castiglioni 2009: 94-97; Rottoli & Pessina 2007: 143-44). Occasional finds of millets (*Panicum/Setaria*), spelt and rye (S*ecale cereale*) have been interpreted as cereal weeds, whilst frequent finds of *Bromus* sp. suggest that it may have been cultivated (Rottoli & Castiglioni 2009: 94-97; Rottoli & Pessina 2007: 143-44). There is some evidence that *Bromus arvensis/hordeaceus/secalinus* was also a gathered food or possibly even cultivated during the LBK (Bakels 2009: 32; Bogaard 2002: 145, and references therein). Gathered wild fruits and nuts were numerous but arable weeds were scarce (13 taxa) (Rottoli 2006: 249; Rottoli & Castiglioni 2009: 94-97; Rottoli & Pessina 2007: 143-44). Archaeobotanical evidence from the Middle/Late Neolithic is even more limited but suggests a continued use of the same cereals and an increase in the use of flax, opium poppy and gathered fruits (Rottoli 2006: 249; Rottoli & Castiglioni 2009: 97; Rottoli & Pessina 2007: 149). The rise in flax has been associated with an increase in loom weights and the possible development of a textile industry (Rottoli & Pessina 2007: 149). The presence of millets (*Panicum milliaceum, Setaria italica)* and spelt remains uncertain, and broad bean (*Vicia faba*) was only recorded from one site (Valgrana-Tetto Chiappello, North-Western Italy) (Rottoli & Castiglioni 2009: 98). Arable weed seeds continue to be under-represented. The diverse range of crops evidenced during all phases of the Italian Neolithic has been compared to the restricted range of LBK crops, to conclude that it was more similar to the Greek and Bulgarian 'packages' (Rottoli & Castiglioni 2009: 101).

	South and Central Italy		North Italy		Adriatic Croatia		Slavonia	
Phase	Early	M/Late	Early	M/Late	Early	M/Late	Early	M/Late
Emmer	✓	✓	✓	✓	✓	✓	✓	✓
Einkorn	✓	✓	✓	✓	✓	✓	✓	✓
Barley	✓	✓	✓	✓	✓	✓	✓	✓
Free-threshing wheat	✓	✓	✓	✓	✓	✓		✓
Spelt	? ✓	? ✓	? ✓	? ✓	? ✓	✓		✓
'new' glume wheat		✓	✓	✓		✓		✓
Rye			✓					✓
Broomcorn millet			? ✓	? ✓		? ✓		? ✓
Lentil	✓	✓	✓	✓	✓	✓	✓	✓
Pea	✓	✓	✓	✓	✓	✓	✓	✓
Grass pea		✓	✓		✓	✓		✓
Common vetch	✓		✓	✓				✓
Bitter vetch		✓	✓	✓		✓		✓
Broad bean	✓	✓		✓				✓
Flax	✓	✓	✓	✓	✓	✓	✓	✓
Opium poppy	✓			✓				✓
Taxa of fruits & nuts	3	7	13	14	5	11	4	8

Table 4.1a: The presence of crop types and the number of edible fruits and nut taxa in the research area. Key: '?' indicates questionable identifications and/or date. Smaller ticks indicate infrequent finds. Latin binomials can be found in the text or Table 6.4. The taxa of fruits and nuts account for the groups described in Table 6.4.

4.1.2 Croatia (Table 4.1a)

4.1.2.1 The coastal zone (Dalmatia and the Trieste Karst)

Early Neolithic plant remains have been obtained from four open settlements and one cave site (Table 8.1; Reed 2016). Grapčeva cave was also sampled but only small quantities of charcoal were recovered (Borojević *et al*. 2008). Archaeobotanical data from Krćina cave, Crno Vrilo and Kargadur-Ližnjan are minimal, with only the presence of taxa noted, namely emmer, einkorn and barley (sites 38, 41 and 42, Table 8.1). The most robust Impressed Ware plant data from Croatia therefore comes from only two sites: Pokrovnic (Reed & Colledge 2016) and Tinj-Podlivade (Huntley 1996). Emmer was the predominant crop at Pokrovnic, followed by similar proportions of hulled barley and einkorn (Reed & Colledge 2016: 3). At Tinj Podlivade an unspecified hulled wheat dominated the assemblage in which an additional cereal, spelt, was also identified from glume bases (Huntley 1996: 188). The range of 12 weed taxa is broader than that seen along the

Italian coast, though most seeds could not be identified to species (Reed & Colledge 2016: Table 4). The Middle/Late Neolithic archaeobotanical evidence is also restricted to five sites, though all five were sampled for flotation (Table 8.3; Reed 2016). Emmer, einkorn and hulled barley continued to dominate. Free-threshing wheat was infrequent and the 'new' glume wheat has been identified at Čista Mala Velištak (Reed & Podrug 2016: Table 2). The importance of gathered fruits and nuts appears to increase into the later Neolithic, as does the representation of weed seeds (Reed 2015: Table 5; Reed & Colledge 2016: Table 4). The best represented weed/gathered taxa is fat-hen (*Chenopodium album*), found as 4,732 seeds in three samples at Turska Pécina (Reed 2015: Table 5). Its presence, along with a higher range of wild plant seeds compared to other Croatian sites, may have resulted from the burning of dung that accumulated in the cave (Reed 2015: 615; Wallace & Charles 2013; see Chapter 9.2).

4.1.2.2 The inland zone (Slavonia)

The Early Neolithic archaeobotanical assemblage is only known from two sites: Sopot and Tomašanci Palača (sites 6 and 7, Table 8.1; Reed 2016). Although remains of the hulled wheats were more numerous than barley, the latter was found in as many, if not more, samples (Reed 2015: Table 3). Sixteen weed taxa were found, of which only *Agrostemma githago* and *Galium aparine* were identified to species (Reed 2015: Tables 4&5).

Nine Middle/Late Neolithic sites have been sampled for plant remains (Table 8.3; Reed 2016). Naked barley (*H. vulgare* var. *nudum*) seems to have been the most common variety of barley, though hulled was also present (Reed 2015: 607). The rare finds of rye, broomcorn millet and spelt are not thought to have been cultivated (Reed 2015: 614). The earliest findings of 2-grained einkorn in the area come from Slavča (3 grains) and Sopot (1 grain) (Reed 2015: Table 3). Three flint sickles found at Tomašanci suggest that sickle harvesting was practised. Lentils (*Lens culinaris*) and peas (*Pisum sativum*) became more common, and grass pea (*Lathyrus sativus*), vetches and broad bean have also been found, but only as one or two specimens (Reed 2015: Table 4). Flax also increased, as did the number and range of weed seeds (Reed 2015: Tables 4&5), and opium poppy was found for the first time (Chapter 7.7). Edible fruits and nuts seem to have been more important at Slavča, Sopot and Hermanov Vinograd (Reed 2015: Table 4; Chapter 7.7).

	Bosnia and Herzegovina		Serbia		Hungary	
Phase	Early	M/Late	Early	M/Late	Early	M/Late
Emmer	✔	✔	✔	✔	✔	✔
Einkorn	✔	✔	✔	✔	✔	✔
Barley	✓	✔	✔	✔	✔	✔
Free-threshing wheat	✓	✓	✓	✔	✓	✓
Spelt		? ✓			? ✓	? ✓
'new' glume wheat		✓		✓	✓	
Rye		✓				✓
Broomcorn millet		? ✓	? ✓	? ✓	? ✓	? ✓
Lentil	✓	✔	✓	✔	✓	✔
Pea	✓	✔	✓	✔	✓	✔
Grass pea		✓		✓		✓
Common vetch					✓	✓
Bitter vetch		✓	? ✓	✓		✓
Broad bean					✓	✓
Flax		✓	✓	✔		✔
Opium poppy					? ✓	
Taxa of fruits & nuts	1	11	6	11	8	10

Table 4.1b: The presence of crop types and the number of edible fruits and nut taxa in the research area. Key: ? indicate questionable identifications and/or date. Smaller ticks indicate infrequent finds. Latin binomials can be found in the text or Table 6.4. The taxa of fruits and nuts account for the groups described in Table 6.4.

4.1.3 Bosnia and Herzegovina (Table 4.1b)

There are no reviews of archaeobotanical research specifically for this area. A total of 15 sites have been sampled, four of which were sampled for this thesis (Chapter 7). The two Early Neolithic sites, Kakanj and Obre I, were some of the first sites in the western Balkans to be sampled (Renfrew 1974: 47-50). Although infrequent compared to emmer and einkorn, Renfrew notes that the presence of hexaploid free-threshing wheat is of interest as it is also observed on the early farming sites in the Near East and Knossos, but not in Greece (Renfrew 1974: 49, 1979: 252). Barley was only present at Kakanj and in very low quantities. Only two 'weed' seeds were found, but as no information is given on the method of flotation used, the absence of smaller seeds may simply be a result of the mesh size used. Only *Triticum* sp. impressions were identified on SKC ceramics from Gornja Tuzla (site 3, Table 8.1) (Hopf 1967).

Middle/Late Neolithic plant macro-remains have been retrieved from 12 sites (Table 8.3). The types and relative importance of cereals is similar to that found in Slavonia: emmer, einkorn and barley (both naked and hulled) were the main cereals, followed by free-threshing wheat. Both hexaploid and tetraploid types of free-threshing wheat were identified at Okolište (Kroll 2013a; In press.). Two-grained einkorn was identified at Obre II (Renfrew 1979: 254) and Korića Han, which also contained a few rye grains (Chapter 7.5). Possible spelt was found as a single grain from Jagnilo (Kroll unpublished), and only two finds of the 'new' glume wheat have been noted to date (two grains from Okolište; Kroll in press.). The large concentration of millet seeds at Donje Moštre (a satellite site of Okolište), though recovered from a Neolithic level, have been dated to the Medieval period (Kroll pers. comm. 5/08/14). Flax, lentil and pea were common; other rarer pulses included grass pea and bitter vetch (*Vicia ervilia*). The range of gathered fruits and nuts is larger than in Slavonia, and some form of management of fruit trees (such as opening woodland and protection against grazing animals) has been suggested on the basis of numerous crab apple pips found at Okolište (Kirleis & Kroll unpublished). A broad range of weed seeds is evident, particularly from the lager sites of Okolište, Donje Moštre and Jagnilo (Kroll 2013b; unpublished). Kroll (in press.) observes that many of the weeds are edible and could in fact represent gathered vegetables. He interprets common finds of *Solanum nigrum, Lapsana communis* and *Echinochloa crus-galli*, which seem to become rarer in the Bronze Age, as having economic rather than ecological importance. Weed seeds from Okolište House 38 suggest that both winter and summer-sowing were possible (Kroll 2013a: 119).

4.1.4 Serbia (Table 4.1b)

In 2006 K. Borojević included a review of archaeobotanical findings from Neolithic sites in Serbia in her book on the Late Neolithic site of Opovo (Borojević 2006). More recently, two other reviews were published which highlight the lack of consistency in sampling and analysis of Neolithic plant remains across Serbia (Filipović 2014; Filipović & Obradović 2013). Ten Early Neolithic sites have been sampled, although only single samples were obtained from four of these sites (Table 8.1). Emmer and einkorn were equally represented whereas barley, although often present, was never found in large quantities, and “it is questionable whether barley should be considered a crop in its own right” (Filipović 2014: 201). A few finds of broomcorn millet have been made, at Starčevo and Nossa Biserna Obala[1], though those from Nossa were never confirmed by an archaeobotanist (Bogaard *et al*. 2007a: 434; Borojević 2006: 63). Pulses consisted of lentil and pea, with bitter vetch

---

[1] Acorns, beech-nuts, millet seeds and 'charred crops', were reported from Nossa by Garašanin in 1961 (Borojević 2006: 63, Filipović & Obradović 2013: 40, 43). These findings have never been confirmed by a specialist and so are not included in the overall analyses of plant remains in Chapter 8.

identified from Jaričište 1 Mali Borak, though its context is dubious (Chapter 8.2.1.2). The latter site is the only SKC site in Serbia to contain any flax seeds (Filipović 2014: 202). Edible fruits and nuts were found at all sites sampled more than once; the most common taxa were elder (*Sambucus* sp.) and cornelian cherry (*Cornus mas*). By including charcoal in their study of Bulgarian and Serbian Late Mesolithic and Early Neolithic wild plant resources around the middle Danube, Marinova and colleagues (2013) concluded that a rich array of wild plant foods was available, such as oak (*Quercus* sp.), sloe (*Prunus spinosa*), grape (*Vitis* sp.), hazelnut and hornbeam (*Carpinus* sp.). Interestingly, species identified through charcoal were far more common as seeds/fruits on Bulgarian Early Neolithic sites which lie in the same ecology as the Serbian ones (Marinova *et al*. 2013: 472-3). The only similarly rich Serbian site is Late Mesolithic Vlasac which was systematically sampled over two excavation seasons (Marinova *et al*. 2013: 471; Borić *et al*. 2014). The discrepancy between the Neolithic Serbian and Bulgarian sites may, to a large extent, reflect differences in sampling and analyses (Marinova *et al*. 2013: 471). 'Weed' seeds were not numerous, the most ubiquitous taxa was fat-hen though its numbers are not suggestive of intentional gathering (Filipović & Obradović 2013: 46).

Fourteen Middle/Late Neolithic sites have been sampled for plant-macro remains, and one (Divostin) has had cereal grains identified from a pollen core (Table 8.3). The overall picture, compared to the Early Neolithic, is one of an increase in both the quantity and range of crops and gathered foods (Filipović 2014: Fig.1). Emmer and einkorn continued to predominate, and 2-grained einkorn has been identified from one site (Selevać: Hopf 1974: 4-5). Barley continued to be less frequent, and although free-threshing wheat became more common, it is still considered a weed rather than a cultivar (Borojević 2006: 62; Filipović 2014: 201; Filipović & Obradović 2013: 43). At Gomolova however, it was found in 59% of Vinča samples, occurring in greater numbers and frequency than barley (van Zeist 2001: Table 2). Broomcorn millet was only found at two sites (Vinča-Belo Brdo: Filipović & Tasić 2012: 11, and Gomolova van Zeist 2001: Table 2), although finds of 648 seeds across 56% of Vinča samples at Gomolova led van Zeist to conclude that, like hulled barley, “millet had a modest role in Vinča times” (van Zeist 2001: 109; see also van Zeist 1975: 320). Conversely, radiocarbon dates on a suite of millets from across Eurasia suggest seeds from Neolithic contexts are most likely intrusive, as the crop was not cultivated in Europe before the Bronze Age (Hunt *et al*. 2008; Motuzaite-Matuzeviciute *et al*. 2013, see also Stevens *et al*. 2016: 1544-45). At Vinča-Belo Brdo a large concentration of bitter vetch seeds was found in a deposit from a burnt house, mixed with emmer grains and flax seeds (Borojević 2010, cited in Filipović 2014: 201). Flax seeds were found at seven sites, and, as in northern Italy, their increased presence during the Late Neolithic has been associated with the production of linen as well as oil; linen textile and cord from Opovo (Borojević 2006: 65), textile impressions on Vinča pottery sherds and a large concentration of burnt seeds at Vinča-Belo Brdo (Filipović & Tasić 2012: 11) all attest to such practices. Possible arable weeds were poorly represented and are rarely used as ecological indicators (this may change with additional material from Drenovać and Pavlovać-Gumniste, currently being analysed by D. Obradović for her doctoral thesis; Obradović pers. comm. 4/07/16). At the flat/open site of Opovo small plots on rich chernozem soils could have been cultivated as part of a crop-rotation system, within a three kilometre radius around the settlement (Borojević 2006: 133-136). The author further suggests that fields were not weeded or manured as this would have been too labour intensive (Borojević 2006: 130). However, these interpretations are not drawn from the arable weeds but from the modern distribution of soils and ethnographic examples of emmer and einkorn cultivation. During the successive occupational phases of Selevac it is thought that shifting garden plots were gradually replaced by larger permanent fields located further afield on the outskirts of the tell (Chapman 1990: 37-39). Again, however, these ideas stem from calculating settlement size and population density rather than an ecological study of the arable weed flora. A predominance of black-bindweed (*Polygonum convolvulus*) and *Vicia* (both climbing species) at Gomolova led van Zeist to suggests that ear-plucking was a common method of harvesting during the Vinča phase (2001: 112-14).

4.1.5 Hungary (Table 4.1b)

In his most recent review of the archaeobotanical data from Körös sites, Gyulai concludes that “the most important cereal of the Körös culture was barley, followed by emmer and einkorn” (Gyulai 2012: 226). It is difficult to understand how that conclusion was reached (Figure 4.1). If one compares all the barley varieties to all the wheat ones barley is less frequent. If one compares the 12.61% of barley to any of the individual wheat varieties, one erroneously ignores the 14.77% of indeterminate wheat. In addition, this does not include the fact that seven of the 13 sites only had plant remains from ceramic impressions, none of which were of barley (Gyulai 2010a: 72).

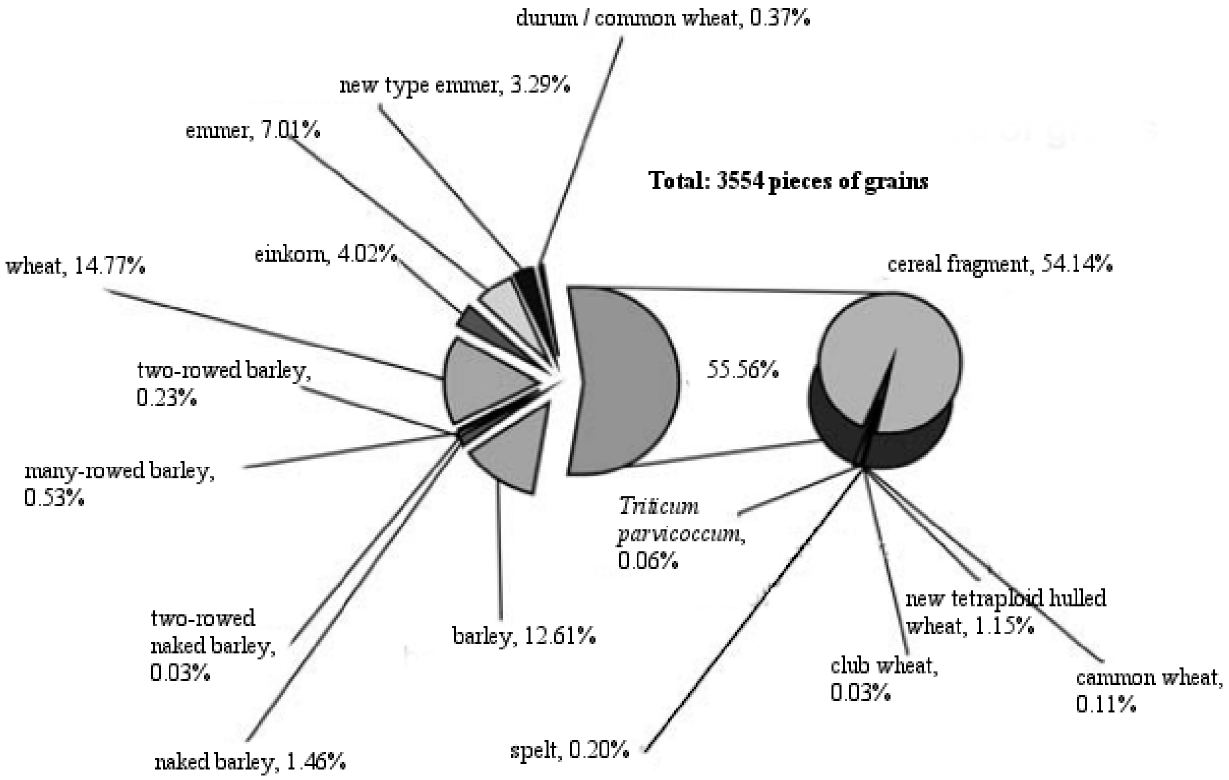


Figure 4.1: Distribution of cereals in Körös culture sites (Gyulai 2012: Fig.3)

Barley does have the highest ubiquity score in the Pannonian Basin (which includes northern Serbia and north-eastern Croatia – Figure 8.5), and seems to have been used more frequently in Hungary than in Serbia. Gyulai mentions the significance of the two grains of Early Neolithic tetraploid free-threshing wheat (*T. parvicoccum* – probably a form of compact durum) from Ibrány-Nagyerdő and Tiszaszőlős-Domaháza (sites 21 and 24, Table 8.1), as the species originates from the Anatolian crop package (Gyulai 2010b: 235). Currently, the 'new' glume wheat has only been identified at one site: Ecsegfalva, whose glume bases were found in similar quantities to those of emmer and einkorn (Bogaard *et al*. 2007a: Table 23.I). Other possible crops include flax and hemp (*Cannabis sativa*). Imprints of linen and hemp fibres were found on the underside of a ceramic vessel at Gyomaendrőd (Gyulai 2010b: 225; 2012: 224), though no seeds have yet been recovered from Early Neolithic levels. A single, charred possible fragment of an opium poppy seed was found at Ibrány-Nagyerdő (Gyulai 2010b: Fig.1, Table 1), which could be significant for the earliest domestication and/or distribution of opium poppy (Carolan *et al*. 2006; Salavert 2010), but identification criterion are not provided.

Pulses were rare on Early Neolithic Hungarian sites: only four lentils and one pea have been recorded to date (Gyulai 2010b: Table 2). The lentils tend to be small and are described as the *microsperma* subspecies. A single broad bean, recorded as *V. faba* var. *minor*, was found at Tiszaszőlős-Domaháza (Gyulai 2010a: Appendix table). Edible wild fruits and nuts were much better represented, in both their range and absolute numbers; "for example a finger-thick layer of hazelnut shells was found in one of the pits at the Méhtelek–Nádas" (Gyulai 2007: 131). Cornelian cherry, various bramble berries (*Rubus* sp.), water-chestnuts (*Trapa natans*), crab apple (*Malus sylvestris*), elder berries and oak (*Quercus robur*), to mention but a few, offer evidence for a varied diet of wild plants (Gyulai 2007: 131; 2012: 227).

Based on enriched anthropogenic soils, Halstead suggested that the distribution of Körös material on river levées reflected the spreading of midden material to fertilise plots, indicating small-scale intensive agriculture (Halstead 1989: 32-33; see also Bogaard 2004a). To date, this claim has only been investigated, and corroborated, through archaeobotanical material at one site. The assemblage from Ecsegfalva 23, Békés county, is probably the most famous of the studied Starčevo-Körös archaeobotanical assemblages. The site was systematically sampled, revealing a low density but steady presence of charred plant-macro remains. The greatest density of plant remains by feature (excluding charcoal) was found in pit complex 23A and it is from those that Bogaard and colleagues (2007a) based their main interpretations of the cultivation regime. To measure the intensity of cultivation the wild seed assemblage was compared to modern weed floras from intensively hand-cultivated plots and extensively ard-cultivated plots in Evvia, Greece (Jones *et al.* 1999, Jones *et al.* 2000b). A discriminant analysis based on the presence/absence of taxa, resulted in a greater than 99% probability that the weed assemblage derived from intensively cultivated plots; 90% of the wild seeds were annuals, pointing to fixed plot as opposed to shifting cultivation. Indeed, experimental shifting cultivation in woodland zones in Germany have shown that weeds will be predominantly perennial (Bogaard 2002, 2004: 88; Rösch *et al.* 2002: Table 4). Although the area around Ecsegfalva was not densely wooded (Willis 2007), grassland perennials associated with the plant communities cleared to make way for temporary cultivation would be more frequent. The presence of autumn-germinating weeds (e.g. *Bromus sterilis*) suggests at least some autumn-sown crops. These crops would not, therefore, have been sown on the naturally fertile floodplain, as was often previously assumed (*cf.* Sherratt 1980). Instead, higher ground less prone to flooding would have been cultivated during a time traditionally considered to be one of gathering. The archaeobotanical data from Ecsegfalva therefore resembles those from LBK sites by pointing to fixed cereal plots intensively managed through manuring or middening, tillage and weeding, with at least some crops being sown in the autumn (*cf.* Bogaard 2004; see below). Of note within the wild taxa is hairy vetch (*Vicia hirsuta),* an introduced LBK weed which was previously unknown outside the LBK area (Bogaard *et al.* 2007a; Bogaard *et al*. 2008).

During the Middle/Late Neolithic barley, particularly naked barley, continues to be better represented whilst emmer and einkorn appear to be equally abundant (Gyulai 2007: Table 8.2). Two-grained einkorn has been identified at one site: Szentgyörgyvölgy-Pityerdomb (Berzsényi & Dálnoki 2005). Free-threshing wheat remains a minor crop/contaminant as supposedly does spelt. Broomcorn millet, though only present as charred seeds at five sites, has been found in counts of 20 to *c*.100 seeds (Gyulai 2010a: Appendix table). Impressions of millet seeds in ceramics from two sites (sites 153 and 155, Table 8.3) suggest *Panicum milliaceum* was present in the Late Neolithic (*contra* Hunt *et al*. 2008). Wild fruits and nuts continued to be well represented into the Middle/Late Neolithic, and the range of arable weeds increased. The most frequent were grasses, such as *Bromus* sp. and *Avena fatua*, and twinning plants, such as black-bindweed and *Galium* sp. The substantial increase in plant macro-remains between the Early and Late Neolithic is thought to be related to the increased number and size of settlements, which, unlike those of the Early phase, are considered 'truly' sedentary and 'fully' agricultural (Gyulai 2007: 135; 2010: 71-72).

4.1.6 A note on the archaeobotanical evidence from Early Neolithic LBK, Bulgarian and Greek sites

4.1.6.1 Linear-Bandkeramik

Crop agriculture during the Early LBK was focused on einkorn, emmer, lentil, pea, flax (for both its fibre and oil) and to a much lesser extent hulled and naked barley (Bogaard 2004b: 14-15; 2011: 37; Colledge *et al*. 2005: 143-145; Kreuz *et al*. 2005: 243; 2007: 269-70). A study of 30 sites demonstrated that einkorn had been found in higher quantities than emmer, suggesting it was more commonly grown (Kreuz *et al*. 2005: 244). Flax and peas are less likely to become charred than glume wheat chaff and so their economic importance may be underestimated (Bogaard 2011: 92). The 'new' glume wheat was also present, and occasional finds of rye and oat suggest they were crop weeds (Bogaard 2004b: 15; 2011: 37-8). The same is debated for opium poppy, which is only found in high concentrations in waterlogged deposits (Bogaard 2011: 38). Its scarcity may therefore be due to preservation conditions rather than infrequent cultivation (see Chapter 9.3 for further discussion on the distribution of poppy). Millet occurs from the earliest LBK but remained rare, in both counts and presence (Bogaard 2011: 37). The narrow spectrum of ubiquitous and abundant crops is considered to be a very restricted version of the original Near Eastern crop package, and both cultural and climatic reasons have been put forward to explain such a reduction in diversity (*cf.* Colledge & Conolly 2007; Colledge *et al*. 2005; Kreuz *et al*. 2005: 243-46).

In 1989 Halstead noted that the absence of intensive stock breeding and the composition of the arable weed flora (an abundance of Chenopodiaceae species), both conformed with an agricultural system based upon intensive, small-scale garden cultivation (Halstead 1989: 33-34). More recently, the analysis of ecological traits of the LBK weed flora has demonstrated that cultivation was indeed practised on a small, intensive scale that involved fertilising and weeding (Bogaard 2004a; 2004b, 2005; Bogaard *et al*. 2008). These results are corroborated by elevated nitrogen isotope values ($\delta^{15}N$) of cereal grains, demonstrating the use of animal and/or other manure as fertiliser (Bogaard *et al*. 2013; Chapter 5.4.2). Assessments of the cereal crop sowing season have differed in opinion. Studies in Germany on the ecological characteristics of modern varieties of Neolithic weeds suggest LBK cereals were mostly sown in the spring/summer (Kreuz *et al.* 2005; Kreuz & Schäfer 2011). Conversely, the measurement of functional and morphological attributes of the main weed species, and comparisons with weed floras from known cultivation regimes indicate a predominance of autumn-sowing for emmer and einkorn (Bogaard 2004b; 2011). The majority of the LBK weeds were anthropochores (weeds brought in from a different environment as opposed to apophyte, or native species) (Kreuz *et al.* 2005: Fig.6; Kreuz & Schäfer 2011: Fig.1). Interestingly, their frequency increased with the development of the LBK, suggesting a continued long-distance movement and distribution of crops. A predominance of tall weeds (>80cm high) during the first half of the LBK suggests that crops were harvested at the base of the ear, separately to the straw (Kreuz & Schäfer 2011: 334).

4.1.6.2 Bulgaria

Einkorn was the dominant crop during the Early Neolithic, followed closely by emmer and barley (both naked and hulled) (Dennell 1972, 1978; Marinova 2007: 96-99). Stores of hulled barley have been found at some sites (Kapitan Dimitrievo, Brezani, Vaksevo and Rakitovo), “that speak clearly for its cultivation” (Marinova & Krauss 2014: 185). Lentil, pea and grass pea (*L. sativus/cicera*) were present at most sites and were evidently an important part of the diet (Marinova 2007: 96-99; 2009: 59; Marinova & Krauss 2014: 186). Flax and chickpea (*Cicer arietinum*) were rarer, having been found at four and two sites respectively (Marinova 2007: Table 6.3). About ten wild taxa are thought to have been regularly gathered as wild foods, particularly cornelian cherry and *Prunus*, and a limited range of other wild taxa (possible weeds) are known (Marinova 2007: Table 6.3; 2009: 60; Marinova & Krauss 2014: 186-87). An ecological study of the weed flora concluded that summer and winter crops were equally common in Bulgaria, and that the small number of low growing species (≤40cm) suggests ear-plucking was common (Kreuz *et al*. 2005). The combination of 'root/row-crop weeds' and 'cereal weeds' (Jones *et al*. 1999) indicate that cultivation was small-scale and intensive (Bogaard & Halstead 2015: 391).

4.1.6.3 Greece

Domesticated plants and animals were ubiquitous during the Greek Neolithic, and, from the Early Neolithic onwards, it is thought that the management of plants and animals was inextricably linked, resulting in the practice of intensive, small-scale cultivation associated with fully sedentary long-term villages (Bogaard 2004a: 53-54; 2005: 182; Bogaard & Halstead 2015; Colledge & Conolly 2007: 29; Demoule & Perlès 1993: 362-64; Halstead 1989: 28-32; 1996; 2006; 2011: 132-37). A broad spectrum of cereals and pulses was used: emmer, einkorn, barley (hulled and naked), the 'new' type, free-threshing wheat, lentil, pea, grass pea (*L. sativus/cicera*), bitter vetch and chickpea. Nevertheless, in their review of the evidence, M. Valamoti and K. Kotsakis point out that sites are often poorly sampled and/or remains are not adequately analysed to investigate “the co-occurrence and dominance of different species at each site or the full range of people-plant relationships” (Valamoti & Kotsakis 2007: 79). The authors warn against envisaging one homogeneous agricultural regime and give the example of chickpea, a pulse included in the crop package despite having only been found at two sites (Valamoti & Kotsakis 2007: 84). In addition to the crops, a range of about 11 wild fruits and nuts have been found.

4.2 Large-scale studies on the spread of crops into Europe

The most extensive studies are based on a comprehensive database (Colledge 2016) in which Dr. S. Colledge recorded pre- and Early Neolithic finds of plant macro-remains from SW Asia and Europe available to her at the time (Colledge *et al*. 2004; 2005; Colledge & Conolly 2007; Conolly *et al*. 2008; Coward *et al*. 2008; Manning *et al*. 2015). The database was compiled between 2001 and 2015, under the auspices of two research project: *The origin and spread of plant economies in the Near East and Europe* (funded by the AHRB), and *EUROEVOL: The role of farming in transforming early European societies, c. 6000-2000 calBC* (funded by the ERC). Archaeobotanical data were sought from site monographs, articles and online resources, and by contacting authors/specialists for unpublished reports. Taxa were recorded following a coding system (Chapter 6.3), along with qualitative and quantitative details. All pre- and Early Neolithic reports were included, irrespective of sampling procedures, recovery methods and preservation types. No judgements were made on the accuracy of identifications, but records were standardised to include all synonyms under the same code. Relevant information on the site, samples and preservation status were also included (Colledge 2016).

The EUROEVOL database registers nine sites from Hungary and former Yugoslavia (including two sites from Macedonia), demonstrating the lack and difficulty of access to archaeobotanical information from my research area. Seven crops are recorded (compared to 11 from Greece and 13 from Bulgaria), with over 80% of sites containing no more than four crops, creating a mean average of 2.44 crops per site (Colledge & Conolly 2007: Fig 4, Table 4). The paucity of results led Colledge and Conolly (2007) to conclude that fewer crops were used in former Yugoslavia and Hungary than in Greece and Bulgaria, and that the "the reduction in crop diversity is not entirely due to taphonomic factors" (2007: 34). However, it is worth noting that the Bulgarian data came from ten sites, 50% of which contained 28 or more taxa from bulk soil sampling (Manning *et al.* 2015). None of the seven sites from the western Balkans and Hungary were properly sampled: three contained data from clay impressions and four from *in situ* collections of visible plant remains without any further information on how the latter were collected (Manning *et al.* 2015). Although taphonomy may not have been the single reason for the reduction in crop diversity, it seems to have had a more important role in biasing the data than has been suggested by Colledge and Conolly (2007) (Chapter 8.1).

If taphonomy cannot be solely responsible for the reduction in domestic crops from the S/SE to the NW Balkans, three other possible variables remain: neutral drift, cultural preferences, climate and crop yields:
1) Neutral drift - The transmission of agricultural practices and their associated crops from one generation of farmers to the next was achieved through social learning within an inheritance system (Richerson & Boyd 2005; Hodder 2012: 142-46). However, the effects of neutral drift must be accounted for before patterns of transmission (vertical or horizontal) can be discerned. Neutral, or random drift, whereby "who or what one copies [is] simply a random choice dependent on who or what one meets" (Shennan 2008: 77), would explain the absence of plant taxa by a purely random chance of events, including innovation and genetic mutations. The effect of neutral drift on pre-LBK crop packages was tested using an agent-based model to track changes in diversity over time, which demonstrated that drift alone could not account for the loss of so many crops (Conolly *et al.* 2008). The authors therefore concluded "that the observed reduction of diversity between the pre-LBK and LBK is not likely to have occurred by neutral drift processes alone" (Conolly *et al.* 2008: 2802). Another mathematical simulation performed on the same dataset (with the addition of three pre-LBK records of millet), included spatial, as well as temporal dimensions, to take into account where drift may have occurred within the advancing population (Pérez-Losada & Fort 2011). If a species is lost at the edge of the front where the population is smaller, it is more likely to have a

long-term effect than if it was lost from a site within a densely populated zone (Pérez-Losada & Fort 2011: 1296). Contrary to the agent-based model, results from the spatio-temporal simulation suggest that "drift can explain the decrease of cultural diversity in the LBK culture in Neolithic Europe" (Pérez-Losada & Fort 2011: 1298).

2) Cultural preferences - Conolly and colleagues' (2008) study also tested the possibility of cultural selection on the Neolithic crop package by excluding rare species and those found in pre-LBK sites that could have been removed through climatic pressures alone (such as the chickpea and lentil). Their results suggest that the full range of crops potentially available was not fully utilised and that cultural preferences were clearly a considerable selective mechanism (Conolly *et al*. 2008: 2800; Colledge & Conolly 2007; Colledge *et al*. 2005).

3) Climate and crop yields - Climatic and environmental conditions must have affected the growth of crops moving north (Colledge *et al*. 2005: 149; Bogucki 1996: 245; Fuller *et al*. 2014b; Jones *et al*. 2012). The founder crops of Neolithic agriculture evolved in SW Asia (Zohary *et al*. 2012). Emmer, einkorn, hulled barley, pea, lentil, chickpea and bitter vetch were domesticated in a Mediterranean climate (Zohary *et al*. 2012). The crops evolved in a zone of long, hot, dry summers and relatively mild winters where the quantity and timing of annual precipitation were crucial for the germination and development of crops. As farming moved northwards crops encountered a more temperate climate with less pronounced seasonal yet more accentuated daily variations in temperature, milder summers and colder winters and an altogether different pattern in annual rainfall. It is suggested that bread wheat (free-threshing hexaploid wheat) would have been the best adapted cereal to conditions in the northern Balkans and Hungary (Zohary *et al*. 2012: 48-49), though little is known regarding genetic mutations and adaptations to changing patterns in temperature and day length (*cf.* Brown *et al*. 2015; see below for research on barley). Of the pulses pea was the best adapted to continental Europe. Lentil and chickpea need longer summers and drier autumns to mature and may thus have struggled to tolerate the increasingly northerly latitudes (Zohary *et al*. 2012: 77-89). Indeed, as Bogucki states: "In the early agricultural settlements of the Balkans, there are clear signs of an adaptation to temperate conditions. At most sites, cattle and pigs become more important than sheep and goats, while wheat and barley became summer (rather than winter) crops" (1996: 245), although he does not explain what the latter statement is based on. Recent genetic studies on barley landraces have demonstrated how the crop adapted to colder temperatures (cold tolerance and vernalisation) and shorter day light hours (photoperiodicity) as its cultivation spread northwards (Jones *et al*. 2012; 2013; Jones *et al*. 2016; Lister & Jones 2013). As

the most common former Yugoslavian crops of emmer, einkorn, hulled barley, pea and lentil (Colledge & Conolly 2007: Fig.2) became harder to grow in ever higher latitudes, yields may have reduced until varieties and/or agricultural practices had adapted. Under such a scenario one might expect some SKC sites to have had lower crop yields than contemporary sites further south. In the absence of archaeological evidence with which to test the hypothesis of a cultural selection, Colledge and Conolly concluded "that the variation in the crop packages observed between the southern and northern Balkans can most parsimoniously be accounted for by the differences in climatic conditions (i.e. the increasingly temperate climate in the north) that reduced the effectiveness of some crop species" (2007: 35; see also Colledge & Conolly 2005).

Coward *et al.* (2008) argue that since crop farming in Europe stemmed from a broadly single origin in the Near East (the exact location of domestication events in the Levant being irrelevant at this scale of analysis), and developed with the genetic descendants of the ancestral species a phylogenetic signal should be present in the distribution of Neolithic crop packages and their associated weeds across Europe. Consequently, *c.*7500 records of domestic crops and their associated weeds from 250 pre- and early Neolithic sites were used to draw a phylogenetic tree with the least evolutionary steps. In order to avoid 'noise' created by sampling methods and preservation effects, sites were not included individually but grouped into larger units equivalent to 22 geographical regions. The parameters by which these regions were defined seem arbitrary, as regions respect neither cultural nor geographical boundaries. Region 8 is comprised of Hungary and former Yugoslavia, and region 7 of Bulgaria and FYROM. The resulting tree shows that, on the whole, archaeobotanical assemblages from regions nearest to the original source are less derived than those further away. The study demonstrates that a crop-farming system is in part determined by its ancestral system, independently of modes and rates of transmission, thereby justifying other comparative studies which seek to explain the origins of crop-farming systems by comparing them to earlier, adjacent ones. The authors recognise that several factors could have distorted the phylogenetic signal, such as the possible secondary spreads of crops and associated weeds, as well as the representativeness of the data. (Coward *et al.* 2008)

Coward and colleagues' work also reveals that region 8 contained a restricted plant spectrum that had undergone few evolutionary changes. The SKC assemblage therefore appears to have derived from those of central Anatolia, Cyprus and Greece, and suggests an initial spread of farmers from the Near East (Coward *et al.* 2008: 54; see also Colledge *et al.* 2004, 2005). The data within region 8 were not adequate to establish any possible differences between the inland and coastal signatures.

Compared to region 8, the package from region 7 contained a broader range of species and was more derived from the central Anatolian assemblage (Coward *et al.* 2008: 53). Such differences between regions 7 and 8 are unexpected since the early Neolithic culture of Bulgaria (the Karanovo) shares many similarities with the Starčevo-Körös complex (on material culture see for example Krauss 2008). However Perlès (2005), based on the presence of Anatolian cultural traits present in Bulgaria but not in Greece, has postulated a separate migration from NW Anatolia into the Balkans (Chapter 3.1). Little is currently known about the subsistence practices in NW Turkey, but both Perlès' arguments and the phylogenetic study suggest "the highly derived Bulgarian plant spectrum cannot be considered ancestral to the Körös and Starčevo assemblages […], which look much more like descendants of the Greek/East Mediterranean line" (Coward *et al.* 2008: 54). The phylogenetic study also concludes that, above and beyond obvious geographical connections, the small range of crops and the underived nature of the crop assemblages from region 8 make them plausible ancestors to the LBK complex (Coward *et al*. 2008: 53). These results are corroborated by Colledge and colleagues' (2004) detailed correspondence analyses of archaeobotanical data (using the same dataset) across the Near East and Europe, which describes two distinct 'vegetational signatures': one defined by Greece, Crete, Cyprus and the southern Levant, the other by Anatolia and the northern Levant (Colledge *et al*. 2004: S44-6).

4.3 Summary

The fragmentary Early Neolithic archaeobotanical data has been interpreted as evidence for short-lived sites, and/or societies that used, but did not depend upon cultivated crops (Barker 1975, 2006: 353-54; Greenfield *et al*. 2014: 28; Greenfield & Jongsma 2008: 124-54; Jezik 1998: 164; Gyulai 2012: 226). This interpretation seems fitting with the nature of Early Neolithic settlements, often characterised by a cluster of shallow pits with no obvious storage devices or sturdy, 'permanent' structures (Chapter 3.3.2). It does not, however, "take the lack of suitable recovery techniques into account and makes the unfounded assumption of a relationship between grain yield and preservation" (Bogaard *et al*. 2007a: 434). Plant remains suggestive of a well-developed cultivation regime have been recovered from some sites (such as Ecsegfalva, Tiszaszőlős-Domaháza and Măgura-Buduiasca), and evidence for possible stores of cereals and pulses is present at other sites (Filipović 2014: 196; Tripković 2011: Fig.2). Indeed, a vessel full of burnt peas and lentils found at Drenovać is supporting evidence that these pulses were important crops (Perić & Obradović 2012; Stojanović & Obradović 2016: 88-9). Poor preservation and the fact that many of these early sites have not been systematically sampled for plant remains (Table 8.1), make it impossible to provide an overarching explanation for the relatively low plant-spectrum evident in the research area. Comparisons with Greece and Bulgaria have led to suggestions that a reduced range of crops was used in the western Balkans, probably as an outcome of having to adapt to changing climatic conditions (Colledge *et al*. 2005; Colledge & Conolly 2007; Bogaard *et al*. 2007a: 434-36). Indeed changes in vegetational zones between southern and northern latitudes within the Balkans are known have affected agricultural practices (Halstead 1994, 2014: 36-38; Krauss *et al*. 2017). Large-scale statistical analyses suggest that the plant-spectrum associated with the SKC is more likely to have originated from Greece than Bulgaria (Coward *et al*. 2008).

A greater number of plant remains and a broader range of crops during the Middle/Late Neolithic suggests that crop farming was well established, in accordance with the increased population size and permanency indicated by large tell sites. Sites are often discussed individually and general overviews on the type or intensity of cereal farming by region or cultural entity are not given. Interestingly, the range in gathered wild plants does not diminish during this period, indicating that their presence in early sites should not be used as supporting evidence for a 'casual' approach to cultivation, or indeed an ancestry to hunter-gatherers (*contra* Greenfield *et al*. 2014).

The archaeobotanical data and its current interpretations raise a number of concerns, listed below. These are formally addressed in Chapters 8 and 9 where the data is collated, analysed and re-evaluated.

1. the apparent lack of evidence for a well developed agricultural economy during the Early Neolithic should be re-evaluated in light of preservation and sampling strategies;
2. similarly, the reduced range of crops in the Early Neolithic should be re-assessed in light of additional archaeobotanical data;
3. the relative importance of particular crops (such as the apparent near absence of barley) should also be re-evaluated in light of preservation and sampling strategies;
4. the use of edible fruits and nuts may reflect adaptations to local environmental conditions and/or a diversification in the management of food resources, rather than a return to more 'hunter-gatherer' practices;
5. the presence of broomcorn millet in Neolithic contexts needs to be explained in light of dating programmes that suggest it was not cultivated in Europe prior to the Bronze Age (Hunt *et al.* 2008; Motuzaite-Matuzeviciute *et al.* 2013);
6. the identification of spelt before the formal description of the 'new' glume wheat should be viewed with caution as the two species can look very similar (Jones *et al.* 2000a; Kohler-Schneider 2003);
7. the increased presence of flax seeds and impressions of fibres during the Neolithic add to current knowledge on its history of cultivation and development into both oil- and fibre-producing varieties (*cf.* Allaby *et al.* 2005; Fu 2011);
8. likewise, finds of poppy should be evaluated and assessed in light of evidence for its distribution and cultivation during the Neolithic (Antolín 2013; Salavert 2010, 2011);
9. descriptions of arable farming should be defined from the ecological requirements of arable weeds rather than on estimates of population densities, modern soil distributions and ethnographic literature.

CHAPTER 5

The Formation of Archaeobotanical Assemblages, their Recovery and Interpretation

Before the archaeobotanical data described in the previous chapter can be combined and analysed, it is essential to understand how assemblages were formed and retrieved. This chapter begins by exploring the natural and human processes involved in the creation and recovery of archaeobotanical remains. The crop-processing stages for hulled and free-threshing cereals are explained. The effects of sampling procedures on eventual interpretations are then discussed, and identification procedures are described. Approaches to the interpretation of weed assemblages for understanding ancient husbandry regimes are reviewed, including their strengths and weaknesses. The information gained from arable weed seeds is explored in finer detail in section 5.4, in which the biological and ecological traits pertinent to this thesis are defined.

5.1 Pre-Excavation: the formation of archaeobotanical assemblages

> "How seeds enter into the seed record is a more complicated issue than identifying the seeds themselves." (Pennington & Weber 2004: 14).

Prehistoric plant macro-remains have survived to the present day through two main channels: either as a result of being buried in conditions unfavourable to organic decay (e.g. freezing, desiccation, waterlogging), or by being transformed into mineral components (e.g. mineralisation, carbonisation, imprints - where the shape of the plant part is left in mineral form). It is only through the latter channel that Neolithic plant macro-remains have been preserved in the western Balkans. Whilst carbonisation is by far the most common form of preservation, there is a longer archaeological tradition of noting and recording imprints of plant parts, in ceramics and structural plaster (see previous chapter). Mineralised seeds are rare and have only been found as the occasional specimen within otherwise charred assemblages. The three modes of preservation will not only relate to different uses of fresh plants, but will also have exerted different selective pressures on the original plant assemblages (*cf.* Gallagher 2014). These varying formation processes must therefore be understood to justify the analyses and interpretations of the archaeobotanical data.

5.1.1 Mineralisation

The mineralized plant macro-remains are all seeds from non-domesticated plants, preserved through calcium phosphate replacement of the organic matter. They are orangey-brown, harder than charred seeds and present varying levels of cellular detail. Whilst in most cases only the overall shape of the seed is preserved, detailed patterning of the seed coat is visible in others. Calcium phosphate mineralisation occurs when dissolved calcium percolates through a phosphate rich medium (Gallagher 2014: 25; Green 1979; McCobb *et al*. 2003). Depending on the permeability of the seed coat, calcium phosphate will infiltrate into decaying seeds, replacing organic structures by a mineral pseudomorph (McCobb *et al*. 2003). Seeds with thin seed coats low in lignin are more likely to decay and be affected by phosphatisation than those with hard, lignin-rich seed coats (McCobb *et al*. 2003: 1278). Consequently the former will often retain seed coat patterns whilst the latter survive as indeterminate embryos as their hard seed coats tend to decay before mineralisation can ensue (McCobb *et al*. 2003: 1278). Phosphatisation is usually attributed to manure or cess-rich contexts such as latrines, in which mineralized seeds are taken as direct evidence of diet (e.g. Green 1979; Carruthers 1986, 2005). However, conditions favourable to calcium phosphate replacement can also be attained through the decomposition of animal protein and/or vegetative matter (Green 1979; McCobb *et al*. 2003). Therefore, although the mineralized seeds in this study indicate primary phosphate-rich contexts, they were not necessarily part of the human and/or farm animal diet.

5.1.2 Plant impressions

The Early Neolithic pottery in the western Balkans was sometimes tempered with cereal chaff and grains, leaving some clear, identifiable imprints (Manson 1995). Imprints have often been used to study ancient agricultural systems (e.g. Costantini 1983; Gyulai 2010a, 2010b; Helbaek 1952, 1959; Hopf 1958, 1967). However, recent comparative studies on Bronze Age Irish and prehistoric African data have shown that cereals used in pottery production represent a very specific and narrow selection of the range of crops found as charred remains (Fuller *et al*. 2014a: 199-205; McClatchie & Fuller 2014). When examined alongside charred remains imprints can provide additional information on past arable economies by preserving cereals, or parts of cereals, which may be under-represented in the charred assemblage (Dennell 1972: 150; Fuller *et al*. 2014a: 199-205; McClatchie & Fuller 2014). Nevertheless, marks of other seeds are seldom recorded, either as a result of preservation, the difficulty of spotting and identifying smaller imprints and/or the selective use of plants and plant parts in the clay temper. Consequently, the range of information on past agricultural systems usually available from carbonised plant macro-remains is much narrower within the record of imprints. Since imprints are directly associated with the pottery or plaster production, and have a very different taphonomical pathway to charred remains, their inclusion into an analysis of all archaeobotanical data, be it from a site or region, must be carried out with caution and only to address specific questions.

5.1.3 Carbonisation

5.1.3.1 How do plants burn?

When plants are exposed to extreme heat their volatile constituents react with oxygen and combust, releasing energy (Scott & Damblon 2010: 2). Any remaining organic materials are transformed into inert carbon in the absence of oxygen (Scott & Damblon 2010: 2). The resulting carbon structure will therefore depend upon the physical and chemical make-up of the plant part (including its moisture content), as well as the length of firing, its temperature and degree of available oxygen (*cf*. Wright 2003). Experiments focused on cereal grains and chaff have tested how they react to different firing conditions (Boardman & Jones 1990; Braadbaart 2008; Braadbaart *et al*. 2004, 2005; Hillman *et al*. 1993; Märkle & Rösch 2008; Nitsch *et al*. 2005; Valamoti 2002). These studies demonstrate that during carbonisation dense storage organs rich in carbohydrates, such as grains and pulses, retain more integrity than lighter chaff. Straw and leaves are the first to be destroyed, followed by the cereal ear chaff and finally caryopses, creating an obvious bias in the archaeobotanical record (Boardman & Jones 1990). As grains and pulses are altered during combustion their key identifiable features can be deformed or destroyed; indeed Braadbart's experiments of charring de-husked emmer (*Triticum dicoccum*) under different firing conditions produced an extraordinary - and a somewhat worrying - range of results in which some grains took on free-threshing characteristics (2008: 163). The epidermis of pulses rarely survives and their cotyledons tend to separate, damaging the diagnostic hilum (Colledge 2001: 66; Valamoti 2002). They are consequently difficult to identify and often ascribed low preservation indices. Seeds of non-cultivated plants tend to be smaller, more fragile and more easily incinerated than caryopses. Experiments show that no more than fifty percent of wild/weed seeds survive controlled charring conditions, and that seeds of oil plants are quickly damaged beyond recognition (Märkle & Rösch 2008; Wilson 1984; Wright 2003). It is remarkable that seeds and grains survive at all; perhaps, being denser and heavier than chaff, they “drop quickly through the flames and into the ashes without being burnt to ash themselves” (Hillman 1981: 140). A comparison with desiccated and waterlogged plant remains, whose preservation is more dependant upon natural than human conditions, exemplifies the extent of sub-sampling expressed through carbonisation (e.g. Bouby & Billaud 2005; Colledge & Conolly 2014; Jacomet 2004; van der Veen 2007). When whole sites are submerged in water with low oxygen content, or exposed to extreme droughts, all the plants are exposed to the same preservation conditions. Finer plant parts such as leaves and stems often survive, along with a broad and diverse range of wild plant seeds, which would either never be exposed to fires or simply not survive charring (Bouby & Billaud 2005; Colledge & Conolly 2014; Gallagher 2014: 22-25; Jacomet 2004; van der Veen 2007). Taphonomic filtration and preservation, therefore, have significant effects on the survival of wild plants (*cf*. Antolín *et al*. 2017; Steiner *et al*. 2017); it has been estimated that only 35% of the range of wild plants found in waterlogged samples are also recovered charred (Colledge & Conolly 2014: 199).

5.1.3.2 When are plants burnt?

Plants were burnt in fires constructed for heat and/or cooking, as well as in larger conflagrations. In the majority of cases, plants recovered from archaeological sites are burnt through human action, intentionally and unintentionally, so that the assemblage of charred plant remains reflects specific human behaviours. The most frequent activities on any settlement involving fire and plants are the daily routines involved in the preparation and consumption of food (Gallagher 2014: 30; Jones 1985a; Knörzer 1971 cited in Stevens 2003: 61; Stevens 2003: 71-74).

> “Thus, with charred assemblages we are concerned with a relatively limited range of plant species: mostly cereals and cereal by-products and, to a lesser extent, pulses and the shells of nuts and stones of fruits. Most other food plants tend to be represented through chance accidents only. This highlights a significant aspect of charred assemblages, namely that they are remarkably similar in composition across chronological periods and geographical regions” (van der Veen 2007: 978).

The provenance of most carbonised plants/plant parts can be split into four broad categories:

1. fuel, such as wood, dung and specific plants for a particular type of fire (e.g. the use of *Cladium mariscus* in Late Medieval Cambridge bakeries; Rowell 1986: 143);
2. burnt food stores and storage pits;
3. burnt residues/waste from crop processing and food preparation, and possibly from the manufacture of other plant-based products;
4. accidental burning of foods, namely grains and occasionally pulses, during food preparation and consumption.

1. Remains from this category will be mostly charcoal which is not analysed in this thesis. Some seeds are possible, particularly from dung, which may also contain crop remains if animals were fed cereals and/or crop-processing waste. The use of dung as a fuel has been identified at prehistoric sites in Greece and South-West Asia (Charles 1998; Charles & Bogaard 2001, 2005, 2010; Filipović 2014; Miller 1984; Valamoti 2007; Valamoti & Jones 2003: 26), but not from LBK sites (Bogaard 2002b: 145; 2004b: 66; 2011: 162). Dung-derived archaeobotanical material has only been suggested at one site from the research area. At the Late Neolithic cave site of Turska Pećina in

Dalmatia large concentrations of wild seeds found in 'grey layers' were interpreted to represent the cyclical burning of accumulated dung (Reed 2015: 615; see also Bonsall *et al*. 2013: 152). *Chenopodium album* (which in large quantities is toxic to livestock; Grime *et al*. 1998: 188) made up 94% of the seed assemblage. This assemblage differed to those retrieved from other areas within the cave, which contained cereal remains and fewer wild seeds (Reed 2015: 615). Whilst the grey layers may represent burnt dung the plant remains from Turska Pećina do not suggest that dung was used as a fuel. The composition of dung-cakes will vary depending on what the animal(s) eat and what other materials (such as cereal processing waste) were added during their preparation (Charles 1998: 112; Shahack-Gross 2011). Waterlogged dung from Neolithic Lake-shore dwellings in the Alps indicate that domestic herds were fed twigs, budding branches and leaves, as well as cereals and cereal processing waste (Bogaard 2004a: 52; 2011: 236; Jacomet 2009: 55). At Çatalhöyük herds grazed on wetland vegetation and on the stubble of arable fields (Filipović 2014: 94). Ethnographic and experimental studies carried out to investigate the effects of herbivore digestion on plant remains revealed that cereal chaff and particularly grains are rarely recovered as identifiable items (though hulled barley tends to 'survive' better than free-threshing and glume wheat grains) (Anderson & Ertug-Yaras 1998; Charles 1998; Valamoti & Charles 2005; Valamoti 2013; Wallace & Charles 2013). Conversely, many small wild/weed seeds 'survive' digestion, especially those with hard, lignin-rich testa (Anderson & Ertug-Yaras 1998; Charles 1998; Miller 1984; Miller & Smart 1984; Valamoti & Charles 2005). Based on criteria developed by Miller (1984) and Miller and Smart (1984), Charles (1998) described four analytical criteria through which dung-derived material may be recognised:

1 – the presence of burnt pellets of dung. Such remains are undeniable evidence that dung had, for one reason or another, been burnt. Sheep/goat pellets have a distinctive surface texture and are readily identifiable (Charles 1998: 113);

2 – the biology and ecology of plants. Some plants are unlikely to have grown on arable fields, and/or are unlikely to have been fruiting at the time of harvest. The difficulty with this criterion is that the time of harvest and the ecological conditions of ancient arable fields are not always known. Certain taxa that may not normally be classified as arable weeds, such as sedges, may in fact have grown amongst the crops (see section 5.4.3). The palatability and toxicity of taxa should also be considered;

3 – the behaviour of wild seeds in relation to crop processing. An assemblage of dung-derived seeds

is not expected to represent a product or by-product of a specific processing stage when the seeds are classified by their physical attributes relevant to crop processing (see below). Dung-derived assemblages from Abu Salabikh (southern Iraq), Jeitun (Turkmenistan), and Çatalhöyük formed distinctive groups in the discriminant analyses when compared to the ethnographic samples of known processing stages from Amorgos, indicating that they were not formed by a cereal processing stage (Charles 1998: Charles & Bogaard 2010: 156; 115; Filipović 2014; 92; Jones 1984; 1987a);

4 – the association of crop varieties and plant parts. This criterion takes into account the likelihood of maslins and the expected proportion of plant parts at particular stages of the processing sequence (Tables 5.1 and 5.2). For example, hulled and free-threshing crops are unlikely to have been fully processed together, and processing waste from one crop would not be added to the product of another. The 'unusual' association of crop types and plant parts may therefore be suggestive of animal feed and/or additions to dung cakes. However, it is possible that such assemblages represent deliberate mixes of processing waste and infected products to be burnt.

There is no clear evidence to suggest that dung was burnt as fuel during the Neolithic in the research area. Burnt dung pellets and/or fragments were not found in any of the flots analysed for this thesis (Chapter 7), and none are mentioned in the archaeobotanical records included in this thesis (dung pellets associated with mineralised seeds were found in Slatina and Kapitan Dimitrievo; Marinova 2006: 38-9). Wild taxa that are unlikely to have been crop weeds consist of edible species gathered for their fruits/nuts and the aquatic *Utricularia vulgaris* found at Anza (site 1, Table 8.1) (Renfrew 1976). Wetland species are included within the 'weed' assemblages for reasons discussed in section 5.4.3. Although assemblages in Chapter 7 are not compared to those from Amorgos using discriminant analysis, the physical attributes of individual seeds within assemblages all point to the same crop processing stages, in accordance with the type and relative proportions of cereal remains. Assemblages in Chapter 7 are predominantly composed of emmer and/or einkorn chaff and/or grains, indicative of crop processing stages. Consequently, with the possible exemption of a sample from Tasnad Sere (Chapter 7.1.3), dung is not thought to have been a source of wild/weed seeds analysed in this thesis.

2. Remains from this category are rare and usually identified when found *in situ*. They are difficult to interpret – why would anyone burn their food reserves? Reasons include the sterilization from infestations of pests or fungi, and destruction during the common practice of house burning

(Stevanović 1997; Tringham 2005). Another possibility is the spontaneous combustion of stored grains as heat is released from fermentation. Indeed modern silos are kept well-ventilated to avoid, amongst other problems, such catastrophes (*cf*. Sigaut 1988: 8-10). Burnt grain and/or pulse stores are readily noticeable during excavations and may be collected even if other forms of archaeobotanical sampling are not planned. Of the samples examined for this thesis two are from such stores, and both are from sites where other deposits were not sampled (Korića Han and Bapska, Chapter 7.5 and 7.6).

3. Cereal processing – the stages through which cereal plants are processed in order to obtain clean, edible grain – acts as a series of filters through which plant parts are separated or grouped according to size and weight (Tables 5.1 and 5.2). Consequently, every stage will have a signature product and by product, which if burnt and recovered as an archaeobotanical assemblage, should be informative as to the cereal processing sequence (Dennell 1972, 1974, 1976). As is alluded to above, arable weeds, chaff, grains and pulses removed during crop-processing and food preparation constitute the most commonly recovered charred archaeobotanical finds; "...charred plant material is 365 times more likely to relate to waste from routine processing activities conducted day-in, day-out than to the once-in-a-year or occasional burning event" (Fuller & Stevens 2009: 40). Heat is often required during crop-processing, in stages such as drying for malting, hardening for grinding and drying for dehusking (Nesbitt & Samuel 1996: 42). Burnt crops may also originate from roasting for beer and other forms of cooking. Although parching (heating spikelets to 150°C or above, Nesbitt & Samuel 1996: 42) to facilitate dehusking is often suggested to explain the presence of burnt grain and chaff, ethnographic studies have shown that the exposure of hulled grains to facilitate dehusking is not an *a priori* but in fact depends upon several environmental, technological and cultural factors (D'Andrea & Haile 2002: 204; Hillman 1984a: Fig.3; Nesbitt & Samuel 1996; Nesbitt *et al*. 1996: 237; Peña-Chocarro 1996: 139-40; Peña-Chocarro 1999: 41; Peña-Chocarro *et al*. 2009: 107). In areas with short, wet summers fires/ovens may be used to dry, but not necessarily parch, spikelets that are harvested early and/or cannot be dried under the sun (Hillman 1981: 138-40; Meurers-Balke & Lüning 1999: 241; Monk & Kelleher 2009; Nesbitt & Samuel 1996: 46). Peña-Chocarro notes the use of raw flames during the processing of emmer and spelt in Asturias; "the final result is a quick burning of the awns and partial parching of some glumes" (1996: 139). Hillman (1984b: 141-3) describes the burning of glume wheat sheaves in Turkey: sheaves are laid out on the threshing floor and fired to remove the straw, though weed seeds and spikelets may also become burnt. The absence of charred straw culm nodes in samples from the research area suggest that if this practice did occur it was performed outside the settlements. Ethnographic observations of non-mechanised

farming communities and experimental research have helped to tease out the various stages of crop processing, where these are likely to have taken place and the resulting products and by-products (e.g. D'Andrea & Haile 2002; Hillman 1981, 1984a, 1984b; 1985; Jones 1984, 1987; Meurers-Balke & Lüning 1999; Palmer 1998a; Peña-Chocarro 1996; Peña-Chocarro 1999; Peña-Chocarro & Zapata Peña 2003; Peña-Chocarro *et al*. 2009). The most obvious and pertinent conclusion from these studies is that there are only a limited number of ways by which clean, edible grains and pulses can be obtained from their plants. Crop-processing clearly follows a logical sequence with slight variations adapted to the crop type and climatic conditions (Tables 5.1 and 5.2). Threshing and winnowing, for example, are commonly thought to have been done outside and away from the habitation zones, but Sigaut (1989: 119-121) notes that in northern Hungary where rains were likely after harvest, horses were used to thresh wheat indoors. With the latter in mind, G. Hillman (1981, 1984a; 1984b; 1985) and G. Jones (1984) described and illustrated the crop-processing stages of hulled and free-threshing cereals, as well as pulses, observed during ethnographic studies in Turkey and Greece. The stages are divided into those that probably required a greater input of labour and occurred on the periphery of a habitation zone, such as winnowing and threshing of the whole crop, and those that could be done within households on a more piecemeal basis, such as pounding, sieving, hand sorting and grinding. Consequently, products and by-products from the more 'domestic' stages are more likely to have come into contact with fire, possibly the same fire, and be preserved in the archaeological record (Fuller & Stevens 2009; Fuller *et al*. 2014a; Jones 1987a; Stevens 2003, 2014). For example, the bias between free-threshing and hulled cereal chaff may be due to the fact that the former is removed during the first threshing and winnowing, whilst hulled grains are often stored in their glumes which are later removed (along with any remaining weed seeds) before cooking. Hillman (1981) and Jones' (1984) models are described in Tables 5.1 and 5.2. Additionally, hulled wheat processing stages, their products and by-products are illustrated in Figure 5.1.

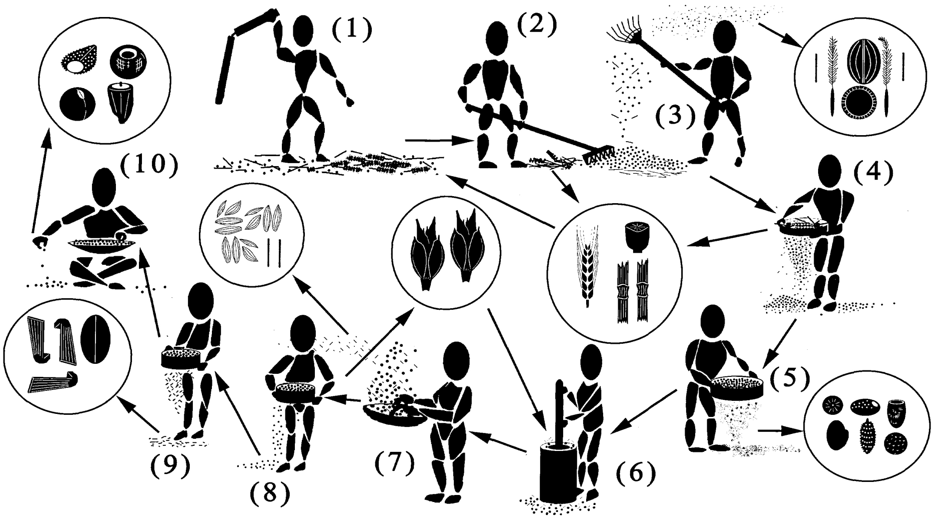


Figure 5.1: Processing stages for hulled wheats. (1) threshing (2) raking (3) 1st winnowing – light weed seeds, some awns removed (4) coarse sieving – weed seed heads, unbroken ears, straw fragments removed (5) 1st fine sieving – small weed seeds and awns removed (6) pounding (7) 2nd winnowing – paleas, lemmas and some awns removed (8) sieving with medium-coarse sieve (9) 2nd fine sieving – glume bases, awns, remaining small weed seeds and tail grains removed (10) hand sorting – removal of grain-sized weeds by hand (Stevens 2003: Fig.1).

EVENT	METHOD	PURPOSE	RESULTS	COMMENTS
Harvesting	By reaping (sickle, scythe), or uprooting	If by sickle some straw nodes may be removed, less with scything, whilst uprooting will lead to some basal culm nodes within the assemblage		May be stored in sheaves and ears plucked off daily
Drying	In fields, barns and rarely kilns or ovens	To reduce moisture content to facilitate threshing	All the weeds, weed heads, straw and grain in ears are still present	Drying by fire is unlikely to be practised at this stage, so charring is less likely
Threshing	By flailing, lashing, trampling or sledging	To separate the spikelets from the ears and main chaff	Straw and broken ears, consisting of rachises, awns and spikelets	Sweepings from threshing floor high in rachis nodes, weed seeds, awns and some spikelets
Raking	With rake	To remove coarser components: straw and weed plants	Straw and coarser weeds separated from spikelets, free weed seeds and rachises	Straw may be burnt as tinder but is more likely used for animals or as temper for daub
Winnowing	Outside or in large barns	To remove lighter components: straw, chaff and light seeds	Removes chaff and SFL seeds from spikelets and heavier seeds	Fragile by-product is unlikely to be collected; may be burnt
1st Sieving (I)	With medium to coarse riddle	To remove larger components: headed seeds, seed-heads and straw nodes	Spikelets, smaller weed seeds and rachis fragments fall through the sieve	By-product in sieve may be burnt
1st Sieving (II) especially seed grain	With 'wheat-sieve'. Sometimes omitted	To remove finer components: weeds, awns and loose rachis segments	Spikelets, spikelet-sized weed seeds and maybe some straw are retained	By-product may be burnt: smaller seeds, rachises, straw and freed grain
Hand Sorting	Picking out of large weed seeds/heads	To remove contaminants the same size as spikelets before they are broken up		By-product may be burnt: larger seeds, seed-heads, straw, stones, etc.
Drying	In ovens or kilns prior to storage	To reduce the moisture content of spikelets	To prevent loss to fungi/bacteria during storage	Accidental burning of spikelets and large seeds if no prior hand sorting
Parching	In ovens or kilns. May be omitted	To ease the removal of grains from glumes if their moisture content is high	Spikelet forks become brittle & easily removed during pounding	As above. Parching may be omitted in warmer climates
Pounding	With pestle and mortar or widely set quern	To release grains from glumes, paleas, etc.	Grain, empty spikelet forks, glumes, awns, etc. (unless parched)	Some freed grain and chaff may spill over the edge and later swept into fires
2nd Winnowing	Outside or covered area in light breeze	To remove the lighter chaff: awns, paleas, lemnas	Free grain and heavier chaff are retained	If waste is burnt it is unlikely to survive as macro-remains
2nd Sieving	With medium-coarse riddle	To remove unbroken spikelets, spikelet forks, larger glume bases and spikelet-sized seeds	Grain, glume bases and small spikelet forks fall through as a product	Retained spikelets may be re-pounded until most of the grain has been collected
3rd and 4th Sieving	With 'wheat sieve'	To remove SFH seeds and chaff. Light chaff brought to the surface by agitation	Free grain, larger seeds and chaff are retained	By-product may be burnt
Hand Sorting	Removal of any remaining large weed seeds	To remove any remaining contaminants, namely BFH seeds	This stage may be omitted but will guarantee clean grain	By-product may be burnt: grain-sized weed seeds and any remaining heavier chaff
Preparation of Groats, Milling, Malting, etc.	By boiling, cracking, roasting, milling with saddle or rotary quern, germinating the grains, etc.	Preparation of grain for immediate consumption or brewing, bread making, etc.	Chaff may be present depending on efficiency of sorting and milling. Malting: germinated grain and some spikelet forks	These products, as ingredients and prepared food, are the least likely to become charred

Table 5.1: Crop-processing stages for hulled wheats, after Hillman 1981: Fig.5 (modified from Stevens 1996: Table 5.1). See below for explanations of SFL, SFH and BFH seeds.

EVENT	METHOD	PRODUCT	BY-PRODUCT	COMMENTS
Harvesting	By reaping (sickle, scythe), or uprooting	Uprooting: ears, straw, weeds, culm bases, root nodes	Reaping: culm bases, depending on harvesting height	By-products usually of use and so not burnt
Drying	In fields, barns and rarely kilns or ovens	As above	Uprooting: roots and culm bases removed	Drying by fire is unlikely to be practised at this stage, so charring is less likely
Threshing	By trampling, beating or sledging	Grains, awns, weeds and chaff	Rachises, coarse weeds and undamaged straw	
Raking	With rake	Free grain, fine chaff, rachises and weed seeds	Coarser straw fragments, some rachises and awns	
Winnowing	With a fork. outside or in large barns	Grain, heavy chaff, rachis fragments and heavier weed seeds	Lighter weeds, lighter chaff and most awns	Used for fodder, fuel and temper. Less likely to be preserved as charred macro-remains if burnt
Coarse sieving	With a medium-coarse riddle (mesh > grain)	Grain, weed seeds, some rachises and awns	Straw, weed heads, large weed seeds and some rachises	Sometimes omitted, possible fodder or fuel
Grain storage	In pits, granaries, baskets, etc.	As above	As above	Stored as food or fodder. Perhaps charred when storage is sterilized?
Fine sieving	Mesh < grain	Grain, grain-sized weed seeds and few rachis fragments	Most small weed seeds (including tail grains), remaining rachis fragments and awns	Often used as chicken feed, though could be used as fuel
Grain storage (Hillman 1984: fig.2)	In wet areas dried in kilns/ovens	As above	As above	Possible charring during drying or cleaning of storage areas
Hand Sorting	To remove final contaminants	Clean grain ready for milling, roasting, etc.	Grain-sized seeds, larger rachises and straw nodes	Either burnt or mixed with fine sieving by-products

Table 5.2: Crop-processing stages for free-threshing cereals, after Jones 1984: Fig.1 (modified from Stevens 1996: Table 5.2)

At every stage described above weed seeds are retained with or removed from the crop depending on their physical characteristics. Based on three physical characteristics, Jones (1984; 1987a) defined six groups by which weed seeds could be classified, and demonstrated that the association between these groups and the by-product of cereal processing stages are statistically significant:

1. SFL (small, free, light - possibly with aerodynamic appendages like wings or hairs). These seeds will be removed during winnowing;
2. SHL (small, headed, light), SHH (small, headed heavy) and BHH (big, headed, heavy); These will be removed during coarse-sieving. The 'headedness' of a seed refers to its allocation in a seed head or cluster, or attachment to an adherent fruit (that may not survive

charring), making it larger than the individual charred seed;

3. SFH (small, free, heavy). These will be removed with a fine sieve;
4. BFH (Big, free, heavy) seeds that remain in the fine sieve (with cereal grains) are removed by hand.

When using the above models to interpret archaeobotanical remains it is important to consider four main points:

1. Carbonisation and other taphonomical factors will affect assemblages so that original ratios of grains, chaff and weeds in products and by-products are unlikely to be retained;
2. a headed seed may not remain so during processing. Coarse sieving may loosen seeds from ripe seed-heads;
3. the mesh size of sieves will determine the size categories of seeds. Although these artefacts are not usually recovered, mesh size can be estimated from the cereal grain sizes, since these tools are used to let spikelets through, retain spikelets and finally grains, (Dennell 1974: 276). D'Andrea and Haile (2002: 200-2) describe how in Ethiopia different grain varieties and plant parts were separated through the skilled handling of flat baskets, suggesting that the sequential use of coarse and fine sieves (separation by size) is not the only way to remove impurities;
4. burnt waste usually ends up mixed together so that by-products (and possibly products) of several stages, even from different crops, may be found amalgamated.

5.1.4 After carbonisation

The plant parts that survive carbonisation are then subject to cultural and natural processes that can further transform the composition and preservation of charred assemblages (Schiffer 1972, 1976, 1983, 1987). Many authors have devised models showing the life history of archaeological artefacts in order to more accurately define formation processes and human behaviours (e.g. Binford 1964, 1983, 2001; Flannery 1976). Between charring and their archaeological recovery the preservation and location of plant macro-remains will be affected by the way in which they are discarded (from being thrown onto a more or less trampled surface to being directly discarded into a pit or ditch); buried and possibly re-buried; the weather before and after burial (effects of wind, rain, freeze-thaw, desiccation of the soil matrix); bioturbation; ploughing and other physical and chemical disruptions of contexts (Binford 1964, 1983, 2001; Brantingham *et al*. 2007; Gallagher 2014: 28-33; Pearsall 2015: 34-44; Flannery 1976; Hillman 1991; Hilton 2003; Needham & Spencer 1997).

In the Balkans the concentration and ubiquity of charred plant macro-remains varies between flat/open and tell sites (Bogaard & Halstead 2015: 391; Valamoti 2004: 132, 2005); indeed the difference in the quantity and range of taxa between the tell and small flat sites included in this research is clear (Table 8.6). The necessity to burn waste may have been dictated by the relative lack of living space within tell sites compared to flat sites. In open settlements waste from food preparation may easily have been discarded uncharred or beyond the habitation zone, or more readily kept as animal feed. Plant foods at tell sites may also have been more regularly burnt through the wide-spread social practice of house burning (Stevanović 1997; Tringham 2005). Once burnt, plant remains are more likely to have been buried in growing tell sites than at ephemeral open sites.

Hubbard and Clapham (1992) devised a tripartite classification of archaeobotanical samples to describe their contextual integrity. 'Class A' encompasses samples whose provenance can be clearly defined and whose wider archaeological contexts is also unambiguous. Such samples are invariably from category two described above and include such examples as the *in situ* bowl of burnt peas at Drenovać (Perić & Obradović 2012: 18). 'Class B' incorporates samples whose origins are as clear as those from Class A but that have then undergone a degree of mixing, “that can be dis-entangled (at least partially) with a high degree of confidence” (Hubbard & Clapham 1992: 118). Samples in this class could originate from categories one, two and three if the association between burnt assemblage and context is clear. 'Class C' represents the majority of samples: those of ambiguous origins and/or with a high and obscure degree of mixing. More recently Fuller and Weber (2005: 103-7) devised another classification that places samples into one of four grades, depending not only upon their context and taphonomical histories, but also upon the detail of their recording/reporting. 'Grade 1/Grab Samples' include samples from unknown or poorly described contexts and chronology, and whose provenances (in terms of human behaviour) are ambiguous. Samples that have been combined, regardless of context or phase also belong to this grade. 'Grade 2/Presence Samples' include samples of known contextual provenance but whose descriptions lack the detail required to enable quantification. Only the presence/absence of plant remains is obtained. 'Grade 3/Diffuse Samples' include samples with quantified plant remains of known contextual provenance, but for which the correlation between the plant assemblage and the behaviour(s) that created it is unclear. 'Grade 4/Behavioural Samples' are those representing primary or *de facto* refuse from well-defined contexts, and from which quantified remains can be more confidently interpreted. Grades 1 to 3 are equivalent to Class C samples but enable further separation according to the level of their analyses/descriptions and interpretations. Grade 4 is equivalent to Class A, and

Class B samples could be assigned to any of the grades depending upon the level of sample description and interpretation. Since the majority of archaeobotanical data used in this thesis were obtained from literary sources with varying methods of recording, Fuller and Weber's (2005) system was deemed more appropriate to define the interpretative value of assemblages (Tables 8.1 and 8.2).

5.2 Excavation: the recovery of archaeobotanical assemblages

5.2.1 Retrieving samples

The sampling strategy will define both the analyses and interpretation of the plant remains, and so should be adapted to the research questions as well as to the type of plant preservation (D'Alpoim Guedes & Spendler 2014; Jones, M.K. 1991: 64-67; O'Connor & Evans 2005: Part IV; Wilkinson & Stevens 2008: 149-59). Summarised below are the sampling approaches described by M. Jones (1991: 54-5), and the possible biases created upon the plant records. Haphazard or grab-sampling does not follow a structured pattern or reasoning but tends to result from chance finds, such as 'charcoal-rich' contexts. As a result spurious patterning may be seen in the data. Judgement sampling assumes an *a priori* knowledge as to where plant macro-remains are likely to be found, an assumption which is then reinforced by the recovery of expected assemblages. Interval sampling relies upon a fixed grid or approach, such as ten litres every other square metre, over a defined area. Problems arise when possible patterning in the data is confused with that of the sampling. Total (or blanket sampling) and random sampling lend themselves best to subsequent statistical manipulation of the data as the patterning in the sampling should not affect the distribution of plant remains. Random sampling is best combined with an additional form of sampling to avoid missing 'rich' contexts or those relevant to research questions. Once contexts have been chosen for sampling, a composite or pinch approach should be taken in which the sample is composed of soil from across the context rather than from a single point (Pearsall 2015: 76). When sampling a feature it is useful to also sample around it for comparison. The majority of the site reports used in this thesis do not describe the sampling strategy, their contextual provenance or how many of the features/layers were sampled. At the site level therefore, it is mostly impossible to evaluate how representative the plant remains are, or to gain any understanding of their economic importance (*cf.* Dennell 1976).

5.2.2 Processing samples

As carbon floats water is usually used to separate charred plant macro-remains from the soil matrix (Pearsall 2015: 46-74; White & Shelton 2014: 99-105). Separation by size through wet or dry sieving does not isolate carbonised plant parts from other mineral and organic items as efficiently. There are various, slightly differing ways of doing flotation though all rely on differences in density between the mineral and organic constituents of bulk soil samples (Pearsall 2015: 46-74; Pennington & Weber 2004: 15-16; White & Shelton 2014: 99-105). The two main techniques are bucket and machine flotation. Personal experience has shown that the former tends to be less efficient, requiring more labour and time to process larger samples. It is also more difficult to avoid fine minerals being washed into the flot, making post-excavation laboratory work lengthier. Machine flotation allows for many more and much larger samples to be processed in a given time. Processing time is directly affected by soil type. Although seeds may be better protected in dense, cushioning clay than rough, scabrous sand, clay-rich samples will take more time and energy to process. Loosening of the soil is helped by a constant input of pressurised water below the sample, and its constant flow facilitates lighter components to drain into the flot mesh. The size of the latter is paramount and should be recorded; the absence of small seeds in assemblages can simply be due to the use of too large a sieve (*cf.* White & Shelton 2014: 101). Contamination between samples is more problematic in machine than bucket flotation as buckets are easily cleaned between samples. Small buoyant seeds, carbonised or not, can remain adhered to the surface of the flotation tank until the next sample is processed (*cf.* Keepax 1977). Not all plant macro-remains will float however. Dense charcoal with low porosity, carbon structures covered in fine clay and mineralised seeds tend to remain in the heavy fraction. Froth flotation (the Cambridge machine) was developed in the late 1960s to avoid problems arising from inefficient buoyancy and the risk of losing materials through the mesh retaining the heavy fraction (Dennell 1978; Pearsall 2015: 51-52). Unfortunately, its reliance upon a frothing agent (terpineol) and a paraffin (often kerosene) make for obvious complications. Though painstaking and slow, it is therefore important to manually sort through the heavy fraction, not only for plant remains but also for small bones and other artefacts. Carbon structures can burst if dried too quickly so light and heavy fractions are best left to dry naturally in a shady and well ventilated area.

5.3 Post-Excavation: the identification, quantification and interpretation of archaeobotanical assemblages

5.3.1 Identification

As noted above, the size and shape of plant macro-remains can be greatly altered before, during and after their inclusion into the archaeological record, making identifications more or less possible (*cf.* Fritz & Nesbitt 2014). Correct identification relies upon a low-powered microscope and a modern seed reference collection. Seed manuals with photographs and/or drawings are helpful but should not replace the necessity to compare ancient specimens with modern ones (Fritz & Nesbitt 2014: 130). Reference collections vary in the array and provenance of their taxa so that the use of a particular collection may be more appropriate than another (Hillman *et al.* 1993: 98-99). The collections and manuals used should be noted, along with the state of preservation of the archaeobotanical remains. Defined parameters by which to describe the state of burnt plant remains create a useful scale by which descriptions can be standardised between samples and sites. Such scales are used for cereal grains and are often created by the analyst as a common scale has yet to be universally accepted and used (e.g. Hubbard & al Azm 1990). Archaeobotanists at the 1992 London workshop on the identification of wheat concluded that: chaff is more identifiable than grain; identifications of charred caryopses are not absolute as their morphology changes over time and space (not to mention the effects of preservation conditions), and that the identification to ploidy level can be reached but the use of terms such as einkorn, emmer and spelt are not directly equivalent to modern taxa (Hillman *et al*. 1996: 206-7). They concluded that “adequate explanation of how specimens have been identified, and suitable illustrations should be a routine part of publication.” (Hillman *et al.* 1996: 206). Nevertheless, and thanks to detailed descriptions and illustrations, it is possible to confidently identify cereals and to separate the glume wheats, including emmer and the 'new' type (Bogaard *et al*. 2013a; Charles & Bogaard 2010; Fritz & Nesbitt 2014: 135-36; Jones 1998; Jones *et al*. 2000a; Kohler-Schneider 2003).

5.3.2 Quantification

“The purpose of quantification is accurate description, and the purpose of description is comparison” (Hubbard & Clapham 1992: 117). Hubbard and Clapham (1992) have argued that quantifying remains from Class C samples is simply a waste of time. Scales of abundance however, are problematic and prone to subjectivity. Class C samples tend to represent routine, daily activities which can be understood through relative proportions in adequate samples (Fuller & Weber 2005: 104-5; Fuller & Stevens 2009: 40; Fuller *et al.* 2014A: 206; Stevens 2003: 71-2). Other reasons to quantify remains in Class C samples would be to explore taphonomical histories within and between sites. It is only through quantification that archaeobotanical data lends itself to statistical analyses, enabling robust, measurable and repeatable descriptions and comparisons (Jones, G. 1991; Lange 1990; Marston 2014).

5.3.3 Interpretation

Interpretation can begin once the taphonomical history, context and composition of a sample (both in terms of quantity and quality) have been described and understood. One must remember that although it is the ancient use of plants that archaeobotanists may try to decipher, it is mostly that which was discarded that is discovered, making it necessary to work 'backwards', from the waste to the wanted. As is described above, ethnographic and experimental models provide useful comparative schemes by which the proportion of plant parts and their physical characteristics may be interpreted (grain vs chaff, light vs dense, large vs small, smooth vs rough, etc.) (Hillman 1981, 1984a; Jones 1984, 1987a; Stevens 2003: 63; Wilkinson & Stevens 2008: 74-5).

5.3.3.1 Cereal grains

As grains are the desired product of cereal farming, samples rich in grain are problematic and have been interpreted in various ways (e.g. van der Veen & Jones 2006: Table 1). Large quantities of carbonised grains have been used to indicate both producer and consumer sites (Hillman 1981; Jones 1985a). Hillman (1981) argued that clean grain would be more frequent on consumer sites, especially in comparison to waste from the early stages of crop processing performed on producer sites. Conversely, Jones (1985a) suggested that clean grain would be more frequently burnt at producer sites where it was more common. Such approaches, however, have been critiqued for being over simplistic, masking more complex roles and relationships between sites (Fuller *et al*. 2014a: 182-86; Stevens 2003; van der Veen 1992: 91-99; van der Veen & Jones 2006). Furthermore, research now indicates that concentrations of burnt grain are more likely to reflect the frequency and scale of handling grain be it on producer or consumer sites (Fuller *et al*. 2014a; Stevens 2003; van der Veen 1992: 91-99; van der Veen & Jones 2006).

5.3.3.2 Edible wild plants

The consumption of wild plants can be difficult to prove and the full array of wild foods utilized in prehistory surely remains unknown (*cf*. Jacomet 2009: 53; Tolar *et al*. 2011: 212). Ethnographic and literary studies describe a broad spectrum of plants that remain important nutritional supplements to a crop based diet (e.g. Bharucha & Pretty 2010; Redžić 2006; Selleger 2014; Tardío & Pardo-de-Santayana 2006). Few of the gathered edible plant parts will be retrieved from carbonised assemblages. Whilst heat may have been required to process some wild plants, it is reasonable to suggest that many leaves, seeds, bulbs, young stems, *etc.* were eaten raw or boiled. Even if burnt, only seeds and parenchymous tissue are likely to have survived. The latter is a useful source of evidence for the consumption of roots and tubers (Hather 2000). Most vegetative parts would have been collected young before the production of seeds, so that the latter cannot always be direct evidence that a plant was eaten. Nutshells and fruit stones are the clearest evidence for gathered edible plants, partly because they are still considered food today and partly because they generally retain their shapes during carbonisation. Evidence for the gathering of plants in the Early Neolithic is often used to infer connections with hunter-gatherers, either through ancestry or local interactions, though such arguments are clearly invalid (Colledge & Conolly 2014: 202). It is for instance, estimated that gathered wild plants represented 40% to 50% of the diet at the Neolithic Alpine lake shore settlements (Arbogast *et al*. 2006: 410; Jacomet 2006b: 81; 2009: 54).

5.3.3.3 Arable weed seeds

'Weed' seeds growing amongst crops are of great interpretative value, revealing information on the habitat conditions and husbandry regimes under which crops were grown (Bogaard 2004b; Fuller *et al*. 2014a: 182 and references therein; Jones 1988a, 1988b; Palmer 1998b; Stevens 1996; and see below). Weed management, irrigation, fertilization, sowing times, fallowing and crop-rotation are just some of the crop husbandry practices that can be elucidated through the study of 'weed' seeds. Such studies are based on four main approaches: 1- Ellenberg numbers; 2- modern phytosociological groupings of wild taxa; 3- modern ecological traits of individual taxa; 4- functional attributes of modern taxa and their ecological significances: FIBS – Functional Interpretation of Botanical Surveys.

1. Ellenberg numbers, or 'indicator values', are a series of scales that subjectively measure a species' tolerance to major environmental variables (Ellenberg 1988). These values are used to create groups of taxa, or units, which can then be associated with particular growing conditions and agricultural regimes. Ellenberg numbers were created from field observations for a large number of central European plant species (Ellenberg 1988: 675). However, equating these groups to specific agricultural practices can be ambiguous as 'indicator values' do not explain what attribute(s) enable(s) a particular plant to be present in a particular habitat (Charles *et al*. 1997: 1151-2). An additional concern is the applicability of these values to ancient arable weeds growing in different climatic and geographical milieus (Behre & Jacomet 1991: 83-4; Hillman 1991; Jones 1992: 103-4; Küster 1991). 'Ellenberg indices' must be used with caution, bearing in mind that plant phytosociological groupings are sensitive to anthropogenic changes and that many plants have a broad ecological amplitude; “the farther one reaches back in time, the higher will be the hierarchical level in plant sociology that can serve for comparison.” (Behre & Jacomet 1991: 83).

2. The science of phytosociology began in the late 19th century with the Swiss botanist and ecologist Josias Braun-Blanquet (van der Maarel 1975: 213; Westhoff & van der Maarel 1978: 290-92). Phytosociology describes plant communities, or syntaxa, by the presence and dominance of species; each syntaxon is thereby defined by particular character species (Braun-Blanquet 1932; van der Maarel 1975: 214-15; Westhoff & van der Maarel 197: 293-99). These are constructed from field

observations and although they can be a valuable tool for reconstructing past ecologies, their use in archaeobotany relies upon finding a reliable group of associated taxa (*cf.* Braun-Blanquet 1932: 336-340). Prehistoric agricultural regimes were certainly different to those of today and, as noted above in connection with Ellenberg numbers, the assumption that phytosociological groups have remained unchanged is questionable. Two commonly encountered phytosociological classes in archaeobotany are the Secalietea and the Chenopodiatea (Braun-Blanquet 1932: Table 42). They represent the weed communities of winter cereal and summer root/row crops, respectively (Oberdorfer 1979, cited in Ellenberg 1988: 627). Weeds of the Chenopodiatea class are nutrient-demanding species, need higher temperatures to germinate and tend to have short life cycles (*c*.6 months) (Ellenberg 1988: 628). Conversely, those of the Secalietea have longer life cycles and are not as demanding for light, warmth and temperature (Ellenberg 1988: 628). They are therefore at a competitive advantage in winter crops. The classification of weeds into these two classes is based on observations in fields of winter rye and summer oats and beets grown in central Europe during the first half of the 20th century (van der Veen 1992: 106). Such crops were not grown during the Neolithic in the western Balkans (Chapter 8), and rye is not a good example of a winter cereal; “It develops more quickly than the other cereals, casts more shade than the others earlier on in the growing season, [and was] not normally harrowed and hoed in spring.” (van der Veen 1992: 107). Winter rye and summer oat represent extreme arable conditions, whilst intermediate conditions existed with winter and summer wheat (Ellenberg 1950, cited in van der Veen 1992: 107). In fact, as husbandry practices (particularly intensive ones) change natural conditions, habitats of the two classes can become increasingly similar, to the extent that some authors place all arable weed communities into a single class: *Stellarietea mediae* (Richard & Tüxen 1973, cited in Ellenberg 1998: 629). Nevertheless, a study on the weed flora of pulse crops in Evvia (Greece) demonstrated that plants of the Chenopodiatea and Secalietea classes are associated with particular husbandry regimes (Jones *et al.* 1999). Weeds of the root/row-crops were found within the small, intensively managed plots, whilst the 'winter' weeds were restricted to larger plots where pulses were grown less intensively.

3. Biological and ecological traits of taxa can be used to explore certain aspects of husbandry regimes. Kreuz and colleagues (2005, 2011) used modern data on the life forms, life span and reproductive methods of modern taxa in Germany (available from the BIOFLOR database) to assess the LBK weed assemblages. By grouping and comparing the weeds by ecological characteristics, Kreuz and colleagues were able to argue for certain agricultural practices, mostly in opposition to those suggested by other authors using other analytical approaches, as, for example, sowing times

and intensity of disturbance of LBK cereals: autumn-sowing with high disturbance through weeding (Bogaard 2004b: 164-65) versus spring-sowing with low disturbance (Kreuz *et al*. 2005: 251; Kreuz & Schäfer 2011: 341-42, 346). The latter conclusion is drawn from the relative proportion of competitors (said to be indicators of stable, undisturbed habitats) and ruderals, rather than on a FIBS approach and comparisons to weed floras of known cultivation regimes from Germany (Bogaard *et al*. 2005: 508).

4. The application of FIBS in archaeobotany is based on a plant's measurable physical characteristics developed in response to specific ecological factors (such as leaf thickness, stomatal density and canopy height) (Bogaard 2002a; Bogaard *et al*. 1998, 2016a,b; Charles *et al*. 1997; Charles *et al*. 2002; Jones 2002; Jones *et al*. 2000b, 2005, 2010). It should therefore be possible to understand the past land management practices of agricultural systems (representing the ecological conditions under which arable weeds grew), from the functional attributes recorded in modern species. “FIBS provides a means of relating the behaviour of individual plant species to specific ecological variables, thus overcoming the limitations of previous approaches based on field observations” (Bogaard 2004b: 7). Functional attributes have been recorded from modern weed floras across NW Europe, the Mediterranean and the Near East (Bogaard *et al*. 1999, 2001; Charles *et al*. 1997; Charles *et al*. 2002; Charles & Hoppé 2003; Charles *et al*. 2003; Jones *et al*. 1995, 1999, 2000b; Palmer 1998). Apart from flowering data which is best sourced from local floras, the use of combined attribute measurements seems to be applicable across broad geographical areas, at least within those mentioned above (Jones *et al*. 2005: 503). Problems arise when a single functional attribute is seen to be an adaptive trait to more than one habitat; when a single habitat can evoke different adaptive strategies, and when a single ecological factor can affect attributes usually associated with other conditions (Jones *et al*. 2005: 503-4). These difficulties can be minimised by using independent means to establish certain parameters, such as sowing time, and by the careful selection of a group of attributes (Jones *et al*. 2005: 503-4).

the first three approaches rely on the principle of uniformitarianism, but to various degrees. Approaches one and two assume that a community of plants growing in particular conditions in the present, would have grown under the same conditions in the past. As is alluded to above, both plant communities and arable conditions, may not be directly comparable between the past and the present. The third approach assumes that the phenotypic and genetic traits of wild plants have not changed since the early Holocene. FIBS mitigates these problems by relying on a suite of species, which as an ensemble provide the most robust interpretation of past husbandry regimes (Charles *et* *al*. 1997). All approachers are subject to the careful selection of archaeobotanical data after due consideration of taphonomical pathways (Hillman 1991: 36-7). As mentioned above, phenomena affecting the formation of seed assemblages make it difficult to evaluate the integrity of a sample. Not only will seeds have been lost but those of various provenances may end up buried together, including modern burnt seeds. In March 2015 I noticed farmers burning the stubble from their fields in eastern Croatia and northern BiH, potentially transforming remaining seeds lying on the surface. If, through ploughing, bioturbation, *etc*, the latter were to contaminate the archaeological record (such as the buried soils under the plough horizon excavated in northern BiH: Chapter 7.4), they would be very difficult to separate. Particular wild plants may have grown both within and outside crops (true and pseudo-facultative weeds). It is also worth remembering that not all archaeobotanical wild plant seeds came from arable weeds; some could originate from dung or represent wild foods and plants collected for other uses. Others, such as perennials and rhizomatous plants like sedges may not be obvious weeds, but can in fact be indicative of the level of cultivation longevity and intensity (see section 5.4.6). An additional problem lies in differentiating seeds that were brought with the crops from other regions (anthropochores) to those from native plants (apophytes), as clearly these would form an unnatural grouping. The 'weediness' of a species may be even more inconclusive on early agrarian sites where land was first cleared for farming. In their study on archaeophyte and neophyte species in former Yugoslavia, Šilc and colleagues (2012) found that the former were closely associated with habitats of high stress (low availability of resources) and disturbance. “Archaeophytes originate from the Mediterranean basin or the Near East and have expanded their range with agriculture […] The importance of stress tolerant species […is] probably linked to their warm and dry habitats of their home environmental conditions,” (Šilc *et al.* 2012: 727). Therefore, as well as being introduced as arable weeds, wild plants may have 'travelled' in dung or colonised new phytogeographical areas recently altered by advancing farming lifestyles.

In this thesis, farming practices and the conditions of arable fields are explored through carbonised grains and the autoecology of individual weed species. No attempt is made to identify phytosociological units, not only for the reasons mentioned above, but also because the analysis of weed seeds includes species from various sites. The following section defines and describes the plant characteristics, such as height and seed size, and the ecological requirements, such as soil type and habitat, obtained for the weed species.

5.4 Ecological and biological traits of arable weeds

Wild plants are adapted to a particular range of ecological conditions, such as temperature, soil moisture and pH, light intensity and disturbance. The requirements vary between plants and between the different phenological stages of a plant's development (Grime *et al*. 1988). Arable weeds have adapted to anthropogenic conditions created for the benefit of a crop. Indeed successful arable weeds will have adapted their life cycles to coincide with those of its host crop so as to benefit from the right ecological conditions during specific phenological stages (*cf*. Royo-Esnal *et al*. 2012: 459). Germination, flowering time and even plant size can differ between a species growing in the wild or as an arable weed (*cf*. Royo-Esnal *et al*. 2012: 459). These adaptations have enabled species to grow in areas in which they were not native, but may subsequently become naturalised. This level of plasticity should be taken into account by considering the full potential of a species (rather than individual plants). Additionally, using a suite of species reduces the effects that biological evolution may have had on any one species, and results in a more robust description of past husbandry practices (e.g. Bogaard *et al*. 1998; Charles *et al*. 1997; Jones *et al*. 2000).

5.4.1 Soil texture, pH and moisture

The ratios of sand, silt and clay will determine the soil pore space, which in turn will affect the pH (also determined by the bed rock), drainage capacity and available nutrients of a soil (French 2003: 36-37; Grigg 1995: 42-44; Limbrey 1975: 48-58). Soils with a high sand content will have larger pores, enabling the circulation of water and air. Very light (sand-rich, >70% sand) soils tend to be deficient in nutrients as these are regularly leached away and/or lost through evapo-transpiration. Conversely, circulation is impeded in heavy clay-rich soils with micro-pores (French 2003: 14; Limbrey 1975: 50). Nutrients are mainly transported to plant roots through water, but very wet and waterlogged soils also tend to be poor in available nutrients as the lack of oxidising conditions inhibits the decomposition of organic matter.

Removal of the natural vegetation and persistent cultivation can degrade and/or change a soil's physical and chemical properties. As soils are laid bare and their texture altered through ploughing the propensity for leaching increases. Whilst this may temporarily improve drainage and air circulation nutrients and bases may be lost, lowering the soil's pH and fertility (French 2003: 24-25; Limbrey 1975: 94-95). Interventions, such as tilling, ploughing, irrigating and the addition of manures will create a new micro-environment attractive to a group of weeds that may not otherwise be found in the natural surroundings. As arable weeds are susceptible to soil texture, pH, moisture and fertility levels their presence can be used to describe the soil conditions under cultivation. For example, at the Iron Age Hillfort of Danebury (Hampshire, England), the ecological requirements of weed species indicated three different cultivation locations: well-drained alkaline soils around the fort, damp loams in the valley and more acidic gravel soils (Jones 1984: 488-89). Increased levels of soil moisture, possibly through artificial irrigation, can be investigated via the carbon isotope ($\delta^{13}C$) values in ancient grains and pulses (Bogaard *et al*. 2013b; Fiorentino *et al*. 2014; Fraser *et al*. 2013; Styring *et al*. 2016; 2017a). When water is not limited stomata in the leaves will open to allow the absorption of carbon dioxide for photosynthesis. High levels of carbon dioxide discriminate against the heavier ^{13}C isotope, “resulting in more negative plant $\delta^{13}C$ values” (Styring *et al*. 2016: 6). The technique needs to consider the changes in $\delta^{13}C$ values of atmospheric carbon dioxide over time, and the differential rates of carbon dioxide absorption between crop species (Lightfoot *et al*. 2016; Styring *et al*. 2016: 6; Wallace *et al*. 2013). Additionally, all sources of water, such as rainfall, seasonal flooding, increases in ground water levels and the soil water holding capacity must be considered for the interpretation of $\delta^{13}C$ values (Riehl 2008; Styring *et al*. 2016: 6; Wallace *et al*. 2013). Results from the isotopic analyses of grains and pulses from four Neolithic sites in Bulgaria and one from the Peloponnese suggest pulses received more water than wheat, indicating the use of well-watered soils or artificial irrigation (Bogaard *et al*. 2013b: 12590). Higher $\delta^{13}C$ values in pulses also reflect their greater sensitivity to available water; comparisons between the $\delta^{13}C$ values of wheat and lentils have found that those for lentils have a greater range and are more sensitive to levels of available water (Wallace *et al*. 2013: 394). The texture, pH and moisture levels preferred by the arable weed species considered in this thesis are used to describe the arable fields from which they came, and the possible farming practices responsible for such conditions.

5.4.2 Fertility (mineral and organic)

For its successful growth and development wheat, along with most other crops, requires about 15 different elements, the most important ones being (after Peterson 1965: 34-35): 1- carbon, 2-hydrogen, 3-oxygen, 4-nitrogen, 5-phosphorous, 6-potassium, 7-sulphur, 8-calcium, 9-magnesium. These will be absorbed from the soil's natural reserves and because the natural vegetation cover and ecosystem will have been removed, the addition of fertilizers will usually be required to sustained persistent cultivation. There is no hard and fast rule on the need and application of fertilizers as an agricultural soil's mineral and organic nutrient levels depend on many factors, such as the soil's properties, the crops grown, agricultural techniques and climate (e.g. Diacono & Montemurro 2010; Grigg 1995). For example, some floodplain soils will be naturally replenished with every flood, and some agricultural regimes, such as crop rotation, may maintain soil fertility without the need to apply fertilisers (Grigg 1995: 45-46; Palmer 1998b; Reynolds 1981: 107-9; 1999; Sigaut 1999: 276-

77). Crops of the Fabaceae family host *Rhizobuim* spp. bacteria in their roots which enable them to fix atmospheric nitrogen (e.g. Peix *et al*. 2015: 18-19). This symbiosis not only allows such crops to grow in poor soils but lets the soil's nitrogen levels replenish. Long term agricultural experiments on the effects of fertilisers vary in their results. Yields of old strains of *Triticum aestivum,* einkorn and emmer on the experimentally burnt and non-manured plots at Schwäbisch Hall-Wackershofen and Forchtenberg (SW Germany) varied between 2.2 and 4.1 tonnes per hectare in the first two years, but thereafter declined dramatically (Ehrmann *et al*. 2014: Fig.16). The authors concluded that, due to a depletion in nitrogen, fields could only be used for up to three years in a regime of permanent cultivation using fire, and that the soil then requires a regeneration period of around 10 to 15 years (Ehrmann *et al*. 2014: S16). During the two year experiment of growing 1393 accessions of einkorn in Italy, it was found that yields and plant height were not affected by the three different inputs of nitrogen (0, 80 and 120kg/ha) (Castagna *et al*. 1996: 183-85). At the experimental plots of the Rothamsted Research Institute (Hertfordshire, England) wheat yields between 1852 and 1900 were relatively stable at 1 tonne per hectare (Poulton 2006 cited in Baum *et al*. 2016: 618). Fertilizers were never added to the plots which were cultivated on a one year fallow system with added chalk to maintain a neutral pH. The difference in yields between manured and non-manured plots is nevertheless striking, as six to seven tonnes of wheat per hectare are harvested from plots annually fertilised with 35 tonnes per hectare of farmyard manure (http://rothamsted.ac.uk/long-term-experiments-national-capability/classical-experiments). Higher yields of wheat (emmer and spelt) on manured compared to non-manured plots were also noted during the 1987 to 1990 British experiment (van der Veen & Palmer 1997). Interestingly, no difference was noted in the yield of *Triticum compactum* (van der Veen & Palmer 1997: 168). Whether a particular Neolithic farm needed to manure in order to produce required yields is difficult to evaluate. Nevertheless, it is reasonable to suppose that within a mixed Neolithic farming system the benefits of adding manure were recognised, if only to ensure that yields were sufficient for the survival of farming families (Bogaard 2004b: 42-44; 2012: 28-31; Halstead 1989: 30; 2011: 134-5).

The application and benefits of animal manure will depend upon various factors, such as manure source, storage, the timing and method of application, and soil properties (*cf*. Halstead 2006: 46-48; 2014: 212-29). Farmyard manure will enrich the soil with nitrogen, potassium, phosphorous, calcium, manganese and other essential nutrients, though these will be mostly available to crops only a year after its application (*cf*. Halstead 2014: 219; Palmer 1998a: 149-50). Importantly, too much nitrogen can be detrimental: experiments have shown that wheat yields cease to increase when over 100kg/ha are applied and even decline with applications of over 125kg/ha (see also Halstead 2006: 46-47). Farmyard manure will quickly loose most of its soluble nitrogen and potassium content if it is not adequately stored (under dry conditions) and/or ploughed-in shortly after application. In the 1970s it was calculated that one cow would, on average, produce 40L of excreta (faeces and urine) per day, and that 5000L of undiluted slurry provides 20kg of nitrogen. It was also recommended that 50 to 150kg/ha of manure should be added to plots of wheat and barley. It follows that a minimum of 313 cows would be required to produce enough slurry per day to fertilise one hectare (Eddowes 1976: 28-39).

These measurements cannot easily be transposed to Neolithic times when cattle were smaller and the required crop yields were different, but they do show the scale and complexities involved in manure production, storage and application. Ethnographic studies of non-mechanised agricultural communities suggest that the cost of transporting manure was key; only fields closest to houses were regularly manured (Halstead 2006: 46-47; 2014: 216-18; Jones 2005: 170). Indeed Gunda notes that in 18th century Slovakia emmer was grown in areas difficult to access, “where dung cannot be carted out” (1983: 149). The intensity and quantity of manuring must therefore have varied within and between Neolithic settlements, namely depending upon field location, quantities and management of farm animals, crop species grown and natural levels of soil fertility (*cf*. Bogaard 2012: 32-37). It has been estimated that a Neolithic household with few cattle, sheep/goat and pigs “could, by strategic folding of animals on stubble and spreading of manure as well as household refuse, manage to replenish nutrients in intensively cultivated plots” (Bogaard 2004b: 46).

Ancient carbonised grains and pulses can provide direct evidence for soil enrichment through their crop nitrogen isotope values ($\delta^{15}N$), which, put simply, increase beyond their natural values in soils where nitrogen levels have been improved (Bogaard *et al*. 2007b; Bogaard *et al*. 2013b; Bol *et al*. 2005; Fiorentino *et al*. 2014; Fraser *et al*. 2011; Fraser *et al*. 2013). Care must be taken however, as high $\delta^{15}N$ values usually associated with artificial manuring can occur in crops grown on naturally fertile (no added manure) and/or seasonally waterlogged soils (Bogaard *et al*. 2016a: 66, 69). In order to interpret $\delta^{15}N$ values these must be compared to a herbivore baseline (reflecting non-manured forage); values for crops grown under known conditions; effects caused by charring, and conditions indicated by the arable weed assemblages (Bogaard *et al*. 2007; Fraser *et al*. 2007, 2013; Styring *et al*. 2013). It is also important to compare results to Analyses of grains and pulses from Neolithic sites in Bulgaria, Vaihingen in Germany and Kouphovouno in the Peloponnese have shown that manuring was practised at these sites (Bogaard *et al*. 2013b). Differences in the labour investments on particular plots are evident as not all crops were manured to the same extent (Bogaard *et al*. 2013b: Table 2), and one can begin to understand the complexities of the farming regimes in which the degree of interplay between animals, crops and land affected both the social and economic livelihoods of farming communities (Bogaard 2005, 2012: 25-8; Bogaard *et al*. 2013b: 12593; Jones 2005: 172-74). Evidence for manuring has also been suggested for the PPNB and later Neolithic at Abu Hureyra (northern Levant), though elevated levels of $\delta^{15}N$ may also reflect cultivation on floodplains (Styring *et al*. 2016: 15). Conversely, manuring does not appear to have been practised during the pre-pottery Neolithic B and C at Ain Ghazal (southern Levant), where the large quantities of carbonised pulses suggest land fertility was maintained through a system of cereal-pulse rotation (Styring *et al*. 2016: 16-17). Although it is beyond the remits of this thesis to analyse the isotopic nitrogen and carbon values of recovered grains, fertility levels required by arable weeds are recorded in order to investigate arable conditions and the possibility of manuring and/or middening. Spatial and temporal variations in these levels may be indicative of different farming practices and/or changing soil conditions.

5.4.3 Habitat

Archaeobotanical seeds are sometimes classified by habitat based upon modern floras (e.g. Antolín & Jacomet 2015: Tables 4&5; Kreuz & Schäfer 2011: Table 1; Rösch 1998: Fig.5). Although this can be useful for separating obvious outliers to the arable weed assemblage, such as true aquatics, the assignation of a modern habitat type is problematic. One problem with such classifications is that habitat types may have had quite different vegetation formations in the past, particularly at the onset of agriculture. Additional problems are that habitat types do not have precise ecological conditions (e.g. a grassland can be wet or dry, on alkaline or neutral substrates), and that species can be found in more than one type of habitat (Greig 1988: 39-42; Hillman 1984a: 27). Modern descriptions of pasture, meadows and grasslands depend on the intensity and frequency of grazing, mowing and other forms of management which are difficult to compare with Neolithic practices (*cf*. Greig 1988; Jones 1988). Identifying the specific conditions within a habitat that enabled one or some species to grow is not easy, particularly as only a selection of the weed assemblage is likely to have been recovered (Jones 1992). It is evident that Neolithic arable fields contained species that would now only be classified as ruderal, grassland or other (van der Veen 1992: 104, see also Lange 1990: 94-97). A more reliable technique for describing past arable conditions and the human actions that created them is to correlate the physical characteristics of species with specific ecological conditions (Bogaard *et al*. 1999; Charles *et al*. 1997; Jones *et al*. 1999; 2005; 2010). As is described in section 5.3.3.3 point 4, the use of functional attributes (FIBS) enables ecological characteristics to be associated with particular agricultural practices.

One habitat type which may not be easily equated with arable is wetlands. However, species associated with wetlands, such as sedges and reeds, are not true aquatics and may have been weeds on cultivated floodplains (Hillman 1991: 31-2). One in particular (*Eleocharis palustris*) is often found associated with ancient cereal grains and has been argued to represent cultivation upon relatively open, poor soils of low-lying areas close to rivers (Jones 1985b; 1988: 89-90; Stevens 1996: 18). The seeds are not edible and so were not a gathered food. As a perennial reproducing vegetatively through rhizomes it would have benefited from shallow ploughing. Other wetland species documented from modern arable fields include *Phragmites* and *Scirpus maritimus* in unirrigated fields in Turkey (Hillman 1991: 31), and *Montia fontana, Stachys palustris* and *Carex nigra* in oat crops in Shetland (Hinton 1991, sited in Hillman: 1991: 31).

A woodland habitat associated with shifting cultivation has a particular archaeobotanical signature (Bogaard 2002a,b; Rösch *et al*. 2002: Table 4). A regime in which plots are regularly cleared from virgin forests (Dennell 1978: 37) would produce assemblages rich in perennial species. Experimental shifting cultivation in the Hambach and Stuttgart forests (Germany) have shown that woodland and shade tolerant perennials predominate under such conditions (Bogaard 2002a; Rösch *et al*. 2002: 151). In fact, woodland perennials accounted for 57-100% of the weed species in the Hambach experimental plots (Bogaard 2002a: 163). Interestingly, woodland annuals were rare. Non-woodland perennials may also be present in newly cleared fields where light is increased and competition reduced; Ellenberg (1996: 768) notes that their seeds are often found in woodland soils (cited in Bogaard 2002a: 161). The presence of perennial seeds can be affected by the intensity of burning, weeding (disturbance: 5.4.5 below), and longevity of cultivation. Intensive burning will reduce all weed species, though woodland perennials were still found to predominate after the first cultivation season of experimental plots (Rösch *et al*. 2002: Table 4). Most perennials will not set seed in the first year and so may only enter the archaeobotanical record after consecutive years of cultivation (Bogaard 2002b: 130). However, experimental and ethnographic records suggest cleared plots fertilised by ash could have been cultivated for about three years, and one can expect shifting cultivation to be clearly represented in the archaeobotanical record (Bogaard 2002a: 163, 2002b: 129 and references therein; Ehrmann *et al*. 2014; Rösch *et al*. 2002).

5.4.4 Weed height

The height of fully grown weed species can be used to indicate the method of harvesting (e.g.

Bogaard 2011: 159-61; Hillman 1981: 148-49; 1984a: 26-7; Kreuz *et al*. 2005: 249; Marinova 2007: 104; Reed 2015: 614-15). Accordingly, a mix of low and tall weeds indicate that the crop was harvested close to the ground, whereas the absence of low weeds could indicate that only the ears were harvested (Hillman 1981: 151; Wilkinson & Stevens 2003: 193). Uprooting crops may select twining weeds over others (Hillman 1981: 148; 1984a: 26), although it may depend on whether plants were uprooted as individual plants or as a bunch, and at what height plants were grabbed. Culms and root nodes would be a better indication of uprooting, although the latter may be removed before further processing (Hillman 1981: 148-49). There are however several problems with correlating weed and harvesting heights. Weed heights depend on environmental factors and crop density (Hillman 1981: 148-52; 1984a: 26; Reynolds 1981: 113), which may have been very different during the Neolithic. Furthermore, these parameters may not have affected the crops in the same way. Indeed field surveys in France looking into the association of weed traits with those of crops and aspects of field management, have shown that “weed height was not related to crop height, … (P>0.05).” (Gunton *et al*. 2011: 545). It is usually assumed that only the tallest weeds grew as tall as the crops. Hillman (1984a: 26) notes that Turkish emmer varied between 60cm to 150cm tall, whilst Peña-Chocarro (1996: 132) writes that Spanish einkorn commonly varied between 80cm and 110cm, with some reaching 150-170cm. Crops of emmer and spelt grown at Butser Ancient Farm produced many tillers of varying heights, with differences of up to a metre between the shortest and tallest tillers of the same plant (Reynolds 1981: 113). Consequently, a mix of medium and tall weeds may not indicate a tall crop. Weed height and canopy diameter have been positively associated with more productive and less disturbed environments (Bogaard *et al*. 1998; Bogaard *et al*. 1999; Charles *et al*. 1997; Jones *et al*. 2000b). Where nutrients and water are not lacking plants will grow to their full potential and taller plants will have a competitive advantage over smaller ones (Grime *et al*. 1988: 34). Taller weeds have also been associated with spring sown cereals for which the growing season under favourable conditions is longer; the period of vegetative growth of winter annuals is curtailed in spring when the rise in day length and temperature trigger flowering (Evans 1969 cited in Charles *et al*. 1997: 1153; Grime *et al*. 1988: 38). The effects of day length and temperature suggest that height may not simply reflect levels of productivity but also the growing season (*cf*. Bogaard *et al.* 2001: 1176). An additional complication when interpreting variations in weed heights or weed height ratios is that possible irregularities in the natural conditions and anthropogenic management of fields (such as irregular manuring and/or watering, rocky outcrops, woodland edges) could support a range of short and tall weed types (Bogaard *et al*. 1998: 21).

5.4.5 Life cycle

The proportion of annual and perennial species in a weed assemblage can be indicative of the intensity and frequency of disturbance. Annual weeds are well adapted to growing with annual crops where life cycles are completed in under a year as long as they can set seed before the harvest, or even afterwards if they do not seed above the harvest line. The length of the flowering season and their type of seed bank are indicative of their tolerance to disturbance (sections 5.4.7 and 5.4.9) Many perennials however, regenerate seasonally from fragments of roots and/or stems (Grime *et al*. 1988), and those with a shallow root stock actually benefit from tillage and weeding. Experiments have demonstrated that these hemicryptophytes were positively associated with more disturbed cultivation plots (Bogaard 2002a: 161). Conversely, woodland perennials were shown to correlate with a low-level of disturbance. As a result, whereas a predominance of perennials with shallow root stocks suggests regular disturbance, perennials with deep tap roots are indicative of minimal disturbance. A predominance of 'annual' perennials (i.e. those that can also regenerate seasonally by seed - van der Veen 1992: 137) could also be representative of an intensive agricultural system.

5.4.6 Germination

Germination is triggered by various factors such as temperature, light, depth of burial, soil moisture and soil pore-space (Hanf 1983: 12). Plants will respond to these conditions differently; whilst increasing temperatures and moist soils will break the dormancy and encourage germination in some species, others will respond to cooling temperatures in the autumn after lying dormant during the summer months (Grime *et al*. 1988: 39-42; Hanf 1983: 12-13). Consequently some plants germinate in the autumn, some in the spring and early summer after a period of dormancy, and some are not restricted to one particular season. Human interventions, such as ploughing and watering, can induce germination by bringing buried seeds to the soil surface and creating good growing conditions. Spring germinating weeds will be more abundant in spring-sown crops, just as autumn germinating weeds will grow better in autumn-sown crops (*cf*. Liebman & Dyck 1993: 101). As well as being adapted to particular spring or autumn conditions, autumn germinating weeds will be removed before spring crops are planted, whereas spring germinating weeds will struggle to compete under the established canopy of autumn germinating crops (Liebman & Dyck 1993: 101; Bogaard *et al*. 2001: 1173).

5.4.7 Flowering time and duration

The onset of the flowering period is an indication of the time of germination and, therefore, the season of crop sowing (Charles *et al*. 1997: 1153; Bogaard *et al*. 2001: 1174-5; Grime *et al*. 1988:

34-38; Sans & Masalles 1995). Species that can flower early and have a brief flowering period are likely to have developed before the destructive spring plough, and so should be more common in autumn-sown crops (Bogaard *et al*. 2001: 1175; Sans & Masalles 1995: 236). Similarly, late flowering plants are more likely in spring-sown crops as the spring plough would have removed growing seedlings of autumn germinating weeds. These weeds would, in any case, be at a disadvantage in autumn-sown crops as they require the summer warmth to regenerate (Bogaard *et al*. 2001: 1175). Late flowering plants may be better represented in crops harvested late in the year (Bogaard *et al*. 2001: 1179). Species with a long flowering period and an early to intermediate onset could be found in both autumn and spring-sown crops, though they are at a greater competitive advantage in the latter. They tend to have a prolonged germination season, allowing the species to 'survive' disturbance events such as spring ploughing (Bogaard *et al*. 2001: 1175, 1179). The long period over which seeds will be dispersed is also advantageous for annuals in arable fields when harvest times can be unpredictable.

Flowering duration is also indicative of a species' ability to withstand events of disturbance (Bogaard *et al*. 1999: 1215, 1220; Bogaard *et al*. 2001: 1175, 1179; Jones *et al*. 2000b: 1076, 2005; Sans & Masalles 1995). The longer the time frame in which an annual can germinate and grow, and the quicker it can reach maturity to fructify, the higher the chances it will have to reproduce within the annual crop cycle without being removed through tilling, ploughing and weeding. In a study on the functional ecological attributes of weeds associated with disturbance, it was found that plants with long flowering periods that regenerate from seeds (both annuals and perennials) were associated with agricultural regimes that included a fallow year, where disturbance can be unpredictable and intensive (Bogaard *et al*. 1999: 1220). Late flowering, associated with spring-germinating species, can also indicative of intensive disturbance, as can perennials with horizontal stolons, rhizomes and roots that rapidly regenerate from root or stem fragments (Bogaard *et al*. 1999: 1215, 1220: Jones *et al*. 2000B: 1077 & 1081, 2005; see also Liebman & Dyck 1993: 97) (section 5.4.5). These perennials are likely to be found in damp environments (naturally or through irrigation) as vegetative reproduction from root or shoot fragments requires damp conditions (Charles *et al*. 1997: 1155).

5.4.8 Seed setting time

Harvesting time can be determined by the seed setting time of ripe weed seeds found associated with the crop. Nevertheless, as the growth and development of species is affected by climatic and more localised whether conditions, seed setting times taken from modern floras may not accurately portray those of Neolithic times. As most plants will set seed over several weeks, a season rather than a precise harvesting time is usually deduced.

5.4.9 Seed bank

Four types of seed banks are discernible (Grime *et al*. 1988: 15-16):

1. Transient seed bank. The seeds of species in this category do not survive until the next season but germinate shortly after being shed;
2. Semi-transient seed bank. The seeds of species in this category can overwinter and germinate in the spring;
3. Mostly transient. The seeds of species in this category will mostly germinate shortly after being shed though some will persist in the seed bank;
4. Persistent seed bank. The seeds of species in this category will survive for at least one year in the seed bank before germinating.

Weeds with transient seed banks will be quickly eliminated unless they are re-sown with the crop. Depending upon the method of sowing these species may be selectively removed; careful row planting, as opposed to broadcast sowing, will not only reduce the number of weeds being sown but make weeding and hoeing around the crops easier. As species of transient seed banks need to set seed every year they may be eliminated through a more intensive agricultural regime. Species of seed bank type two should be able to germinate in both autumn and spring but will be at a competitive advantage if sown with the crop (section 5.4.7). Species with more persistent seed banks will persist if they can avoid tillage, hoeing and weeding and set seed before the harvest. These may be more effectively removed during periods of fallow through weeding or grazing (Liebman & Dyck 1993: 97). Ploughing, especially deep ploughing, will both bury seeds, thereby creating a richer persistent seed bank, and bring seeds to the surface where they will germinate. High persistence is essential to survive in frequently disturbed habitats (Albrecht & Auerswald 2009: 520-522). Species of seed bank type four have high light and fertility requirements, so that most, except for species of the Fabaceae, will germinate in the spring on nitrogen-rich soils (Stevens 1996: 182-83). These plants tend to have small seeds, whereas those from species of seed bank type three tend to be big and to germinate in the autumn (Stevens 1996: 182; see below).

5.4.10 Seed size

Weeds that produce fewer but bigger seeds tend to have transient seed banks and to germinate in the autumn and grow in less favourable conditions (Stevens 1996: 235-36). The opposite is true of most small weed seeds. As cereal processing introduces biases in the weed composition, particularly regarding seed size (Dennell 1972, 1974; Jones 1992) (Tables 5.1 and 5.2), taphonomical biases must be considered when defining husbandry practices (Bogaard 2004b: 64; Bogaard *et al*. 2005). Small seeds are usually associated with spring-sowing and late- and/or long-flowering taxa, whereas early- and short-flowering taxa usually germinate in the autumn and have big seeds. Nevertheless, a study has shown that these associations are not always reliable and that seed size should not be used as a formal indication of flowering onset and duration (Bogaard *et al*. 2005). Small weed seeds (removed by fine-sieving) commonly of the phytosociological class Chenopodiatea, and grain-sized weed seeds (removed during hand-sorting) commonly of the Secalietea class could lead to the interpretation of different husbandry practices (Jones 1992).

5.5 Summary

Two sets of archaeobotanical data are used in this thesis: remains from flots sorted by the author (Chapter 7) and reports of plant remains from sites within the research area (Chapter 8). The different types of data could not be analysed in the same way. In Chapter 7 crop processing activities are investigated through the types and proportions of cereal grains and chaff, as well as through the physical characteristics of wild plant seeds (section 5.1.3.2). The focus of Chapter 8 is not the site but the broader ecological and cultural groups by period (Early and Middle/Late), and the changes in cultivation practices as well as the economic importance of plant foods are explored. The biology and ecology of possible arable weed seeds are included in both chapters in order to investigate cultivation regimes and harvesting methods (section 5.4). The taphonomical histories of plant remains, their preservation, methods of recovery and detail of reporting (sections 5.1-5.3) are all considered during the interpretations offered in this thesis. The better one comprehends the archaeological context and the sampling strategy the more likely one is to grasp how the plant remains came to be burnt, buried and recovered. Such knowledge will lead to increasingly precise analyses of the data, enabling ever more uncompromising and accurate interpretations of past agricultural and economic systems.

CHAPTER 6

Methodology: Chronology, Post-Excavation Treatment of Samples and the Analysis of Data

This chapter is made up of five sections. The first describes the chronological framework adopted in this thesis. Section 6.2 explains how the samples obtained from excavations were treated and how the plant macro-remains were sorted, identified, quantified and analysed (the techniques involved in acquiring the samples are described by site in Chapter 7). Section 6.3 describes how additional archaeobotanical data was retrieved from literary sources and how it was organised and analysed. Section 6.4 is relevant to both datasets and explains how the biological and ecological characteristics of wild/weed seeds are used to define past husbandry regimes. Finally, the fifth section describes how information on Neolithic climatic conditions is used as an additional tool with which to understand ancient cultivation practices.

6.1 Chronological framework

Although there is arguably much local diversity in ceramic traditions and settlement patterns (see Chapter 3.3), the recent radiocarbon evidence shows that sites with particular cultural affinities tend to fall into three large temporal divisions. The chronological system used here is therefore: Early Neolithic (6100 – 5400 cal. BC); Middle Neolithic (5400 – 5000 cal. BC) and Late Neolithic (5000-4500 cal. BC). It is worth noting that six of the sites included from northern Italy date to between 4500-3500 cal. BC (Table 9.3). These have been retained within the defined Middle/Late Neolithic as they belong to the same cultural group as other sites that fall more precisely within the 5400-4500 cal. BC bracket, and are ascribed to the Late Italian Neolithic (4500-3500 cal. BC; Rottoli & Castiglioni 2009). Where radiocarbon dates are not available I have relied upon the cultural attribution (Tables 8.1 and 8.3). Sub-phases within a period were merged. The only possible inaccuracy is with Obre I whose final phase belongs to the Middle-Late Neolithic (between *c.*5480-4780 cal. BC: Vander Linden *et al*. 2014a: 11). Renfrew does not specify the layers from which the archaeobotanical samples were obtained but does cluster her results with other Starčevo sites (1979: 253). The following chapters explore the role of crops and herbaceous wild plants in defining farming communities, and whether such patterns can be mapped onto the zooarchaeological data to provide a holistic view of Neolithic agriculture in the western Balkans.

6.2 Samples sorted by the author

6.2.1 Sorting of the light and heavy fractions

Flots (light fractions) from all ten sites listed below were sorted by the author (Table 6.1), using a binocular microscope (x4 to x40 magnification). Each flot was partitioned through a stack of sieves (4mm-250µm) in order to facilitate sorting. Larger flots, i.e. those form Bapska and Korića Han, were not sorted in their entirety as to do so would have been too time consuming. Flots were therefore split into smaller fractions (e.g. sixteenths, eighths and quarters) using a riffle box. Sorting began with the smallest fraction, followed by additional fractions (of the same denominator) until no further taxa were present. Recovered remains were 'multiplied up' to represent the estimated total within the flot (e.g. if only one quarter was sorted, remains therein were multiplied by four to obtain an estimate per flot). During excavations I dry-sieved and sorted (by the naked eye) all heavy fractions/residues from Hermanov Vinograd and the EUROFARM sites down to 2mm, and all recovered plant remains were added to the corresponding flots. The smaller than 2mm fractions of the heavy residues were only retained if they appeared to contain bones and/or plant macro-remains. Those in storage have not been analysed. Heavy fractions from Potporanj and At were fully sorted by the naked eye and all recovered plant-macro remains were posted with the flots (I was not involved in the excavations, sampling and flotation; Chapter 7.2 and 7.3). All the heavy fractions from Tăşnad-Sere were weighed, measured and sorted by Ms. A. Leon at the Institute of Archaeology, University College London (hereafter IoA). Some of the larger heavy fractions were sub-sampled to 10ml. All recovered plant macro-remains can be found in Appendix I, where they are listed alphabetically within relevant sections (cereal, pulses, fruits/nuts and wild/weed seeds).

Country	Site	Neolithic Phase	N° samples (381)	Total soil volume (4031.5L)
Romania (NW)	Tăşnad-Sere	Early	57 (108*)	570 (1075*)
Serbia (NE)	At	Early	10	100
Serbia (NE)	Potporanj	Mid/Late	11	110
Croatia (E)	Gradac, Bapska	Mid/Late	House 2: 7 House 3: 1	495 ?
Croatia (NE)	Hermanov Vinograd I & II	Mid/Late	I: 96 II: 33	602.5 210
BiH (N)	Laminski Jaružani	Mid/Late	4	144
BiH (N)	L. Jaružani Njiva	Mid/Late	2	56
BiH (N)	Kočićevo	Mid/Late	15 (6*)	115
BiH (N)	Kosjerovo	Mid/Late	30	554
BiH (W)	Korića Han	Mid/Late	1	?

Table 6.1: Flots sorted by the author (* additional flots sorted by others).

6.2.2 Identification

Plant macro-remains were identified by the author using identification manuals (Anderberg 1994; Berggren 1981; Jacomet 2006a) and comparative material from the collections of modern seeds, fruits and nuts at the IoA and the George Pitt Rivers Laboratory, McDonald Institute, University of Cambridge, which houses, amongst other specimens, Dame J. Renfrew's collection sourced from former Yugoslavia and Greece. Nomenclature follows the cereal and pulse classification in Zohary *et al.* (2012: 29, 75-96). Barley however, is named based on the structure of its ear (2- or 6-row) (Zohary *et al*. 2012: 57). As the latter is seldom specified for archaeological specimens, my own classification for barley was used. All other flora follows the nomenclature of The Plant List (theplantlist.org), which provides accepted Latin names and any synonyms. The 'accepted' name was adopted. Identification criteria are described in Table 1.17, Appendix II. The full taxonomic binomial is given after the first mention of a taxon. 'Seed' is used throughout this thesis to denote all archaeobotanical seeds, kernels and nutlets of possible arable weeds and ruderals. 'cf.' (compares favourably) is used to denote a taxon that a specimen most closely resembles when the exact identification is uncertain. Carbonised wood was not identified but was quantified by volume and size in order for comparisons to be made between samples[2]. All ≥2mm pieces were extracted and placed in a measuring cylinder. The remaining <2mm fragments were added after other archaeobotanical material and most mineral inclusions had been removed. Volumes of charcoal were estimated to the nearest half millimetre. Size categories of charcoal (≥4mm, 2-4mm and <2mm) were quantified using a qualitative scale.

6.2.3 Quantification

6.2.3.1 Counting taxa

The total number of charred and mineralised plant macro-remains were counted (see above for charcoal). Apical and embryo fragments of cereal and wild grass seeds were counted, and the larger of the two was added to the number of whole grains/seeds. Many of the caryopses in the Bapska House 3 sample are split in half longitudinally. These were divided into left and right and paired. Any remaining halves were counted as a whole. Smaller fragments were counted and weighed to calculate whole grain equivalents (hereafter WGE), based on the average weight of a charred caryopsis. Twenty of the best preserved grains were measured from Bapska House 3 (all emmer, average weight 0.01825g), twenty from Korića Han (all einkorn, average weight 0.00985g), and twenty from Hermanov Vinograd (an equal mix of emmer and einkorn, average weight 0.0133g). Whole grain equivalents for Potoranj and At where fragments seem to be a mixture of emmer and

---

[2] These measures will also be a useful guide in the choice of samples for any future anthracological analyses

einkorn, were calculated using the average from Hermanov Vinograd. Those from Kočićevo where emmer predominates were calculated using the average from Bapska. The minimum number of pulses was attained by counting two cotyledons, and occasionally four cotyledon fragments, as one whole. Fragments of fruit-stones and nut shells occurred in small enough quantities to judge whole equivalents by eye, by considering the shape and size of fragments. Some samples contained large quantities of goosefoot seeds (*Chenopodium* sp.) that were found as whole, embryos and split seed coats. Two of the latter were counted as one seed and compared to the loose embryos; the larger of the two sums was added to the number of whole seeds.

6.2.3.2 Preservation index (hereafter P.I.)

All seeds and identifiable fragments, except for hazel nut shells, were assigned a numerical value according to the destruction and distortion of certain morphological features. The 0 – 3 scale used by Colledge (2001: 66) is applied here: 0 = very bad (unidentifiable), 1 = poor (identifiable to type, family or genus), 2 = fair (identifiable to species or one of two species), 3 = good (minimal damage, identifiable to species). As cereal grains may have been processed differently to other seeds (roasting, grinding, malting, *etc*.), preservation indices were calculated separately for cereal grains and seeds. The mean and mode of indices are presented for samples and sites. In comparison to most other taxa, large legumes and oil-rich seeds (e.g. flax) preserve 'poorly' when exposed to the same temperatures (Märkle & Rösch 2008; Wilson 1984). Consequently, non-cereal preservation indices were calculated with and without them and the higher value chosen as a truer representation of an assemblage's state of preservation. The P.I. allows for a more objective assessment of the overall state of preservation, enabling comparisons to be made within and between sites.

6.2.3.3 Fragmentation index (hereafter F.I.)

The fragmentation index is a measure of certain pre- and post-depositional conditions, and is used here to enable objective comparisons between cereal assemblages from different contexts and sites. Indices were therefore not calculated for other seeds. The index is the ratio of the number of fragments to that of whole caryopses. It was calculated for each sample and a mean value obtained per site. Following Colledge (2001: 66), a score of 0 signifies an absence of fragments; 0 ≥ 1 indicates low fragmentation; 1 ≥ 5 indicates moderately high fragmentation, and >5 indicates high levels of fragmentation. The F.I. enables objective comparisons of the level of cereal grain fragmentation between contexts. Together, the cereal P.I. and F.I. allow for a better understanding of the taphonomical pathways endured by cereal grains.

6.2.4 Detecting crop-processing stages

Following the theoretical framework described in Chapter 5 (section 5.1.3, Tables 5.1, 5.2 and Figure 5.1), crop-processing stages were assigned to assemblages assessed in Chapter 7 depending upon the type and relative quantity of remains. As such, totals (of cereal grains, cereal chaff and possible weed seeds), glume base to grain ratios and grains to weed seed ratios were calculated. For emmer and two-grained einkorn wheat there is usually a ratio of one glume base to every grain, whilst one-grained einkorn has two glume bases (or one spikelet fork) to every grain. These ratios are to be expected if whole spikelets are burnt, however since grain preserves charring better than chaff, they tend to be over represented (Boardman & Jones 1990; Chapter 5.1.3.1. Similarly, weed seeds tend not to survive charring as well as cereal grains and may be under-represented in crop-processing waste (Märkle & Rösch 2008; Wilson 1984). The physical characteristics of weed seeds were also taken into account, as different seed types will be removed during different cereal processing stages (Jones 1984; 1987a; point 3 of Chapter 5.1.3.1).

6.2.5 A note on fat-hen (*Chenopodium album* L).

Fat-hen is an annual plant that germinates in the spring on fertile and disturbed soils (Grime *et al*. 1988: 188). It was, until the advent of modern weed control, one of the most common spring-sown cereal and vegetable crop weeds across the world (Grime *et al*. 1988: 188; Hanf 1983: 202). Fat-hen absorbs a considerable amount of nutrients from the soil and can produce more than 20,000 seeds per plant (Hanf 1983: 202). Its nitrophilous habit indicates that it would thrive in intensive garden cultivation where fertilizers are added, as indeed has been noted during field observations in Evvia (Greece) and Borja (Spain) (Bogaard 2004: 45). The plant is also a common ruderal, colonising other nutrient-rich areas in and around settlements. As well as representing discarded arable weeds, charred seeds may have become incorporated into archaeological deposits through the burning of dung as they are not affected by the digestion of ruminants (Wallace & Charles 2013). The leaves and seeds are edible to humans, and the latter have been retrieved from prehistoric European sites in large enough concentrations to suggest that they were gathered for consumption (e.g. Behre 2008; Bouby & Billaud 2005: 266; Bogaard 2004: 66; Jacomet 2006b: Table 3; Jeraj *et al*. 2009: 82, 86; Tolar *et al*. 2007: 211-12). Large concentrations of fat-hen seeds indicative of stored food have not been recovered from Neolithic sites in the western Balkans and eastern Italy, though the species is very common and its role as a gathered food and/or arable weed remains problematic (*cf*. Bogaard 2004: 67). Its possible role as a gathered food at one of the examined sites is considered in Chapter 7.7, but it is otherwise included within the assemblage of wild/weed seeds, especially as in Chapter 8 seed counts are not considered/known.

6.3 Archaeobotanical data retrieved from literary and online sources

In order to include additional archaeobotanical findings and contextualise the sites described above, all published and unpublished Neolithic (*c*.6100-4500 cal. BC) data on plant macro-remains (excluding charcoal) were recorded from the western Balkans, Adriatic Italy, Hungary and western and southern Romania. The EUROEVOL database was used as a starting point (Colledge 2016; Chapter 4.2), and original reports were sought wherever possible. Records include site type, location and chronology, sampling strategy, the context, number and treatment of samples, and preservation type. Archaeobotanical data from Early Neolithic (*c*.6100-5400 cal. BC) sites across Greece and Bulgaria were also recorded, without contextual information. In total, records of plant macro-remains were obtained from 254 sites/phases (Table 6.2). Full lists of plant macro-remains by site can be found in Appendix II. The taxon codes are those defined by Dr. S. Colledge during the project *The Origin and Spread of Neolithic Plant Economies in the Near East and Europe* (UCL, 2001-2004) (Colledge *et al.* 2004). They are composed of seven letters: the first four represent the genus or family and the last three the species, 'spe' for an identification to genus only (e.g. *Galium* sp. is GALISPE) and 'ind' for an indeterminate taxon of a family (e.g. an indeterminate Rosaceae seed is recorded as ROSAIND). Variations occur when recording chaff and seeds identified to one of two or three species. The data are explored in two groups: the Early Neolithic and the Middle to Late Neolithic, both presented in Chapter 8. Information on the sites and their samples are given in Tables 8.1 to 8.4.

Sites by country and Neolithic phase	**E. Neo.** 6000-5400 cal. BC		**M/L. Neo.** 5400-4500 cal. BC	
	Impressions	Charred	Impressions	Charred
Greece	0	13	-	-
Bulgaria	0	18	-	-
Italy (Adriatic)	3	22	7	32
Croatia (Adriatic)	1	5	0	6
Croatia (Slavonia)	0	2	1	9
Bosnia and Herzegovina	1	2	3	12
Serbia	0	10	2	15
Romania	1	4	2	6
Hungary	7	6	31	31
Macedonia (FYROM)	0	2	0	0
Total Sites	**13**	**84**	**46**	**111**
Total Sites	**97**		**157**	

Table 6.2: The location and number of sites/phases with plant macro-remains by phase and type of preservation.

6.3.1 Filtering the data

Sites/phases where sampling produced no plant remains, and those with only plant impressions are excluded from most of the quantification analyses. As is explained in Chapter 5.1.2, plant impressions reflect different activities to those that lead to the carbonisation of cereal processing remains. Table 6.3 shows how results can be biased when impressions and charred remains are combined. Although the relative proportions of crops remain equal when both types of preservation are included, crops appear under-represented compared to scores obtained from only charred remains. Pulses and wild plants are rarely present as impressions and there are no taxa that are only found as impressions. Consequently, impressions are not included in the ubiquity scores presented in Chapter 8.

Percentage of sites	All sites	With Charred remains	Impressions only
Barley	76	85	48
Emmer	73	81	50
Einkorn	71	80	43
Free-thr. wheat	42	52	9
Lentil	39	52	0
Pea	31	40	2
Bitter vetch	16	21	0
Grass pea	13	17	0
Flax	13	17	0

Table 6.3: Comparing the ubiquity of the main crops by preservation (see below for binomials).

6.3.2 Nomenclature

In Chapter 8 crops and all seeds, fruits and nuts possibly gathered as a food source are referred to by their vernacular names. Some taxa of the same genus and/or fruit type (e.g. berry) are grouped together (Table 6.4). It is felt that these groups allow for a better representation of gathered food types that are otherwise not as well represented as individual species. Note that the groups of taxa are slightly different between the Early and Middle/Late assemblages. Table 6.4 matches vernacular names with their Latin binomials (authorities are not given for binomials as they are rarely specified in reports). *Lens* sp. and *Pisum* sp. are included with the species of lentil and pea because it is felt that their identification to genus is likely to reflect levels of preservation rather than the possibility of wild forms. These two pulses are amongst the oldest domesticated legumes found in the Fertile Crescent and have always been considered part of the original Neolithic crop-package (Zohary *et al.* 2012: 77-86). None of the archaeobotanical reports used in this thesis note the presence of wild lentil or pea, and the study region is likely to lie beyond the wild range of these species (*cf.* Zohary *et al.* 2012: 78, 83).

Plant names	**Binomial**	
Vernacular	**Early phase**	**Middle/Late phase**
Barley	*Hordeum vulgare sensu lato*	
Hulled Barley	*Hordeum vulgare* ssp. *vulgare*	
Naked barley	*Hordeum vulgare* ssp. *nudum*	
2-row barley	*Hordeum vulgare* subsp. *distichum*	
6-row barley	*Hordeum vulgare* subsp. *vulgare*	
Emmer wheat	*Triticum dicoccum*	
Einkorn wheat	*Triticum monococcum*	
Spelt wheat	*Triticum spelta*	
'New' glume wheat	Striate emmeroid, possibly *Triticum* cf. *timopheevi* (Brown *et al*. 1998; Jones *et al*. 2000)	
Free-threshing wheat	*Triticum aestivum sensu lato*	
Hexaploid free-threshing wheat	*Triticum aestivo-compactum*	
Tetraploid free-threshing wheat	*Triticum turgidum*, free-threshing domesticated	
Rye	*Secale cereale*	
Oat (not wild oat)	*Avena sativa*	
Millet	*Panicum miliaceum*	
Lentil	*Lens* sp., *L.culinaris*	
Pea	*Pisum* sp., *P.sativum*	
Grass pea	*Lathyrus sativus*	
Bitter vetch	*Vicia ervilia*	
Common vetch	*Vicia sativa*	
Broad bean	*Vicia faba*	
Chickpea	*Cicer arietinum*	
Flax	*Linum usitatissimum*	
Opium poppy	*Papaver somniferum*	
Hazel nut	*Corylus avellana*	
Cornelian cherry	*Cornus mas*	
Dogwood	*Cornus sanguina*	
Elder	*Sambucus sp., S.ebulus, S. nigra., S. nigra/racemosa*	
Water chestnut	*Trapa natans*	
Bladder cherry	*Physalis alkekengi*	
Olive	*Olea europaea*	
Berries	*Rubus sp., R.idaeus, R.fruticosus, F. vesca*	also incl. *R.caesius*
Grape	*Vitis sp., V.sylvestris*	also incl. *V.vinifera*
Dog-rose	*Rosa canina*	also incl. *Rosa sp.*
Apple/Pear	*Pyrus* sp., *Pyrus/Malus, M.sylvestris, M.pumila*	excl. *M.pumila*, but incl. *P.sylvestris*
Prunus fruits	*Prunus* sp.	also incl. *P.avium, P.ceracifera, P.domestica, P.fruticosa, P.insistitia, P.spinosa*
Acorn	*Quercus* sp., *Q.robur*	excl. *Q.robur*, but incl. *Q.ilex, Q.pubescence*
Almond	*Amygdalus communis*	also incl. *Amygdalus* sp.
Pistacia	*Pistachia* sp., *P.atlantica, P.terebinthus*	only *Pistachia* sp.
Caper	*Capparis spinosa*	
Pomegranate type	*Punica* sp.	
Fig	*Ficus carica*	*Ficus carica*
Walnut		*Juglans regia*
Hawthorn		*Crataegus* sp., *C.monogyna*
Pine		*Pinus* sp., *P.sylvestris*
Juniper		*Juniperus* sp., *J.communis, J.phoenicea*

Table 6.4: Latin binomials for the vernacular names of seeds, fruits and nuts used in Chapter 8

6.3.3 Quantification

The aims of Chapter 8 are to describe and compare the presence of plants between geographical and cultural areas. It was not possible to make comparisons by context type as the majority of site records do not include that level of information. As few reports include counts of plant remains (Tables 8.2 and 8.4), comparative analysis are performed on presence/absence of taxa per site. This level of detail allows for the ubiquity of crops, gathered plant foods and wild seeds to be established. The latter is presented as a percentage and is calculated by dividing the number of sites in which a taxon occurs by the total number of sites. Ubiquity scores are an effective way of presenting presence/absence data, and have been used successfully in a number of comparative studies (e.g. Colledge *et al*. 2004; Colledge & Conolly 2007; Coward *et al.* 2008; Hubbard 1975; 1980).

Tables 8.1, 8.2, 8.23 and 8.27 include a column for the minimum number of taxa in a site. This was calculated by grouping different plant parts of the same species (e.g. chaff and grain of the same taxon), and excluding any taxon only identified to genus and/or family level if species and/or genus of that family already existed. The count also excludes unidentified specimens (taxon code SEEDIND). The numbers therefore represent the absolute minimum number of taxa identified from a site.

6.3.3.1 Statistical methods

Shannon diversity index (*H*) – this index, also known as the Shannon-Wiener or Weaver index, was adopted from information theory in ecology to characterise the diversity within a habitat or community, by accounting for both its richness (i.e. number of types/species) and evenness (i.e. relative abundance of different taxa) (Shannon & Weaver 1949 cited in Lange 1990: 66; see also Gardener 151, 161-67). *H* is zero when only one species is present and increases with the number of species. However, the relationship between *H* and the total number is not linear as *H* also varies depending on the abundance of species; "*H* decreases when one or more species are dominant and *H* is maximum when all species are equally abundant" (Lange 1990: 67; see also Gardener 2014: 161). The index has been used on archaeobotanical datasets to quantify the diversity of taxa within and between samples (Colledge 2001: 67; Lange 1990: 67; VanDerwarker 2010: 67-68). It is suitable for presence/absence data (Gardener 2014: 151) and was used to quantify the diversity between the Early and Middle/Late periods. As VanDerwarker explains, "comparison of species diversity among contexts or through time is particularly useful in identifying differences in plant and/or animal exploitation – whether people are adding/subtracting types of foods from their diet(s), or if people are focusing their efforts on specific resources” (2010: 67).

The Shannon index was calculated in R (R Core Team 2016) for each site on the assumption that they correspond to a replicated sample within a given population (version 2.4-4; Oksanen *et al.* 2017). In order to turn presence/absence data into relative proportions, the probability of a given species at a particular site was calculated; i.e. the value for a species (0/absent or 1/present) was divided by the total number of species present within a site. The probability was then multiplied by its log, and the sum of all values was obtained for each site to get their Shannon index. Results are presented on violin plots, with the median and quartile values (using the ggplot2 software; Wickham 2009). The Shapiro-Wilk test was used to determine whether the values were normally distributed (Teetor 2001: 209). The statistical significance of the differences in diversity between the two assemblages were tested using the *t*-test when the distribution of values was normal, and the Wilcoxon-Mann-Whitney U-test when these were not normally distributed (Teetor 2011: 212-14). The difference is statistically significant when $p \leq 0.05$.

Correspondence analysis (CA) - the multivariate statistical method of ordination can be used on abundance or presence/absence data. It is used to search for patterns in complex data, by ordering the units of analyses (i.e. samples) according to their similarities. Results are presented on two-dimensional scatter plots, where the first (horizontal) axis presents the greatest amount of variance, whilst less variance is shown by the second (vertical) axis. Similar samples cluster around the central point whereas those very different from the average plot in the outer-edges (enabling the identification of outliers) (Gardener 2014: 446-450; Lange 1990; Smith 2014: 187-90).

CA (performed in R, package ‘ca’; Nenadić and Greenacre, 2007) was used to search for diachronic and spatial patterns within the dataset. Species that occurred in less than 5% of sites were removed, along with three sites that proved to be outliers (Fiorano, Moha-Homokbánya and Méhtelek-Nádas). The axes did not account for more than 23% of the variance but do agree with patterns discerned in the bar charts of the ubiquity scores.

6.4 The autoecological interpretation of possible weed seeds

In order to describe past husbandry regimes ecological and biological characteristics were obtained for the possible weed species. Only true aquatics, tree seeds and wild taxa gathered as edible fruits or nuts are excluded. Potential arable weeds are classified according to the following characteristics and ecological tolerances: preferred soil pH, fertility levels, texture and moisture; plant life cycle, reproductive strategy, height and modern habitat; seed attributes including size, seed bank type, and season of germination; and the onset and length of the flowering season, and season of seed setting. The main references used include Hanf (1983), Grime and colleagues (1988) and Stevens (1996: Tables 4.3–4.30), who consulted over 108 floras. Others are listed with the tables. A few details on how particular information was obtained are clarified below.

Flowering time is best obtained from local floras (Jones *et al*. 2005: 501-3), but none could be found. The Flora of Serbia (2012) does not include flowering time, or many of the characteristics sought for. Flowering time was therefore obtained from the Arable Weeds of Europe (Hanf 1983), and an online French flora (http://www.tela-botanica.org) as France has maritime, alpine and continental ecozones much like the research area. The categories of flowering length and onset used follow those defined by Bogaard and colleagues (2001).

Classes	Date of flowering onset	Length of the flowering period
Short-flowering with **early**-intermediate onset	January-June	1-3 months
Late-flowering (and so of short-medium duration)	July or later	1-5 months
Long-flowering (and so with early-intermediate onset)	January-June	>5 months
Medium flowering duration with intermediate onset	April-June	4-5 months

Table 6.5: Classes of flowering onset and length (Bogaard *et al*. 2001: Table 3)

Seed size (big or small) was attributed relative to an average cereal grain size. The latter was determined by calculating the mean breadth of 184 emmer and einkorn Neolithic domesticated grains from Croatia, Hungary, Bulgaria, Turkey, Greece, Crete, Cyprus and the Near East (Fuller *et al.* 2017), which came to 2.5mm. Seed measurements were obtained from the Atlas of Seeds and Fruits of Central and East-European Flora (Bojňanský & Fargašová 2007), except for seeds identified by the author. If either their breadth or length measured more than 2.5mm they were classified as 'big'. The breadth and length of 'small' seeds are both smaller than 2.5mm. The shape and headedness of seeds (Chapter 5.1.3.2) is taken from Reed 2012: Table 6.2 and Bogaard 2002b: Table 2.12. These seed attributes are used in the analysis of cereal processing stages and husbandry practices (Chapter 5.4.11).

6.5 The importance of climatic factors

As climate affects the growth of plants, climatic parameters were sought and compared to the diachronic and spatial variations in the crop-packages (e.g. Stamnes 2016). Given the overall dearth of precise palaeoenvironmental reconstruction for the research area (Chapter 2.3.1), preference was given to European-wide data recently published by Mauri and colleagues (Mauri *et al*. 2015). On the basis of palynological data and statistical interpolation, this paper offers reconstructed values for several climatic parameters (e.g. summer and winter temperatures and precipitations) under the form of a series of gridded data with coarse geographical resolution (each grid tile covering a degree of latitude and longitude), spanning each millennium for the entire duration of the Holocene (Chapter 2.3.2, Figure 2.5). The temperature values found in this publication are expressed as deviations from a pre-industrial baseline (1850 AD), rather than as past "true" absolute values, required for comparison with crop temperature thresholds. These relative values were turned into absolute ones using a modern (1960s) baseline for average summer (June-July-August, hereafter JJA) and winter (December-January-February, hereafter DJF) temperatures obtained from the World Clim – Global Climate Data (http://www.worldclim.org, version 2), by Dr. M. Vander Linden for the EUROFARM project. In this case using a modern baseline is deemed appropriate and comparable to the pre-industrial baseline due to uncertainties in the chronological control and the slow vegetation response time (pers. comm. from Dr. B. Davies to Dr. Vander Linden). Nevertheless, the obtained values should not be taken as "real" given their limited spatial and chronological resolution, but rather as an approximation.

In Chapter 8.2.4 the winter and summer average temperatures at individual sites (Tables 2.2 and 2.3, Appendix II) are compared to the critical temperatures in a crop's life cycle. The latter were obtained from the Food and Agriculture Organization for the United Nations (http://ecocrop.fao.org/ecocrop/srv/en/home, (Table 6.6), for modern varieties. Growing conditions for emmer and einkorn are not available so values for winter wheat are used. It was not possible to compare precipitation requirements as the nature of the data in Mauri and colleagues' (2015) article does not allow for accurate reconstructions of seasonal averages. Based on Table 6.6 and the calculated JJA and DJF average temperatures, Tables 8.9 to 8.20 sort all the sites with charred crops into those located outside or within ideal average winter and summer temperature values. Notwithstanding the lack of precision in the reconstructed temperature values, the importance of accumulated temperature (Growing Degree Days: *cf*. Bonhomme 2000; e.g. d'Alpoim Guedes *et al*. 2015), the unknown exact growing conditions required by ancient crop varieties (*cf*. Davies & Hillman 1988), and the range of climatic and ecological conditions that can affect the production of crops (*cf*. Grigg 1995), it is felt that the approach described above can help explain the Neolithic cultivation practises of the research area.

	Lentil *Lens culinaris* (Medik)*	**Chickpea** *Cicer arietinum* L.	**Pea**: *Pisum sativum* L.	**Broad bean** *Vicia faba* L.	**Grass pea** *Lathyrus sativus* L.	**B. vetch** *Vicia ervilia* (L.) Willd.	**C. vetch**: *V. sativa* ssp. *sativa* L.	**Flax**: *Linum usitatissimum* (L.) Griesb.	**Rye** *Secale cereale* L.	**Oat**: *Avena sativa* L.	**Barley** *Hordeum vulgare* L.	**Spelt** *Triticum spelta* L.	**Winter wheat**: *T. aestivum* L.
Growing season	70-240	90-180	60-140	100-150	100-180	90-150	80-170	80-180	110-270	125-160	90-240	120-180	90-250
Tkill_rest (ºC)	-10	-9	-2	-10		-10	-5	-6	-18	-15	-8		-20
Tmin (ºC)	5	7	4	5	4	5	3	5	3	5	2	4	5
Tkill_grow (ºC)	-4	0	0			-1	-1	-1	-1	-1	0		0
OpTemp (ºC)	15-29	15-29	10-24	18-28	10-28	12-22	14-23	16-24	15-20	16-20	15-20	10-17	15-23
Tmax (ºC)	32	35	30	32	32	28	28	30	31	30	40	24	27
Rmin (mm)	250	300	350	260	320	300	350	250	400	250	200	300	300
Rmax (mm)	2500	1800	2500	2600	3000	1200	1600	1300	2000	1500	2000	1600	1600
OpRain (mm)	600-1000	600-1000	800-1200	650-1000	500-1300	500-700	700-900	500-800	600-1000	600-1000	500-1000	700-900	750-900
Height (cm)	15 - 75	40-50	15-300	80-100	60-90 climber	20-90	10-50 scrambler	75-120	100-150	60-120	50-100	100-120	up to 120
Soil pH	4.5 – 8.2	4.7 – 9.5	4.5 – 8.3	4.5 – 8.6	4.5 – 8.3	5.6 – 8.2	4.5 – 8.2	5.5 – 7	4.5 – 8.2	4.5 – 7.5	6 – 8	5 – 8.3	5.5 – 8.5
OpSoil_text	heavy, medium	heavy, medium	all	medium	all	medium, light	heavy, medium	heavy, medium	all	all	medium	light	medium
Soil_text	light	light		heavy, light		heavy	light				heavy, light	medium	heavy
OpSoil_fer	moderate	moderate	moderate	high	moderate	high	moderate	high	moderate	high	moderate	moderate	high
Soil_fer	low	low	low	moderate	low	moderate	low		low	moderate	low		moderate

Table 6.6: Temperature, precipitation and soil requirements of modern crop varieties (http://ecocrop.fao.org/ecocrop/srv/en/home; *Andrews *et al*. 2007).

Key:

Growing season: maximum length in days
Tkill_rest: killing temperature during rest/dormant
Tmin: minimum temperature required for germination
Tkill_grow: killing temperature during germination and early growth
OpTemp: optimum temperature for successful growth and maturity
Tmax: maximum temperature tolerated
Rmin: minimum annual precipitation required
Rmax: maximum annual precipitation tolerated
OpRain: optimum precipitation for successful growth and maturity
Soil pH: tolerated range
OpSoil_text: optimum soil texture
Soil_text: other tolerated textures
OpSoil_fer: optimum soil fertility
Soil_fer: other tolerated fertility levels

CHAPTER 7

The Analysis, Description and Interpretation of Plant Macro-Remains Sampled from Neolithic Sites in the Western Balkans

Archaeobotanical samples for this thesis were retrieved from ten sites from the northern part of the western Balkans. Laminski Jaružani, Laminski J. Njiva, Kosjerovo and Kočićevo were sampled by the author, whilst samples from the remaining six sites were obtained through collaborations with site and museum directors. I also took part in the excavations of two additional sites (an open site in northern BiH and a cave site in Montenegro) but no Neolithic remains were recovered (section 7.4). The chapter is organised by site, from the Early to the Late Neolithic. In each section the location, research history and excavation of the site is described, followed by accounts of how the samples were obtained and processed. Results from individual sites are presented and interpreted before assemblages are compared in a final discussion. Well preserved grains from Korića Han and Bapska were measured and plotted against other known Neolithic sizes to explore the possible development of landraces. In the following chapter results are amalgamated with all other archaeobotanical data obtained through literary sources, in order to explore large diachronic and spatial trends.

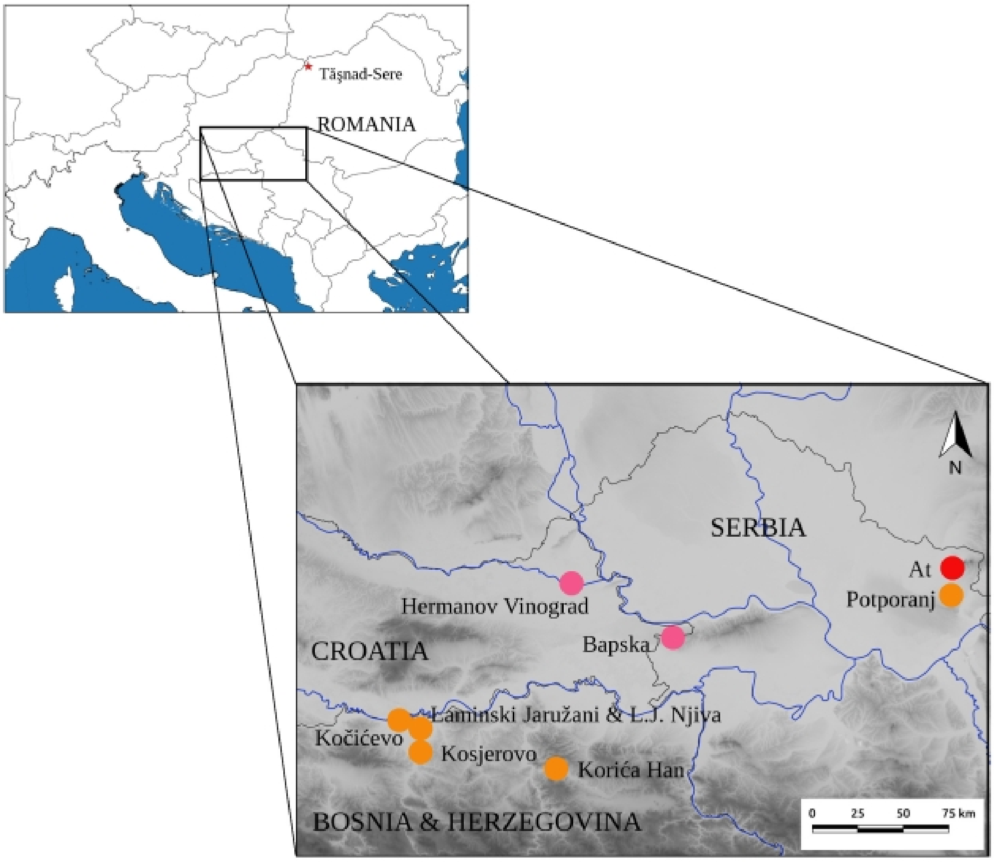


Figure 7.1: The location and name of sites sampled for this thesis. The main rivers are highlighted in blue. Red dots illustrate Early Neolithic sites (At and T.Sere), orange dots Middle/Late Neolithic sites (Potporanj and the five sites in BiH), and pink dots Late Neolithic sites (both in eastern Croatia)

7.1 Tăşnad-Sere (N 47.78, E 22.97) (Astaloş *et al*. 2013; Sommer & Astaloş 2015: 83-91)

The site of Tăşnad-Sere lies on the banks of the Cehal river, a tributary of the Ier, that runs SW of the town of Tăşnad, Satu Mare County, north-western Romania. Positioned on the north-easternmost edge of the Hungarian Plain, the area was marshy until large-scale drainage programmes took place in the 19th and 20th centuries. The majority of the archaeological remains have been dated to the late SKC through ceramic typologies. Later Neolithic, Copper Age and Roman remains have also been recovered.

Dr. U. Sommer (IoA) began excavating in the summer of 2012 and, as part of a larger excavation project, she opened an 8x10m trench to uncover the Criş village. The excavation area was chosen for its deep, well-preserved stratigraphy. Above pits and post-holes of Criş houses lies a 30-50cm thick *in situ* occupation layer (context 5), itself covered by two metres of fine alluvial deposits (context 4). The trench was divided into 1x1m^2 squares and excavated in artificial horizontal 5cm spits, unless a natural layer or feature was uncovered. Only three of the 165 samples originate from archaeological features. Members of the excavation team have so far taken 190 ten litre soil samples and processed them on site using bucket flotation. The flots were collected in 250µm mesh and the heavy residues washed over a 0.5mm sieve. Both were left to dry naturally. Some samples were of almost pure silt and clay with no charred plant remains or other buoyant materials. Consequently, some heavy fractions did not have corresponding flots.

I selected flots from transects A and D (Tables 1.1-1.2, Appendix I). All heavy fractions and remaining flots were sorted by Ms. A. Leon (IoA) (Table 1.3, Appendix I), using the same sorting and identification criteria. The heavy fractions were made up of fine gravel and clumps of dry clay no larger than 2cm across. The larger heavy fractions were sub-sampled to *c*.10ml.

Square	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**ZZ**	**Totals**
Total samples	51	29	29	34	15	1	1	2	3	**165**
Total volume (L)	506	290	294	235	150	10	10	20	30	**1545**
Total cereal grain	**34**	**0**	**1**	**8**	**0**	**0**	**0**	**0**	**0**	**43**
mean/L	0.067	0	0.003	0.034	/	/	/	/	/	**0.03**
Total wheat gl. base	**49**	**0**	**0**	**11**	**0**	**0**	**0**	**0**	**0**	**60**
mean/L	0.097	0	0	0.047	/	/	/	/	/	**0.04**
glume base: grain	1.441	/	0	1.375	/	/	/	/	/	**1.40**
Total fruits/nuts	**10**	**1**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**15**
mean/L	0.020	0.003	0.007	0.009	/	/	/	/	/	**0.01**
Total wild/weed seeds	**21**	**58**	**205***	**9**	**0**	**0**	**0**	**0**	**0**	**88**
mean/L	0.042	0.2	0.697	0.038	/	/	/	/	/	**0.06**
№ items / Litre	**0.23**	**0.20**	**0.71**	**0.13**	**/**	**/**	**/**	**/**	**/**	**0.13**

Table 7.1: Summary results from the analysis of flots from Tăşnad-Sere. * Includes the estimated 153 seeds from sample C1/6.

7.1.1 Preservation

All plant macro-remains were preserved through carbonisation. Charcoal was present in all flots but was mostly heavily comminuted and present as fragments smaller than two millimetres. The flot from square A1/1 had 8mm of charcoal but no other plant remains. A total of 42 grains were found in transects A and D, and a further one grain from the remainder of the samples (Table 7.1). All but one grain from squares A and D were heavily fragmented and/or badly preserved. Overall the cereal grains (sorted by the author) have a mean F.I. of 4.4 and P.I. of 0.2 with a mode of 0, which defines the preservation of cereal grains as very bad and moderately to highly fragmented. There are very few grains and the high degree of fragmentation has limited identifications to the level of family or genus. There were more glume bases than grain (n=60, all from transects A and D). The fact that these spikelet fragments are more susceptible to charring (Boardman & Jones 1990), suggests that grains were not as frequently burnt (as opposed to preferentially destroyed by adverse preservation conditions). As most of the samples were of the same size (10L), the variation in the number of plant remains between samples cannot be related to sample size. Despite very low densities of cereal and other plant remains, differences are evident in their distribution (Table 7.1). Cereal remains are concentrated in transects A and D, whilst wild/weed seeds were mainly found in transects B and C (particularly in sample C1/6 of transect C; Table 1.3, Appendix I). Relative proportions of plant remains and patterns in their distribution do not seem to have been obscured by adverse preservation conditions. No pattern was detected in the distribution of remains by excavation spit (i.e. depth of occupation layer). Modern cereal straw is likely to have been added as the flots were drying since the occupation layer had no visible signs of bioturbation (such as burrows) or mechanical disturbance.

7.1.2 The crops, gathered flora and other wild plants

Emmer (*Triticum dicoccum* Schubl.) was the only cereal species that could be identified with any certainty. Ninety-five percent (n=98) of the cereal remains were identified to emmer and/or einkorn (*T. monococcum/dicoccum*), and a single grain from square D compares favourably with barley (*Hordeum vulgare sensu lato*). The overall glume base to grain ratio is 1.4. Two bladder cherry seeds (*Physalis alkakengi* L.) and 13 indeterminate nut shell fragments constitute the only evidence for wild fruits and nuts. About 54% (>153) of all wild/weed seeds were found in sample C1/6 which contained no cereal remains. Their interpretation as arable weed seeds is therefore problematic.

7.1.3 Discussion

The low presence of remains in such a well sealed site is perhaps surprising but does not necessarily suggest that cereal grains were used or grown infrequently. The high level of fragmentation indicates that grains were damaged, possibly from being discarded onto living surfaces and then subjected to trampling. Bioturbation and fluctuations in the water-table of the flood-plain may also have contributed to the disintegration of carbon structures. Nevertheless, patterns in the distribution of plant remains suggest that waste from the de-husking of emmer and perhaps einkorn was more frequently discarded over transects A and D. The separation of cereal remains from the majority of possible arable weed seeds may indicate that crops were carefully sieved before being de-husked, and that weed and chaff waste were burn separately. It is also possible that the seeds originate from dung, as experiments have shown that even if cereal remains had been eaten, very few, if any, would have survived (Valamoti & Charles 2005: 530; Wallace & Charles 2013: 23). It would be interesting to compare the remains from the occupation layer with further samples from negative features, such as pits and post-holes.

7.2 At (N 45.136, E 21.281) (Chu *et al*. 2016; Pantović Unpublished-a)

On the northern outskirts of the city of Vršac (North-East Serbia), on a loess terrace at the foothills of the Vršac mountains, lies the open air site of At. It spreads over an area of *c*.15ha, with finds dating from the Palaeolithic to the Medieval period, and represents one of the very rare open-air Palaeolithic sites known in the area (subdivided into AtI and AtII). Between May 2014 and May 2015, small-scale excavations were conducted by a German-Serbian team, funded by the Collaborative Research Centre 806 project B1 'Our Way to Europe' and directed by W. Chu (Institute for Prehistory, University of Cologne) and D. Mihailović (Department of Archaeology, University of Belgrade). Whilst AtI contained Upper Palaeolithic material culture, AtII also had deposits associated with the Starčevo and Vinča phases. A 2x5m trench exposed a layer rich in finds from the final phase of the Vinča culture (Vinča D), beneath which were a series of roughly circular pits. The latter have been interpreted as a semi-subterranean Starčevo house composed of two rooms: features 2b, 3 and 6 (3 and 6 are thought to have been part of the same room until a wall collapsed separating them). Feature 2a was an oven and three other features are thought to represent storage or rubbish pits. Recovered artefacts include pig bones, two bone spatulas and canonical and spherical pots. Local stones used in the tempering of clay could suggest ceramics were manufactured by the house's inhabitant(s). Four ^{14}C (AMS) dates place the Starčevo layer at 5842-5668 cal. BC, and overlying deposits to the final Vinča phase (4896-4373 cal. BC). The Starčevo layer, which continues beyond the extent of the trench, is the first methodically excavated Early Neolithic site in SE Banat (North-eastern region of Serbia).

Ten 10L bulk soil samples were taken from the Starčevo layer and processed on site using a Siraf-type flotation machine (Williams 1973) by Ms. I. Pantović (senior curator of the Neolithic collection, Vršac museum) and her team (Table 1.4, Appendix I). A 500µm mesh was used to catch the flots and a 1mm mesh retained the heavy fractions. Both were left to dry naturally. The flots were sorted following the methodology described in Chapter 6.1 and recovered plant remains are listed in Table 1.5, Appendix I.

Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Feature	3	2a	2a	2a	2b	2b	6	6	2b	2b	**Totals**
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	**100**
Total barley grains	1	2	1	4	8					9	**25**
Total hulled wheat grains	2	2	2	2	6	2	1	2	5		**24**
Total grains (incl. indet. grains)	**15**	**17**	**23**	**19**	**36**	**5**	**6**	**4**	**18**	**20**	**163**
mean/L	1.5	1.7	2.3	1.9	3.6	0.5	0.6	0.4	1.8	2	**1.63**
Preservation index – mean	0.3	0.4	0.3	0.6	0.8	0.6	0.3	0.8	0.7	0.8	**0.6**
mode	0	0	0	0	0	1	0	1	0, 1	0	**0**
Fragmentation index	1.6	4.8	1.7	3.5	6.2	4	6	3.7	7.2	3	**4.2**
Total glume bases	**10**	**1**	**1**	**0**	**8**	**4**	**9**	**1**	**1**	**0**	**35**
mean/L	1	0.1	0.1	/	0.8	0.4	0.9	0.1	0.1	/	**0.35**
Glume base:grain ratio	0.7	0.07	0.05	0	0.3	0.8	1.5	0.25	0.06	0	**0.21**
Total fruits/nuts	**1**	**0**	**3**	**2**	**0**	**0**	**3**	**1**	**0**	**1**	**11**
mean/L	0.1	/	0.3	0.2	/	/	0.3	0.1	/	0.1	**0.11**
Total wild/weed seeds	**1**	**1**	**0**	**1**	**3**	**0**	**1**	**0**	**1**	**2**	**10**
mean/L	0.1	0.1	/	0.1	0.3	/	0.1	/	0.1	0.2	**0.1**
Grain:seed ratio	15	17	N/A	9.5	13	N/A	6	N/A	18	10	**16.3**
Non-cereal P.I. – mean	0	1	1.3	1	0.7	/	1.3	2	0	1.3	**0.9**
mode	0	1	1	2,1,0	1	/	2	2	0	1	**1**
Grain/Seed density (excl. chaff)	**1.7**	**1.9**	**2.6**	**2.2**	**3.9**	**0.5**	**1**	**0.5**	**1.9**	**2.3**	**1.84**
№ items / litre (excl. charcoal)	**3.1**	**2**	**2.7**	**2.3**	**4.7**	**0.9**	**1.9**	**0.6**	**2**	**2.3**	**2.28**

Table 7.2: Summary results from the analysis of flots from AtII

7.2.1 Preservation

All plant macro-remains were preserved through carbonisation. Charcoal was present in all samples but was mostly heavily comminuted and present as fragments smaller than two millimetres. The >4mm fragments were more commonly found in the heavy residues, demonstrating their lack of buoyancy during flotation. The cereal grains are all fragmented to some degree, are pitted and have lost all traces of epidermis. Overall the cereal grains have a mean F.I. of 4.2 and a P.I. of 0.6 with a mode of 0, which defines the preservation of cereal grains as very bad and moderately to highly fragmented. The samples' F.I., P.I. and total number of cereal grains are plotted in Figures 7.2a and 7.2b, by ascending F.I. Whilst the P.I. remains below 1, the F.I. varies considerably between 1.6 and 7.2. The lack of a correlation, either positive or negative, between the indices suggests that the identification of cereal grains was not obviously affected by levels of fragmentation. Fragmented cereal grains may still be identifiable, and a fairly well preserved assemblage may still contain numerous fragments. The samples were all ten litres and so the variation in the number of plant remains cannot be accounted for by sample size. Figure 7.2b illustrates that there is no relationship between the total number of cereals and either of the indices. Samples with the lowest number of grains did not have the lowest P.I. or highest F.I., suggesting that the number of recovered cereal grains is not a direct effect of taphonomy. Wheat chaff was present in all but two samples. Glume bases and spikelet forks occurred in similar quantities (n=15 and 11 respectively). The total number of grains in each sample includes the WGE of the grain fragments, which may include fragments of barley caryopses. As the glume base to grain ratio was calculated using the total number of grains, the ratio represents the lowest possible value (since barley does not have wheat glume bases).

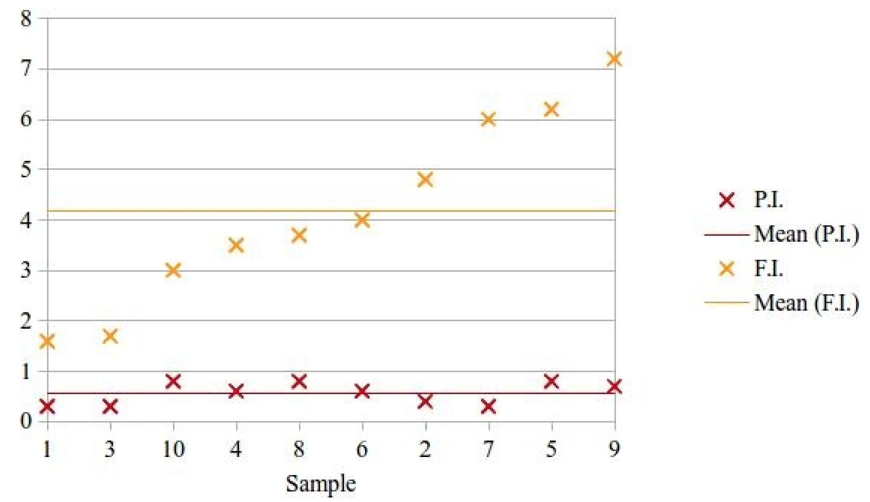


Figure 7.2a: Preservation and fragmentation indices by sample. Plotted by ascending F.I.

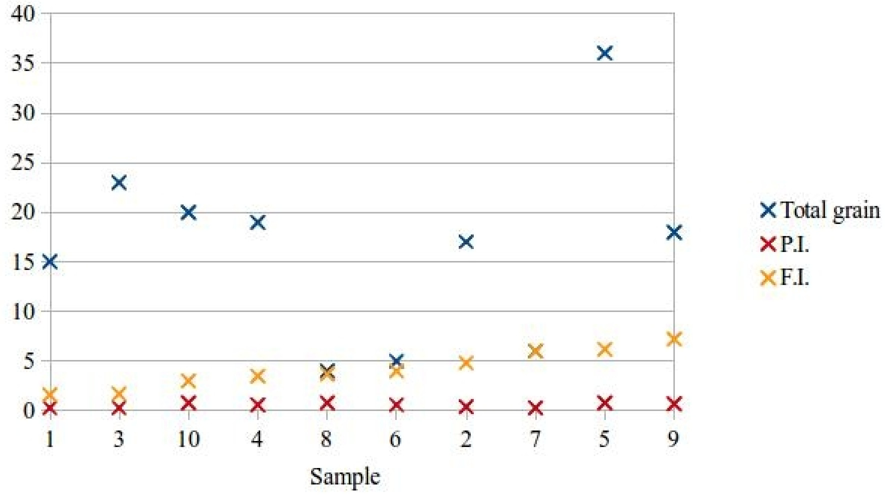


Figure 7.2b: Preservation and fragmentation indices in relation to the number of cereal grains by sample. Plotted by ascending F.I.

The non-cultivated seeds are only slightly better preserved than the cereal grains, especially those from edible fruits and nuts. They have a mean P.I. of 0.9 (mode of 1), which describes their preservation as very bad to poor. The lack of any correlation between grain/seed density (excludes charcoal and chaff) and the preservation indices suggests that the total number of plant macro-remains (excluding charcoal) is not related to preservation conditions (Figure 7.2c). It is possible that crops were not regularly processed within the sampled structure, food waste was not routinely burnt or burnt remains were discarded beyond the sampled areas.

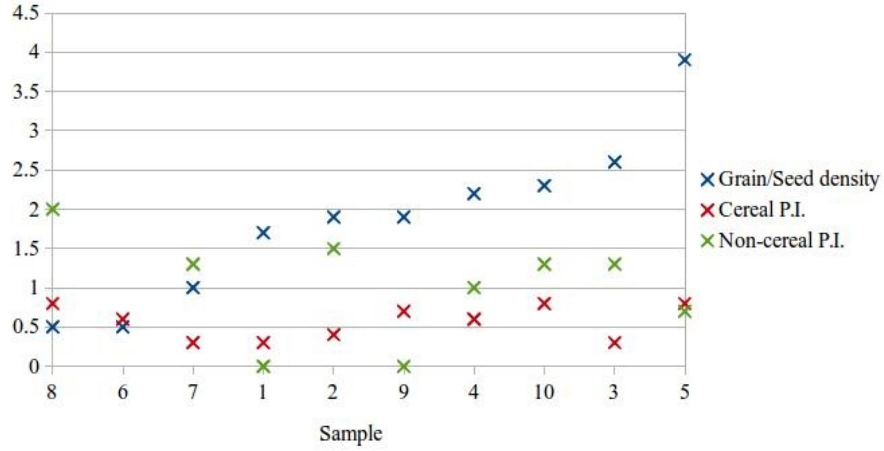


Figure 7.2c: Preservation indices and the grain/seed density by sample. Plotted by ascending grain/seed density.

7.2.2 The crops, gathered flora and other wild plants

Hulled barley grains (*Hordeum vulgare* ssp. *vulgare*) and single-grained einkorn (*Triticum monococcum* L.) grains and chaff appear to be the most numerous cereal remains (notwithstanding the large number of fragments and uncertain identifications). No definite remains of emmer were found and a single grain could belong to the 'new' glume wheat type. The identification of the 'new' type from grain alone is difficult and must remain tentative until the presence of chaff is confirmed (Jones *et al.* 2000a; Kohler-Schneider 2003: 108).

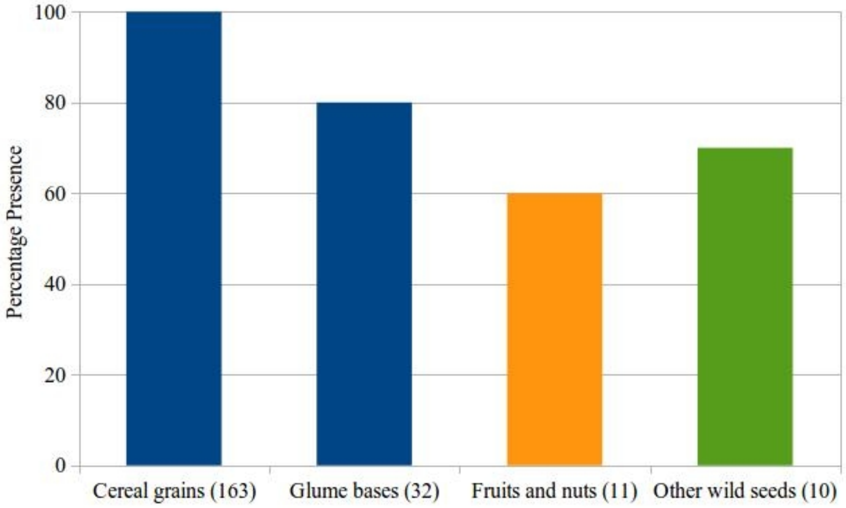


Figure 7.2d: Percentage presence (Ubiquity across 10 samples) of the categories of plants found at AtII.

There were no assemblages that could be clearly associated with a particular plant processing activity. A total of 163 cereal grains were found distributed across all ten samples. The total number of grains per sample ranged from 5-36, and there were 16.3 grains per sample on average. Three samples had six or fewer grains whilst sample 5 had 36 grains. The highest density of cereal grains was not from the oven (Feature 2a, samples 2, 3 and 4) but from the stack of ceramic vessels (sample 5). Glume bases were not as numerous and the highest glume base to grain ratio was 1.5 for sample 7. The glume base to grain ratio for single-grained einkorn is two and for emmer one. The overall ratio for all ten samples is 0.2 (32:163), indicating that the assemblages were predominantly made up of clean grain, rather than spikelets. Fruits and nuts were found in 60% (n=6) of samples, and their total sum per sample ranged from 0-3. Fifty-five percent (n=6) of the fruits and nuts are finds of dwarf elder (*Sambucus ebulus* L.) and bladder cherry, both very common on Early Neolithic sites (Chapter 8.3.1). A total of ten possible arable weed seeds were found in 70% (n=7) of samples. Only three were identified to species or one of two species. A single broomcorn millet (*Panicum miliaceum* L.) seed may be intrusive from post-Neolithic activities.

7.3.3 Discussion

Barley, einkorn and emmer were the main cereal crops of the Neolithic in the western Balkans (*cf.* Colledge & Conolly 2007: Fig.2; Chapter 8.2). The fact that emmer was not identified with any certainty at AtII is therefore unusual. Finds of samples comprising a mixture of the two glume wheats from LBK and Neolithic Bulgarian sites could indicate that these glume wheats were grown as maslin crops (Jones & Halstead 1995; Kreuz *et al.* 2005: 243). However, modern observations suggest that this was unlikely as the wheats may have had different uses, and emmer is taller and ripens sooner than einkorn when the two species are grown together (Filipović & Tasić 2012: 13; Kreuz & Shäfer 2011: 334). Barley, on the other hand, can be successfully mixed with wheat to ensure the harvest of at least one crop (Jones & Halstead 1995: 111). 'New' glume wheat has also been found at the Körös culture site of Ecsegfalva in Hungary (Bogaard *et al.* 2007: Table 23.I), indicating that the cereal was indeed present in the western Balkans during the Early Neolithic. The potential presence of this little understood Neolithic crop at AtII (as well as at Potporanj and Hermanov Vinograd) adds an important point on the map of its currently elusive distribution.

7.3 Potporanj – Kremenjak (N 45.022, E 24.249) (Pantović unpublished-b)

The Neolithic tell site of Potporanj-Kremenjak (hereafter Potporanj) lies under the eastern edge of Potporanj, a village 15km south of the modern town of Vršac, in the South Banat district, NE Serbia. The site is one of about seventy known Neolithic settlements in SE Banat, of which only two have been excavated: Potporanj and At. Located at the foothills of the Vršac mountains and *c*.40km from the Danube, Potporanj was established in a hydrologically active area of fertile soils with abundant mineral and ore wealth. Ongoing climatic research suggests the area around Vršac was much wetter than it currently is, and that both the prehistoric sites of At and Potporanj were established within a swampy landscape (Pantović pers. comm. 11/04/16; Chapter 2.3.1). Potporanj is thought to cover an area of over 100 hectares and reach a depth of 3.4m, making it one of the largest Vinča settlements (Chapman 1981: 44). Areas suitable for archaeological inspection are now limited as most of the Neolithic settlement lies either beneath the Danube-Tisza-Danube canal's embankment (the canal cuts through the eastern side of the site), the modern village or its graveyard. Ms. I. Pantović began ongoing systematic investigations in 2011, under the auspices of the City Museum of Vršac.

In 2011 a trench (Trench 1, 24m^2) was opened after a geophysical survey exposed subterranean anomalies on the western periphery of the archaeological settlement. A single habitation level, thought to date to the Vinča C phase, was uncovered. In 2012 Trench 2 (6x4m) was opened 100m from both the graveyard and the canal, on the eastern side of the village. The trench was subdivided into six equal squares labelled a-e. Eight artificial spits were excavated and the eighth layer (layer 8) revealed the collapsed wall of a house.

e	c	a
f	d	b

Figure 7.3a: Subdivision of Trench 2. The eastern section a-b runs parallel to the DTD canal.

Excavations resumed in 2013 to unearth the house detected in layer 8. The house (layers 8-13, 5292-5018 cal. BC, Vinča B following Whittle *et al*. 2016: Fig.37) contained an oven that showed signs of repair and a broad array of artefacts, including a well preserved bucranium and fragmented vessels that appear to have stood either one above the other, as on a shelf, or stacked inside each other. Sample 1 was taken from layer 13 in square D. At a depth of *c*.1.9m a line of post-holes within a ditch (Ditch 2) was uncovered, running from squares c-a. The ditch was filled with yellow, clay-rich soil, adobe fragments and frequent charcoal (samples 2&3). Another ditch parallel to, and one metre from Ditch 2 also contained post-holes. The ditches and post-holes cut through the oven and collapsed walls, post-dating the house. Their date and purpose remains uncertain. In 2014 work continued within Trench 2 disclosing another house (layers 15-17). The floor of 'habitation level 2' sits at a depth of *c*.2.2m but was not even. A difference of *c*.27cm suggests the floor slopped eastward, either intentionally or due to a landslide. In total eleven 10L bulk soil samples (samples 4-11 from 'habitation level 2') were processed on site using a Siraf-type flotation machine (Williams 1973) by Ms. I. Pantović and her team (Table 7.3a). A 500µm mesh was used to catch the flots and a 1mm mesh retained the heavy residues. The flots were analysed following the methodology described in Chapter 6.1, and recovered plant macro-remains are presented in Table 1.6, Appendix I. Both were left to dry naturally. Four radiocarbon dates, including one from sample 11, place level 2 in the Middle Neolithic, between 5231-4999 cal. BC.

Sample	Volume (L)	Sq./Ditch		Exc. Layer	Description
1	10	D		13	layer of ash concentration in final occupation layer
2	10	Ditch 2		14	ditch for the posts, fill rich in finds
3	10	Ditch 2		14	ditch for the posts, fill rich in finds
4	10	E	Occupation level 2	15	ash-rich layer close to control ditch 1
5	10	D		16	charcoal- and ash-rich layer above house floor
6	10	B		16	light ochre floor and start of layer beneath it
7	10	F		16	charcoal-rich sediment between ditches
8	10	A		17	Adobe and charcoal-rich sediment overlying house floor
9	10	D		17	ash-rich sediment overlying house floor
10	10	D		17	ash-rich layer overlying house floor
11	10	B		17	house floor

Table 7.3a: The contexts sampled at Potporanj.

Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Layer/Square or Ditch	13/D	14/Dit.2	14/Dit.2	15/E	16/D	16/B	16/F	17/A	17/D	17/D	17/B	**Totals**
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	10	**110**
Total einkorn		1	4	11	30	3	4	1	13	15	10	**92**
Total emmer		1		8	31		6	3	7	4	1	**61**
Total 'new' type		1						1		1	1	**4**
Total grains (incl. indet. grains)	**7**	**19**	**6**	**59**	**265**	**29**	**46**	**28**	**66**	**57**	**27**	**609**
mean/L	0.7	1.9	0.6	5.9	26.5	2.9	4.6	2.8	6.6	5.7	2.7	**5.54**
Preservation index mean	0.4	1.1	2.2	1.3	1	0.7	1	1.1	1.1	1.3	1.5	**1.2**
mode	0	1	2	2	1	0	1	0	1	1	1	**1**
Fragmentation index	0.5	0.9	0	0.3	2.7	4.2	4	10.5	3	3	0.7	**2.7**
Total einkorn glume base	4	25	14	9	48	22	36	11	57	419	7	**652**
Total emmer glume base					4					13		**17**
Triticum aestivum sl. rachis										1		**1**
Total glume bases (incl. Indet.)	**7**	**48**	**20**	**22**	**79**	**37**	**69**	**22**	**212**	**954**	**14**	**1484**
mean/L	0.7	4.8	2	2.2	7.9	3.7	6.9	2.2	21.2	9.54	1.4	**13.49**
Glume base : grain ratio	1	2.5	3.3	0.4	0.3	1.3	1.5	0.8	3.2	16.7	0.5	**2.44**
Total pulses (all lentil)	**1**	**1**	**1**	**20**	**6**	**0**	**5**	**2**	**0**	**3**	**2**	**41**
mean/L	0.1	0.1	0.1	2	0.6	/	0.5	0.2	/	0.3	0.2	**0.37**
Total fruits/nuts	**0**	**0**	**0**	**22**	**8**	**22**	**7**	**3**	**15**	**13**	**8**	**98**
mean/L	/	/	/	2.2	0.8	2.2	0.7	0.3	1.5	1.3	0.8	**0.56**
Total wild/weed seeds	**6**	**8**	**9**	**32**	**61**	**129**	**14**	**9**	**17**	**32**	**18**	**335**
mean/L	**0.6**	**0.8**	**0.9**	**3.2**	**6.1**	**12.9**	**1.4**	**0.9**	**1.7**	**3.2**	**1.8**	**3.05**
Non-cereal P.I. mean	1	1.3	1.1	1.9	2.2	1.9	1.6	1.6	1.5	1.9	1.9	**17.9**
mode	1	1	1	2	3	2	2	1, 2	1, 2	2	2	**16**
Grain:seed ratio	1	2.4	0.7	1.8	4.3	0.2	3.3	3.1	3.9	1.8	1.5	**24**
Grain/Seed density (exc. chaff)	**1.5**	**2.8**	**1.6**	**13.3**	**34**	**18**	**7.2**	**4.2**	**9.8**	**10.5**	**5.5**	**23**
№ items / litre (excl. charcoal)	**2.2**	**7.8**	**3.7**	**16.5**	**41.9**	**21.7**	**14.3**	**6.4**	**31**	**106.1**	**7.1**	**23.17**

Table 7.3b: Summary results from the analysis of flots from Potporanj.

7.3.1 Preservation

Carbonisation was the dominant form of preservation. Mineralisation also occurred, exemplified by three black bindweed (*Fallopia convolvulus* (L.) Á Löve) seeds. Charcoal was present in all samples but was mostly heavily comminuted and present as fragments smaller than two millimetres. The >4mm fragments were more commonly found in the heavy residues, demonstrating their lack of buoyancy during flotation. The majority of the cereal grains are fragmented and have lost all traces of epidermis; those that have remained whole are distorted and often puffed. Eighteen of the indeterminate wheat grains from sample 5 are very rounded, puffed and have a bead of tarry matter exuding from their distal end. These protrusions can occur during the firing process as pressure builds up within the grain, eventually rupturing the pericarp to allow the changed endosperm to spill out (Braadbart 2008: 160). They are more likely to occur if the transition between ambient and high temperature is fast, i.e. when grains at room temperature are discarded into a burning fire or hot oven (Braadbart 2008: 160). Overall the cereal grains have a mean F.I. of 2.7 and a P.I. of 1.2 with a mode of 1 (Table 7.3b), which defines the preservation of cereal grains as poor and moderately fragmented. The samples' F.I., P.I. and total number of cereal grains are plotted in Figures 7.3b and 7.3c, by ascending F.I. A high P.I. and a low F.I., as seen in sample 3 with six grains, indicates a majority of well preserved whole grains. Conversely, sample 8 with 28 grains has a poor mean P.I. and very high F.I., indicating that most of the grains are heavily fragmented and could not be specifically identified. The lack of a correlation, either positive or negative, between the indices suggests that, overall, fragmentation was not so severe as to affect the identification of cereal grains. The samples were all ten litres and so the variation in the number of plant remains cannot be accounted for by sample size. Figure 7.3c illustrates that there is no relationship between the total number of cereal grains and either of the indices (note that sample 5 has been excluded because of its disproportionately high number of cereal grains, n=265). This lack of correlation demonstrates that the number of recovered cereal grains is not a direct effect of pre- and/or post-depositional processes, and suggests that grains were preferentially discarded into certain areas of the structure.

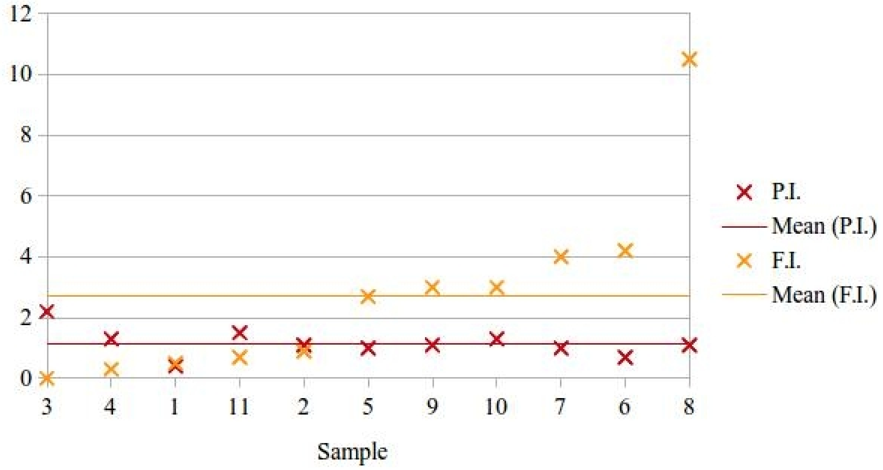


Figure 7.3b: Preservation and fragmentation indices by sample. Plotted by ascending F.I.

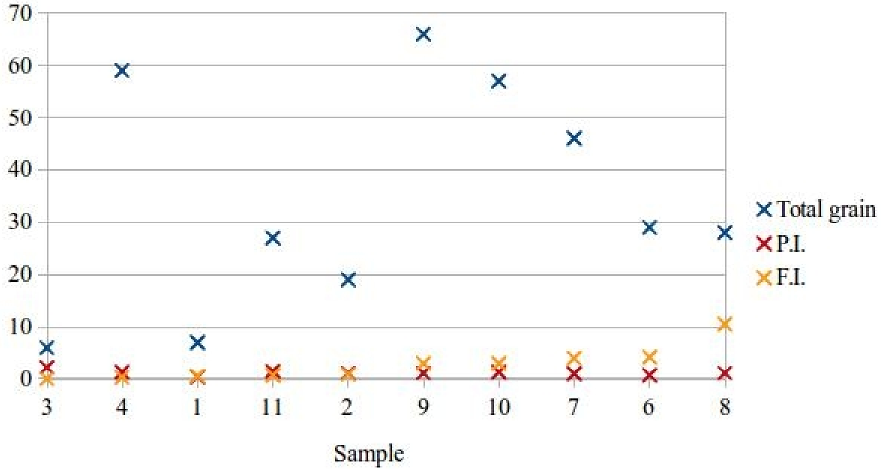


Figure 7.3c: Preservation and fragmentation indices in relation to the number of cereal grains by sample. Plotted by ascending F.I.

The non-cultivated seeds are better preserved than the cereal grains and mostly identifiable to species. They have a mean P.I. of 1.6 (mode of 2), which describes their preservation as fair. Sample 3 is the only one with a non-cereal P.I. lower than its cereal P.I. Similarly to Figure 7.3c, the lack of any correlation between grain/seed density (excludes charcoal and chaff) and the preservation indices suggest that the total number of seeds per litre of soil is not directly related to preservation conditions (Figure 7.3d).

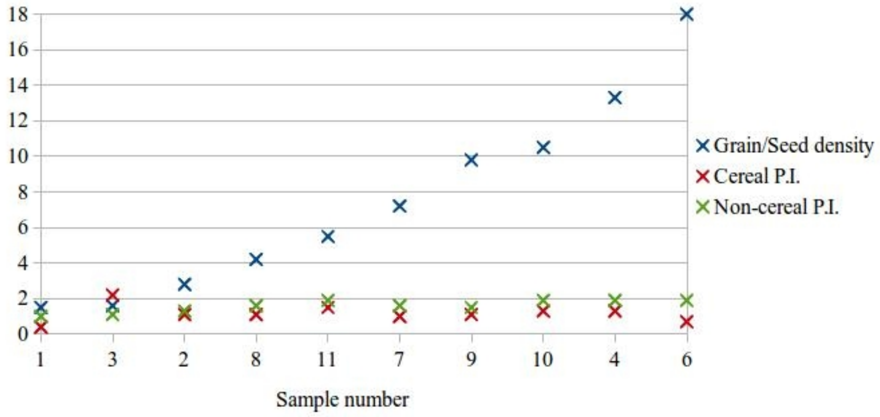


Figure 7.3d: Preservation indices and the grain/seed density by sample. Plotted by ascending grain/seed density.

7.3.2 The crops, gathered flora and other wild plants

Einkorn (mostly of the single-grained variety), was found in all the samples and is represented by 453 identified items. Only 72 items could be securely identified to Emmer, which was present in 73% (n=8) of samples. Eighty-four grains were identified to emmer or einkorn (*T.monococcum/dicoccum*), and chaff was present in all samples but is mostly too fragmented to be identified beyond belonging to a glume wheat. Four possible caryopses of the 'new' glume wheat were recovered (Figure 7.3e).

Figure 7.3e: Lateral and dorsal view of possible 'new' glume wheat from sample 8.

There is a complete absence of barley, and although its status as a Neolithic crop in Serbia has been questioned (Filipović 2014: 201), it is usually found even if in small quantities (Chapter 4.1.4). A single free-threshing wheat rachis was found in chaff-rich sample 10. Free-threshing wheats are uncommon on Neolithic sites in Serbia (Filipović 2014: 198), possibly because their chaff would have been removed during threshing and not burnt (Table 5.2). The presence and role of free-threshing wheat in the Neolithic is explored in more detail in Chapter 9.

Lentils (*Lens culinaris* Medik.) are unlikely to become charred as their processing and cooking does not require direct contact with an intense heat source (as does the parching of cereals to facilitated de-husking, though see section 5.1.3.2) (Hillman 1981: Fig.6; 1984: Fig.2; Jones 1984: Fig.1). At Potporanj, however, 41 lentils were found across 82% (n=9) of samples. Their high ubiquity score may suggest that they were frequently used and constituted a substantial part of the diet, providing an important source of protein (Figure 7.3f).

Gathered fruits and nuts were present in all samples from 'occupation level 2' (samples 4-11), offering a glimpse into the broader range of non-cultivated foods which was probably consumed but is unlikely to have become charred (Antolín & Jacomet 2015; Colledge & Conolly 2014; Marinova *et al*. 2013). Bladder cherry, dwarf elder and cornelian cherry (*Cornus mas* L.) have the highest ubiquity scores. The latter two are very common in Neolithic contexts across the western Balkans (Chapter 8.3.2).

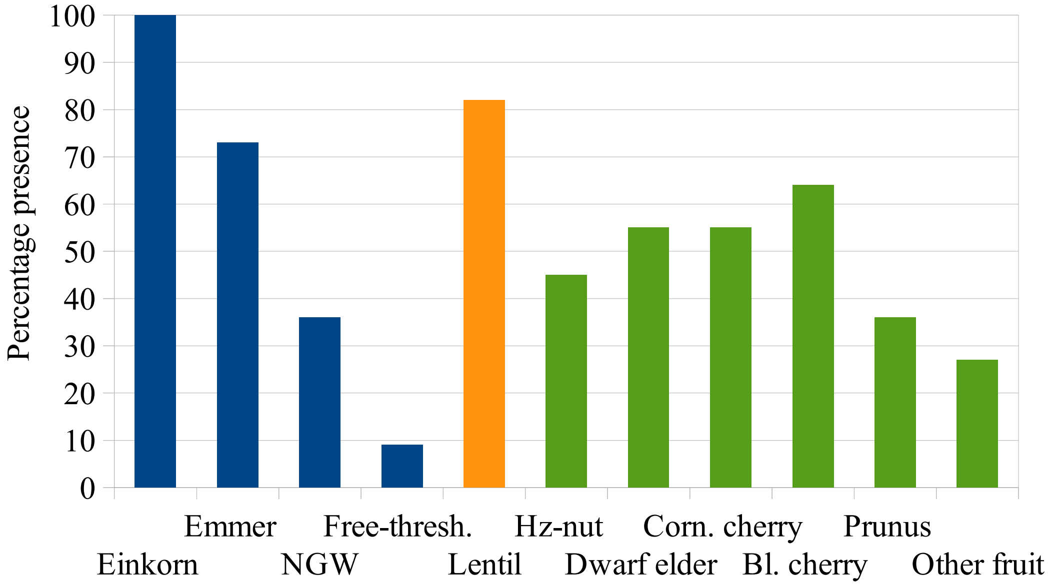


Figure 7.3f: Percentage presence (ubiquity across 11 samples) of the categories of plants found at Potporanj. Fruits in the 'other' column include a possible wild strawberry (*Fragaria vesca* L.) seed and unidentifiable fruit fragments.

Black bindweed seeds are the most ubiquitous of the non-cultivated species, possibly present in all samples (sample 11 contained a single possible seed, too badly preserved to be identified with certainty). Black bindweed is a climbing plant of ruderal and arable habitats, and is commonly found associated with cereals (Grime *et al*. 1988: 272; Hanf 1983: 396). Its leaves and seeds are edible (Redžić 2006: 202; though see www.pfaf.org which give seeds an edible rating of 1(low)). Three mineralised seeds were found but they were not associated with other mineralised fragments (of food or coprolite), and so are included as possible arable weed seeds rather than a gathered food. Black bindweed germinates in the spring and sets seed in the late summer to autumn (Grime *et al*. 1988: 272). Its persistent seed bank (Grime *et al*. 1988: 15; Chapter 5.4.10) and tendency to twine would have made it a difficult weed to eradicate. Two seeds of nipplewort (*Lapsana communis* L.) and mayweed (*Anthemis arvensis* L.) were recovered from samples 2, 4 and 6. There are no previous Neolithic records of mayweed for the western Balkans. Nipplewort is common in the LBK, though its status as an anthropochore shade-tolerant arable weed or as an apophyte from hedgerow species remains unclear (Bogaard 2004b: 27, 39; Kreuz & Schäfer 2011: 341). It has been found in BiH, at the mid-late Neolithic sites of Okolište and Donje Mostre (Kroll 2013a: 119, 121; 2013b: 236), and in Early Neolithic levels in Bulgaria (Marinova 2007: 105). Its presence at Potporanj at around 5200 cal. BC could indicate that nipplewort was introduced as an arable weed into the LBK. Wild millets, such as bristly foxtail and green foxtail (*Setaria verticillata* (L.) P. Beauv. and possibly *S. italica* (L.) P. Beauv.), were found in two samples. Other wild grasses include Brome grasses (*Bromus* sp.), which were the most abundant wild seeds in samples 4 and 5. Brome grasses identified to species from other Middle/Late Neolithic sites in the Pannonian Basin have short flowering periods starting in the early summer, and set seed in late summer/early autumn (Table 8.35). Such ecological attributes are associated with autumn sowing (Bogaard 2001: 1175; see also section 5.4.7). Additional wild plants are represented by poorly preserved seeds and fragments of seeds which could not be specifically identified, such as those in the small and larger legume categories (*Melilotus/Medicago/Trifolium* spp.), those in the bugleweed/germander group (*Ajuga/Teucrium* spp.), and those within the mint family (Lamiaceae types 1 & 2). Four sedge seeds (*Carex* spp.) were also present in sample 6, but could not be identified to species.

7.3.3 Exceptional samples

Whilst all samples appear to represent mixed waste from a range of activities (from grain processing and cooking to the consumption of nuts, fruits and possibly wild seeds and vegetables), four samples from 'habitation level 2' stand out as containing more of one particular type of plant macro-remain. Sample 5, from a layer just above the house floor, has the largest quantity of cereal grains (n=265), 27% of which were found as fragments (n=565, WGE=57). It contained six lentils, eight fruits and nuts and 61 wild/weed seeds, and has the highest grain/seed density (34 seeds/litre). The chaff is composed of 79 glume bases, 61% (n=48) of which was identified to einkorn. The grain to seed ratio is 4.3. but the glume base to grain ratio is 0.3 (79:265). Using only grain and glume bases identified to *T.monococcum*, the ratio is increased to 1.6 (48:30), which is close to the normal ratio of a single-grained einkorn spikelet. The ratio calculated on *T. dicoccum* is low: 0.1 (4:31). The relatively large category of grains and chaff that could not be specifically identified make any interpretation difficult but two are plausible: 1) the assemblage consists of single-grained einkorn spikelets and (mostly) naked/clean emmer, or 2) the assemblage is a mix of (mostly) naked emmer and einkorn. However, high firing conditions are indicated by the 'melted' grains, and it is likely that the original assemblage was richer in cereal chaff and wild seeds as these are more fragile. Ninety-four percent (n=315) of the wild plant seeds are 'big' and mostly (n=247) from large wild grasses. Perhaps the latter, being similar in shape and size to einkorn grains, were not easily removed or even intentionally retained. Indeed, it has been suggested that *Bromus* sp. may have been cultivated at Neolithic sites in North-East Italy (Rottoli & Castiglioni 2009: 94-97; Rottoli & Pessina 2007: 143-44). During the processing of glume wheats grain-sized weed seeds are removed during the later stages (e.g. hand sorting; Figure 5.1), along with any other remaining impurities. The assemblage recovered from sample 5 therefore seems to represent cereal processing by-products from the final stages of fine-sieving and hand-sorting. Mixed with these remains are cereal grains, lentils and fruit stones/pips, presumably lost/discarded during cooking and consumption.

Sample 6 from the floor in square B differs from the others in having about four times as many wild plant seeds as cereal grains. Fat-hen (*Chenopodium album* L.) and black bindweed make up 42% (n=54) and 23% (n=30) of the seeds respectively. For the purpose of categorising seed taxa in terms of processing activities, seeds of fat-hen are considered to be small, free and heavy (SFH), and those of black-bindweed big, free and heavy (BFH) (Jones 1984; Reed 2012: Table 6.2). The remainder of the weed seed assemblage consists of 18 BFH and 18 SFH seeds (see below). There are only 29 grains but 37 glume bases, creating a ratio of just over one glume base to every grain (1.3). Considering that grains survive carbonisation better than chaff (Boardman & Jones 1990), one can expect the pre-carbonisation ratio to have been higher and more representative of the 2:1 ratio in single-grained einkorn. It is possible therefore that whole spikelets were burnt. The association of spikelets with free, heavy seeds, both small and big, could represent the product of coarse sieving when spikelets are separated from large, headed seeds and coarse chaff such as straw (Table 5.1). Conversely, the high weed to grain ratio suggests the assemblage was a waste product, possibly from sieving before de-husking when weed seeds smaller than spikelets (but as big as or smaller than grains) would be removed, along with accidental losses of spikelets. It is interesting to note that fat-hen seeds are associated with black-bindweed and few cereal grains, whereas sample 5 rich in grains also had the highest density of wild grass seeds. Sample 6 seems to consist of waste from the cleaning of spikelets, and the association of fat-hen and black-bindweed seeds with cereal processing waste suggests that they were discarded weed seeds.

Samples 9 and 10 from the same ash-rich layer overlying the house floor in square D, had very high concentrations of glume wheat chaff, with glume base to grain ratios above 2. Sample 9 had just over three glume bases to every grain, and sample 10 almost seventeen glume bases per grain. This waste derives from the de-husking of glume wheats (Table 5.1). As is clear from Figure 7.3g the glume bases from sample 10 exhibited a wide range of sizes quite typical of a cereal ear in which the top spikelets will be riper and larger than those at the base. The complete absence of straw and the small proportion of weed seeds in both samples, and the numerous fragments of awns and rachis internodes in sample 10, suggest that the assemblages are of de-husking (e.g. pounding), rather than threshing waste (*cf*. Stevens 2003: 69). The absence of basal culm nodes suggests that wheat ears were not whole but had already been broken up into spikelets. The only evidence for free-threshing wheat at Potporanj was found in sample 10 (Figure 7.3h). Both samples contained a selection of big and small free, heavy seeds, which supports the interpretation of the assemblage as de-husking, rather than threshing waste (Jones 1984). Sample 9 contained the only headed seed: *Linum catharticum* L.

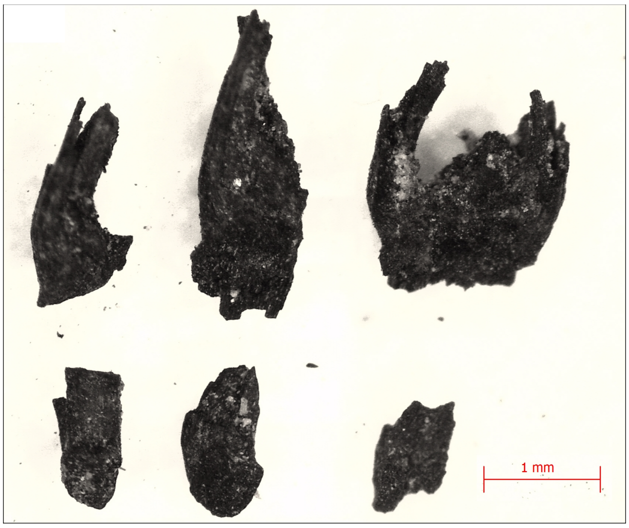


Figure 7.3g: A spikelet fork and glume bases from sample 10 showing the broad range of sizes.

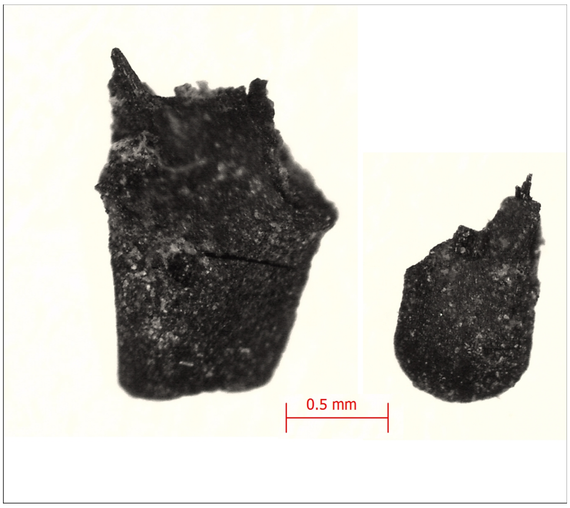


Figure 7.3h: Free-threshing (left) and hulled wheat (right) rachis internodes from sample 10.

Charred pieces with imprints of reeds or straw were found in sample 11 (Figure 7.3i). The provenance of these pieces remains unclear, as reeds and/or straw could have been used as matting, in wattle and daub walls and as roofing.

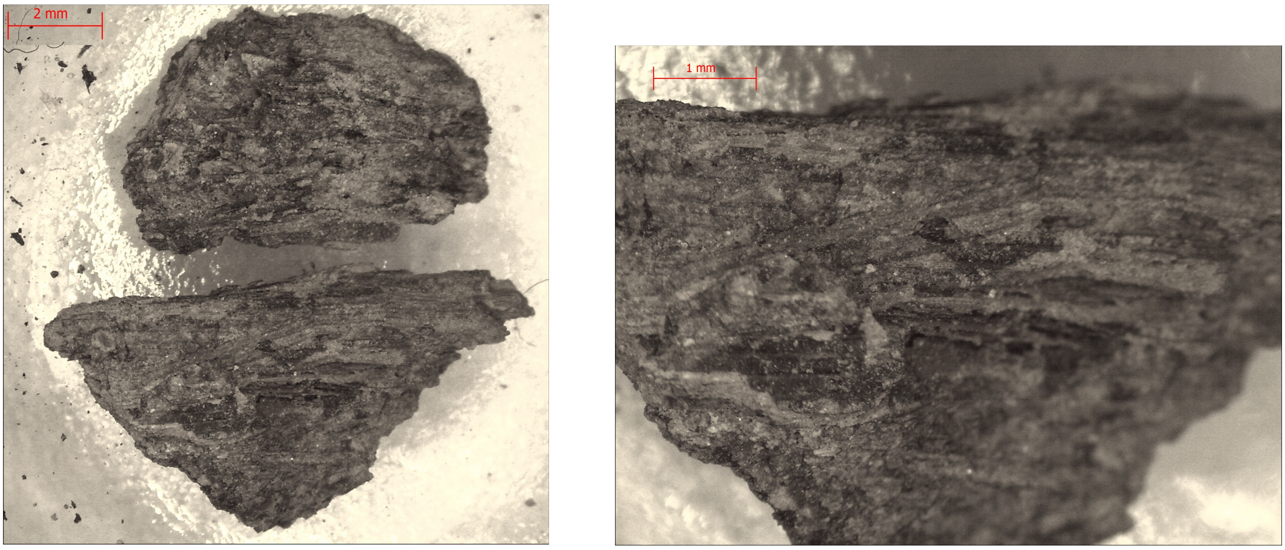


Figure 7.3i: Reed or straw impressions on charred fragments of daub/plaster.

7.3.4 Discussion

Excluding samples 2 and 3 which are from disturbed contexts, the plant remains indicate that crops of einkorn and emmer, as well as wild fruits, nuts and berries were processed and consumed within the structure excavated from habitation level 2. Single-grained einkorn was the most common and ubiquitous cereal. Emmer occurred in low quantities but in 73% (n=8) of samples. Free-threshing wheat is represented by a single rachis internode, and barley and pea are absent. Lentil is more ubiquitous than emmer and its contribution to the diet of the inhabitants of the sampled house must have been significant. The assemblages have not been detrimentally affected by adverse preservation conditions. Sample 5 is mostly composed of cooking and consumption waste/loss, mixed with some contaminants removed during the very last stages of cereal processing. The assemblage from sample 6 also contains the by-products of the final stages of cereal processing but, apart from a few nuts and fruits, without any obvious cooking or consumption remains. The assemblages from samples 6, 9 and 10 suggest that einkorn was stored as spikelets. Obvious storage structures were not detected during excavations and it may be that these were located elsewhere or that spikelets were kept in jars or baskets. The relatively low concentrations of weed seeds in samples 9 and 10 compared to sample 6 are surprising and may suggest that spikelets were sieved to remove weed seeds before de-husking commenced. The separation of weed seeds from chaff may have been advantageous if the former was reserved for animal feed or temper. Evidence for winnowing and threshing is missing, which suggests that these occurred outside the structure. There is no clear distinction of processing activities within the structure although the highest density of remains occurred in square D.

Fat-hen and black bindweed from the small range of weed seeds identified to species suggest that spring-sowing was practised. Brome grasses could be indicative of autumn-sowing although not all *Bromus* sp. species are specifically autum-germinating. Black-bindweed is a very competitive weed which may have also successfully grown in autumn-sown crops, quickly scrambling up the wheat plants in the spring (Grime *et al*. 1988: 272).

The manifestation of new species not hitherto, or poorly recorded, from Neolithic Serbia (nipplewort) and the western Balkans (mayweed, 'new' glume wheat), is exciting as it builds upon the relatively unknown archaeobotanical record for that period.

7.4 EUROFARM (Vander Linden *et al*. 2013)

Between 2012 and 2015 the EUROFARM team carried out several archaeological field seasons in two distinct areas of the western Balkans: northern BiH and south-eastern Montenegro. In collaboration with the Centre for Conservation and Archaeology of Montenegro, four caves were tested in the vicinity of Podgorica: Vezacka, Vruća, Čaja and Seocka. Due to time restrictions I only participated in the excavations of Seocka cave (2013 and 2014 field seasons) during which seven bulk soil samples of an average of 23 litres each were taken. However, OSL and ^{14}C (AMS) dates have since confirmed that the archaeological layers represent a Mesolithic site in secondary position (Vander Linden *et al*. 2014b). As a result, and due to the complete absence of Neolithic archaeobotanical data from Montenegro, no sites from that country are included in this thesis.

In collaboration with the Museum of the Republika Srpska, the Zavičajni muzej Gradiška and the Republic Institute for Protection of Cultural, Historical and Natural Heritage, three field seasons were organised in the Gradiška area, Republika Srpska, BiH. Directed by Dr. M. Vander Linden and Ms. Ivana Pandžić (Museum of the Republika Srpska), field surveys, augering transects, and test pits at selected sites were conducted in order to understand the settlement pattern and landscape use during the Neolithic period. These investigations arose from previous archaeological explorations originally focused on the Palaeolithic period (Pandžić 2014). The findings of a Neolithic site at Kočićevo led to a new research project: *Delayed neolithisation in the Western Balkans* which was launched in 2011 and dedicated to the Neolithic period. Excavations took place in March 2012 under the joint supervision of Ms. I. Pandžić and Dr. M. Vander Linden (then University of Leicester). Since October 2012 excavations of Kočićevo, as well as further investigations of the surrounding Neolithic landscape have fallen under the auspices of the EUROFARM project. (Pandžić & Vander Linden 2015)

Bulk soil samples were taken from five sites: Laminski Donje Dubrave, Laminski Jarużani, Laminski Jarużani Njiva, Kosjerovo and Kočićevo. The former has since been dated to the Bronze Age (Pandžić & Vander Linden 2015: 150-51) and its single sample will not be discussed any further. The six bulk soil samples from the other two Laminski sites were taken from buried soils exposed in 2x1m test pits (Appendix I, 1.4.1). Samples lacked any stratigraphical coherence and plant macro-remains were scarce. Despite larger excavations at Kosjerovo (Tr.4000: 4x2m and Tr.5000: 5x4m), only a buried soil was uncovered and few plant macro-remains were obtained (Appendix I, 1.4.3). Although results from the two neolithic Laminski sites and Kosjerovo are included in Chapter 8, they are not discussed further here.

7.4.1 Kočićevo (N 45.065 E 17.410) (Pandžić & Vander Linden 2015)

This Middle to Late Neolithic site lies on a gravel island in what was then a dynamic braided-river system (Marriner *et al.* 2015: 36). The site was first discovered in November 2009, on the alluvial plain of the Vrbas river, approximately 11km from the confluence with the Sava river and 6.5km from Bardača Lake, by Mr. G. Marriner (then IoA), Prof. C. French and Mr. T. Rajkovača (both from the Department of Archaeology, University of Cambridge). Their augering survey and examination of a profile exposed in a modern well revealed the presence of a buried soil and preserved archaeological features (Marriner *et al*. 2011: 11-13). Three 2x1m test pits opened in March 2010 confirmed the existence of a Neolithic settlement which led to a 15x2/3m trial trench being opened in March 2012. Only the western half of the trench was excavated as it was found that on the eastern side the riverbank sand lay at a depth of only 75cm below the plough soil. On the western side, “the first meter or so of deposits under the plough soil corresponds to three successive sedimentary horizons, each of them corresponding to a mixing of alluvial and colluvial sediments under the action of an ancient plough (or 'overbank'; contexts 1129-1131 [samples 3&4])” (Pandžić & Vander Linden 2015: 19). Indeed, the finds of bone and pottery in the upper two horizons were more fragmented than those from lower levels, indicative of intense physical disturbances. In context 1130 a large lump of red daub, possibly collapsed *in situ*, was found *c*.30cm beneath the plough soil. Although its date remains uncertain, a sample taken for flotation revealed three grains of broomcorn millet (*Panicum miliaceum* L.) which could suggest a Bronze Age or later date (Chapter 9.3). Underlying context 1131 lay a *c*.30-40cm thick buried soil which does not appear to have been disturbed (context 1132, samples 5-7). The low degree of fragmentation and discreet distribution of finds therein suggest that more recent intrusive activities have not reached the buried soil. A series of overlapping pits were found to have been cut into the buried soil and underlying natural sand; these were not sampled. Two animal bones from the pits provide a *terminus post quem* for the buried soil of 5000-4700 cal. BC (Edinborough & Vander Linden 2015: 138).

In March 2013, a smaller 5x5m trench was opened further up the slope. Under the plough soil and preserved over 60cm was the same 'overbank' horizon described in the 2012 trench (sample 8, 0-20cm below the plough soil). Contrary to the latter trench however, the 'overbank' lay directly upon the late Pleistocene / early Holocene compacted gravel; no buried soil was present. About 40cm under the modern plough soil, a fully articulated skeleton of a 30-50 year old female was uncovered (Radović 2015: 126-128). The absence of grave cut marks and the irregular positioning of the body suggests the body was not formerly buried. Six litres of the soil surrounding the skeleton were taken for flotation (sample 9), and a further three litres from soil under the skeleton but above the riverbank gravels (sample 10). The skeleton was dated twice: from a rib (5212-5020 cal. BC) and from a femur (5208-5147 cal. BC). Cutting into the skeleton was a post-hole (F.12, sample 16). Possibly contemporary with F.12 were a dozen small features noticed in the river gravels, underlying the horizon with the skeleton. Ten of these possible post-holes were sampled for plant macro-remains (samples 11-15 & 17-21).

Dates from F.2, the skeleton and other contexts indicate the site was used during the Middle-Late Neolithic (5200-4700 cal. BC; Edinborough & Vander Linden 2015: Fig.37). A preliminary study of the ceramics suggests the site belongs, from a typological perspective, to the Sopot culture (Vander Linden *et al*. 2014a: 15). Disentangling finer phases of settlement within the archaeobotanical record is inadvisable due to the lack of clear separation between features and the likelihood of post-depositional disturbances during the site's various occupations.

In total 21 bulk soil samples were collected during the excavations, equating to 115 litres of soil. However, plant macro-remains from mixed layers above the skeleton (whose condition indicates that samples 9&10 came from layers with minimal post-depositional disturbance) and the buried soil must be interpreted with caution as they could in fact date to the Bronze Age or later periods. Bulk soil samples were processed during the excavations. In 2012 samples were taken and processed by Dr. K. Reed (then University of Leicester, now Warwick University). Bucket flotation was used, with a 250µm mesh for the flots and a 1mm mesh for the residues. Thereafter Ms. D. Koljić (Museum of Kljuc, BiH) and I processed samples using a Siraf-type flotation tank (Williams 1973). Samples were floated next to the Zavičajni muzej Gradiška where there was a constant fresh water supply and good drainage into the Sava river. A 300µm mesh was used to collect the flots and a 1mm mesh retained the heavy residues. Both flots and heavy residues were left to dry indoors. All recovered plant macro-remains are listed in Table 1.10, Appendix I.

7.4.2 Trustworthy contexts?

The buried soils discovered at the four excavated sites contain high densities of ceramics, which on first inspection, date to the Middle/Late Neolithic (Pandžić & Vander Linden 2015; Vander Linden *et al*. Unpublished). As mentioned above, this attribution is corroborated by radiocarbon dates from Kočićevo whose deep buried soil appeared relatively undisturbed despite the presence of overlying Bronze Age artefacts. Radiocarbon dates were not obtained from either of the Laminski sites, and the small exposed areas make it difficult to evaluate the intactness of the buried soils and the nature of the prehistoric occupations. Above the buried soil at Kosjerovo ceramics indicative of a Bronze Age presence were found within TP13 but not further north in trenches 4000 and 5000. Indeed, charred Fabaceae seeds from sample 11 in TP13 were radiocarbon dated to the Late Bronze Age (*c*.1400-1250 cal. BC). The latter illustrates the high potential for latitudinal movement of small artefacts within soil profiles, and the risk of sampling beyond closed archaeological contexts. Further complications arise from the limited interpretative value of plant macro-remains found in open contexts (e.g. Hubbard & Clapham 1992). The samples from the buried soils fall within Hubbard and Clapham's 1992 'Type C' category which prevents the evaluation of plant macro-remains unless these are found in quantities sufficient to reflect routine activities (Chapter 5.1.4). Unfortunately, charred seeds, grains and chaff were very sparse in all the buried soil samples, rendering any interpretation incongruous (Tables 1.8 and 1.9, Appendix I). Consequently, only plant remains from Kočićevo, and only those from the more secure contexts are described and interpreted below (samples 5-7 and 9-21, in bold in Table 1.10, Appendix I).

Sample	**5**	**6**	**7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Context	1132	1132	1132	1157	1166	1193	1194	1195	1196	1197	1198	1199	1200	1203	1206	1209	
Sq./Feature/cm from plough soil	B15	A12	A13	20-40	A1-2	F.9	F.8	F.13	F.11	F.2	F.12	F.7	F.6	F.14	F.15	F.16	**Totals**
Sample volume (L)	3	5	1.5	6	3	8	9	9	7	9	7	4	3	7	2	7	**90.5**
Total Barley						1 cf.	1										**2**
Total free-threshing wheat								1									**1**
Total emmer		6			1			5		1	1	1					**15**
Total grains (incl. indet. grains)	**1**	**12**	**0**	**1**	**4**	**2**	**2**	**24**	**0**	**3**	**3**	**4**	**1**	**1**	**3**	**0**	**61**
mean/L	0.33	2.40	0	0.17	1.33	0.25	0.22	2.67	0	0.33	0.43	1	0.33	0.14	1.50	0	**1**
Preservation index – mean	0	1.4	/	1	1	1	1	1.3	/	0.5	1	1	0	0	0.7	/	**0.8**
mode	0	1	/	1	1	1, 0	2, 0	1	/	0	1, 2	1	0	0	1	/	**1**
Fragmentation index	N/A	2.8	/	0	1.3	0.5	3	0.7	/	1	4	2.7	/	/	2	/	**1.8**
Total glume bases	**0**	**111**	**5**	**2**	**2**	**0**	**0**	**3**	**0**	**1**	**3**	**0**	**6**	**0**	**1**	**0**	**134**
mean/L	0	22.20	3.33	0.33	0.67	0	0	0.33	0	0.11	0.43	0	2	0	0.50	0	**1.4807**
Glume base:grain ratio	0	9.3	/	/	0.67	0	0	0.1	/	0.3	1	0	6	0	0.3	/	**2.1967**
Total pulses		**1**									**1**						**2**
mean/L	0	0.2	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	**0.0221**
Total fruits and nuts		**1**					**1**										**2**
mean/L	0	0.2	0	0	0	0	0.11	0	0	0	0	0	0	0	0	0	**0.0221**
Total wild/weed seeds	**1**	**0**	**0**	**0**	**3**	**2**	**2**	**1**	**0**	**0**	**5**	**0**	**2**	**1**	**2**	**1**	**20**
mean/L	0.33	0	0	0	1	0.25	0.22	0.11	0	0	0.71	0	0.67	0.14	1	0.14	**0.22**
Grain:seed ratio	1	/	/	/	1.3	1	1	24	/	/	0.6	/	0.5	1	/	0	**3.05**
Non-cereal P.I. - mean	0	/	/	/	1.3	0.5	0.5	2	/	/	0.2	/	0.5	1	/	2	**0.9**
mode	0	/	/	/	1	0, 1	0, 1	2	/	/	0	/	0, 1	1	/	2	**0, 1**
Grain/Seed density	**0.67**	**3**	**0**	**0.17**	**2.33**	**0.5**	**0.56**	**2.78**	**0**	**0.33**	**1.29**	**1**	**1**	**0.29**	**1.5**	**0.14**	**2.43**
№ items / litre (ex. charcoal)	**2.67**	**31.20**	**7.33**	**0.50**	**7**	**0.50**	**0.56**	**3.11**	**0**	**0.44**	**1.71**	**1**	**3**	**0.29**	**2**	**0.14**	**3.03**

Table 7.4: Summary results from the analysis of flots from Kočićevo.

7.4.1.1 Preservation

All plant-macro remains were preserved through carbonisation. Charcoal was present in all samples but was mostly heavily comminuted to fragments smaller than two millimetres. The >4mm fragments were more commonly found in the heavy residues, demonstrating their lack of buoyancy during flotation. The plant remains were poorly preserved with most grains being badly puffed and fragmented, making identifications difficult. Overall the cereal grains have a mean F.I. of 1.8 and a P.I. of 0.8 with a mode of 1 (Table 7.4), which defines the preservation of cereal grains as very bad to poor and moderately fragmented. The correlation between sample volume and total number of grains is weak (Pearson's $r = 0.3$), which suggests that the variation in the number of grains per sample cannot be accounted for by the volume of soil floated. The samples' F.I., P.I. and total number of cereal grains are plotted in Figures 7.4a and 7.4b, by ascending F.I. The F.I. varies between zero in sample 9, that contained a single whole grain, and four in sample 16 where one of the three grains was represented by eight fragments. Whereas one might expect a decrease in the P.I. as the F.I. rises, there is no linear relationship between the indices, suggesting that the overall low quantity of caryopses is not a direct outcome of adverse pre/post-depositional conditions. Nor is there a clear unidirectional relationship between the total number of grains and either of the indices. Differences are apparent between the two 'richer' samples: samples 13 and 6 have very similar P.I., suggesting that the grains are preserved to the same level. However, the F.I. in sample 6 is much higher (2.8 compared to 0.7), indicating that its lower number of grains may be due to fragmentation processes effectively turning carbon structures into dust. Cereal chaff is poorly preserved (89% (n=119) of glume bases could not be identified beyond that of a glume wheat) and rare in all but sample 6.

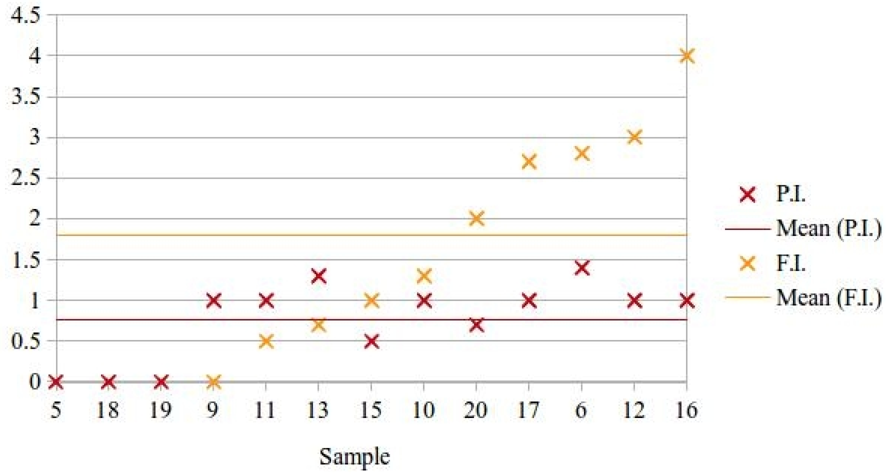


Figure 7.4a: Preservation and fragmentation indices by sample. Plotted by ascending F.I.

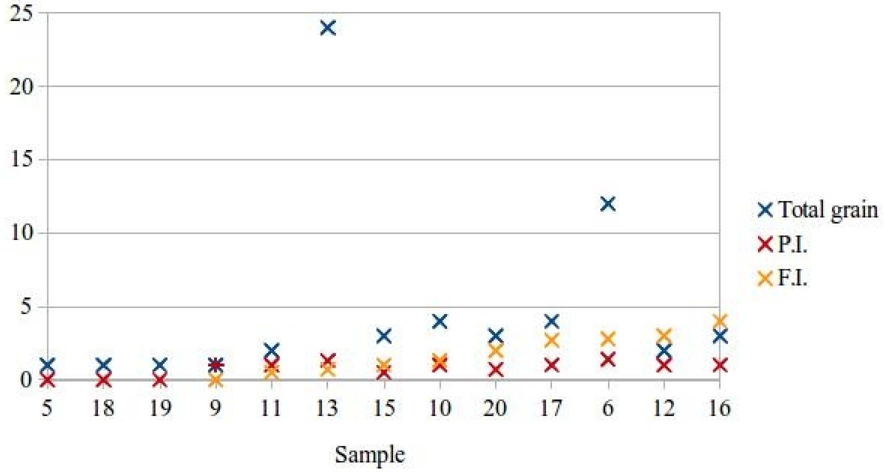


Figure 7.4b: Preservation and fragmentation indices in relation to the number of cereal grains by sample. Plotted by ascending F.I.

The non-cultivated seeds are not quite as well preserved as the cereal grains. They have a mean P.I. of 0.9 (mode of 0 & 1), which describes their preservation as very bad to poor. The only sample where the non-cereal P.I. is higher than the cereal P.I. is sample 13. Seeds were found in 56% (n=10) of samples and the largest quantity was five in sample 16. The lack of any correlation between grain/seed density (excludes charcoal and chaff) and the preservation indices suggests that the total number of plant macro-remains is not related to preservation conditions.

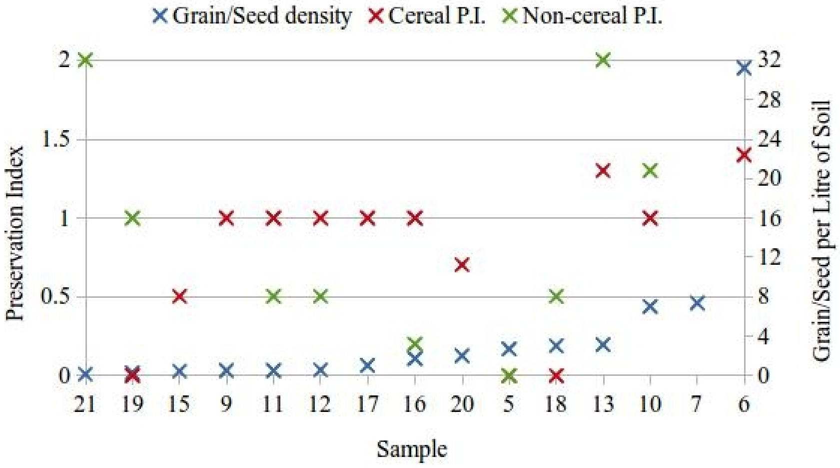


Figure 7.4c: Preservation indices and the grain/seed density by sample. Plotted by ascending grain/seed density.

7.4.1.2 The crops, gathered flora and other wild plants

Glume wheats are the dominant cereals, and most of their remains could not be identified beyond *Tiritcum* sp. or *T. monococcum/dicoccum*. Three items in two samples were specifically identified to einkorn, whilst 16 items of emmer were found across six samples. Hulled barley is present as one, possibly two, grains. Free-threshing wheat (*T. aestivum/durum*) is present as a single grain in sample 13. Sample 13 also holds the largest concentration of cereal grains: 24, and only three glume bases and one wild/weed seed. Another cereal-rich sample is sample 6, with only 12 grains but 111 glume bases. It also contained a pea (*Pisum sativum* L.) and a cornelian cherry stone but no wild/weed seeds. Apart from an indeterminate legume (large Fabaceae) in sample 16 and a fruit stone fragment in sample 12, no other evidence for cultivated pulses or gathered fruits and nuts was found. About 13 weed taxa were found, only one of which could be identified to species. The taxa only occurred as single specimens. At least three of the species (sedge/rushes (Cyperaceae), meadow-rue (*Thalictrum* sp.) and redshank (*Persicaria maculosa* Gray.)) are indicative of damp ground.

7.4.1.3 Discussion

The overall low number of items per litre does not seem to be a direct result of adverse preservation conditions. Archaeobotanical remains were preferentially recovered from the buried soil (samples 5-10), rather than the pits/post-holes (samples 11-21). The buried soil contained most of the cereal processing waste, along with pea, cornelian cherry and possibly other food waste (42 unidentifiable fragments). Although the assemblages are small, concentrations of clean grain, namely in sample 13, and waste from the final stages of glume wheat cleaning, namely in sample 6, are present. The archaeobotanical and archaeological remains are suggestive of a domestic structure(s) were crops were processed and consumed. The overall low presence of weed seeds (range 0-5), particularly in the chaff- and grain-rich samples could be explained through three possible scenarios:

1) cereal processing waste was rarely burnt, or if burnt discarded beyond the sampled area;

2) the harvesting method avoided most weeds, as would the individual plucking of ears;

3) cultivation plots were intensively managed, which included regular weeding, as has been postulated for early farming communities in Europe (Bogaard 2002a, 2004b, 2005; Bogaard *et al.* 2013, but see also Bogaard *et al.* 2016a and Jones 2005: 173-74).

Scenario one is a distinct possibility but does not explain the significant discrepancy between chaff and weed seeds. Scenarios two and three could explain the low presence of weed seeds and are further explored in Chapter 9.5.

7.5 Korića Han (N 44.69, E 18.29) (Kosorić 1972, 1980)

The tell site of Korića Han lies *c*.2km South-West from the centre of Gračanica, in the Federation of BiH. The Sokoluša and larger Spreča rivers flow *c*.200m and 1km from the mound, respectively. The existence of a prehistoric settlement was first discovered in the spring of 1971 when workers where digging foundations for a new construction. Excavations then ensued, initially by surveying a surface of *c*.7.5m^2, followed by opening a 3x5m trench on the eastern side of the mound. The depth of deposits varied between 2.7m and 3m. Well preserved structures with burnt daub and charcoal were apparent, along with many flint and ceramic artefacts, including a statuette. From 1972-75 a further nine trenches were excavated which confirmed the existence of a Middle-Late Vinča (Vinča C and D) settlement (dated through ceramic typologies; *c*.5000-4400 cal. BC following Whittle *et al*. 2016: Fig.37).

In March 2015 Mr. A. Jasarević (curator of the Regional Museum in Doboj, Republika Sprska, BiH) gave me a jar containing 620ml of burnt cereal grains from Korića Han. Neither of the two publications about the site mention the retrieval of carbonised grains (Kosorić 1972, 1980), so it is not known where the grains came from or how they were collected.

Total Flot volume (ml)	620
Total Flot weight (g)	227.28
Fraction sorted	**1/16**
Charcoal >4mm	- -
2-4mm	+
<2mm	++
volume (ml)	0.5
Hordeum vulgare sl.	43
H. vulgare ssp. *nudum*	25
twisted naked barley	5
straight naked barley	96
Hordeum / Triticum sp.	16
T. monococcum, 1-grained	286
T. monococcum, 2-grained	13
T. monococcum	26
Triticum cf. d*icoccum*	7
T. monococcum/dicoccum	461
Secale cf. *cereale*	7
cf. *S. cereale*	2
Total grains	**987**
Preservation index – mean	2.4
mode	2
Fragmentation index	2.9
Est. whole grains in flot	**15792**
Cereal grain frags. weight	4.79g
Fragments >1mm	1592, 1.81g
Fragments <1mm	2.98g, 442 in 1g
Est. frags. in total flot	46547
WGE (1 = 0.00985g)	7781
Est. total grains	**23573**
T.mono./dicoccum gl. base	1
Indet. wild grass frags.	13
Lens culinaris	1
Fallopia convolvulus	2

Table 7.5: Plant macro-remains from 1/16th of the assemblage of burnt grains. An additional 16th was sorted but no new taxa were recovered.

7.5.1 Preservation

All plant macro-remains were carbonised. Charcoal concentrations were low; fragments were mostly heavily comminuted and smaller than two millimetres. Overall the cereal grains have a mean F.I. of 2.9 and a P.I. of 2.4 with a mode of 2, defining their preservation as fair with moderately high fragmentation. The majority of the larger fragments appear to have fresh breaks, exhibiting crisp, porous scars suggestive of post-carbonisation fragmentation (Huiru unpublished; Valamoti 2002). A well preserved lentil and three black bindweed seeds have a mean P.I. of 2.8.

7.5.2 The crops, gathered flora and other wild plants

Single-grained einkorn appears to be the dominant crop (n=286), as no grains could be specifically identified to emmer. Naked barley (*Hordeum vulgare* ssp. *nudum*) made up 13% (n=126) to 17% (n=169, including other barley grains) of the flot. Only 5% (n=6) of the better preserved naked barley grains had twisted ventral grooves, suggesting a 2-row variety is predominantly present in the assemblage. Seven to nine rye (*Secale* cf. *cereale* L.) grains were also found. The only item of chaff was an einkorn/emmer glume base, and wild/weed seeds consist of three black bindweed seeds.

The breadth and thickness of 70 of the better preserved caryopses (with no obvious breaks, puffing or distortion) were measured and plotted against 184 other domesticated Neolithic emmer and einkorn grains (Fuller *et al.* 2017). Despite some overlap, the majority of emmer and einkorn grains are distributed into two main size clusters.

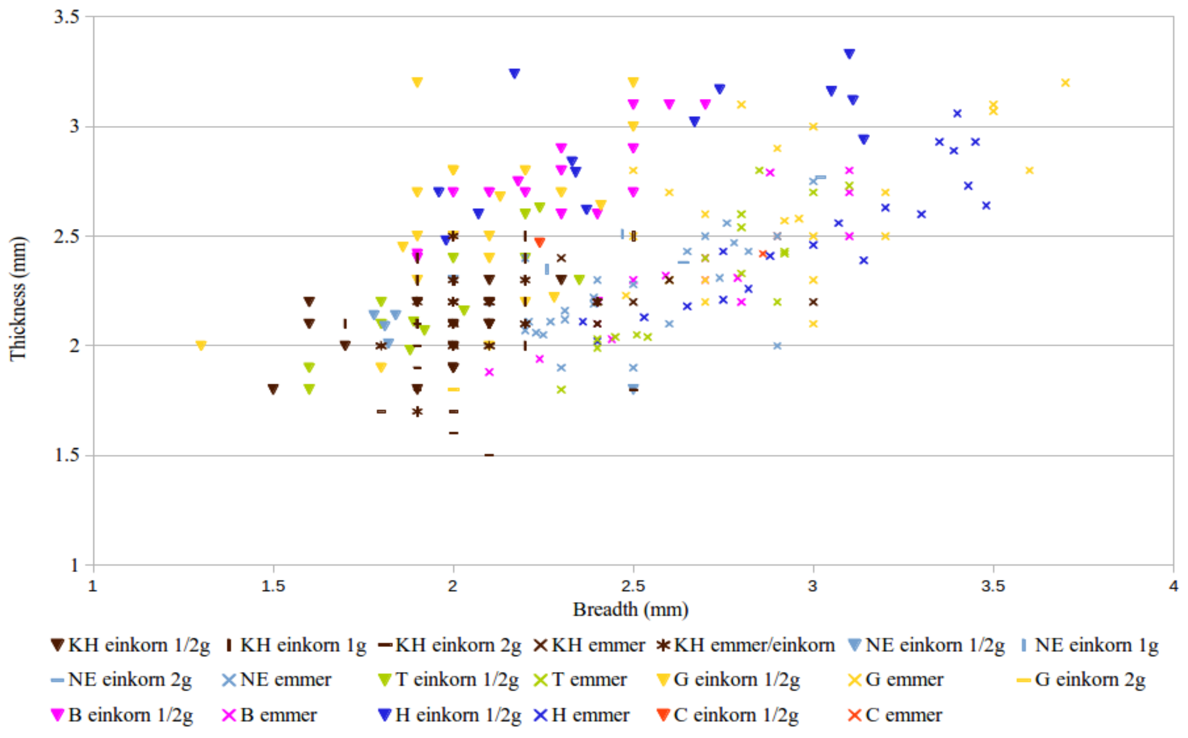


Figure 7.5: Thickness to breadth ratios of Neolithic emmer and einkorn caryopses. Grains from Korića Han are represented in dark brown (KH). NE = Syria, Iraq, Jordan and Palestine; T = Turkey; G = Greece, Cyprus, Crete and Macedonia; B = Bulgaria; H = Hungary, C = Croatia. Note that the axes start at 1mm, not 0.

Emmer and einkorn from the 'G' group have the broadest range of sizes. The group includes five Late Neolithic grains from Greece (*c*.5000-4500 cal. BC, from Saliagos, Dimini, Pyrasos and Dikili Tash (Fuller *et al.* 2017)). The einkorn grain from Dikili Tash is one of the thickest but is relatively narrow (top left yellow triangle). The emmer grain from Saliagos is also one of the thickest but, again, relatively narrow, plotting next to einkorn from Hungary and Bulgaria. The other Late Neolithic grains from the 'G' group plot within the range of Early Neolithic ones. The narrowest einkorn is from Thessaly (Greece). All Bulgarian grains are from the Early Neolithic (late 6th to early 5th millennium BC). The 32 Hungarian grains come from two Late Neolithic sites: Battonya-Parazrtanya (*c*.4700-4300 cal. BC, Tisza/Herpály culture), and Berettyóújfalu-Szilhalom (*c*.4400-4200 cal. BC, Tisza culture) (dates from Guylai 2010a: supplementary tables).

The grains from Korića Han (in brown) are clustered towards the smaller end of the chart, although some outliers are evident. The einkorn grains cluster with those from Turkey, the Near East and two specimens from southern Cyprus. Einkorn from Bulgaria, Hungary and most of the 'G' group are larger. Korića Han grains that could be identified to 2-grained einkorn are slightly thinner than grains within the main Korića Han einkorn cluster, and are much smaller than the emmer grains they were found with. This is in contrast to 2-grained einkorn and emmer from the Near East which seem to have similar breadth and thickness ratios. Single-grained Korića Han einkorn, having had more space to grow within their glumes, are slightly broader than other einkorn grains from the same assemblage, and compare well with those identified from the Near East. The emmer/einkorn grains from Korića Han fall mostly within the einkorn (1 or 2 grained) group which is fitting for an assemblage dominated by einkorn. Korića Han emmer grains are distinct from the einkorn grains and mostly group within the smaller range for emmer. They do not seem to cluster with any geographical area in particular. The broadest Korića Han emmer grain has a breadth of 3mm and a thickness of 2.2mm. All areas demonstrate a broad range of emmer sizes, although some from Greece and Hungary are noticeably larger.

7.5.3 Discussion

The well preserved large concentration of cereal grains from Korića Han probably represents an *in situ* deposit of grains. It is estimated that about 15,800 grains were recovered (Table 7.5), with a predominance of single-grained einkorn. The deposit consists of clean einkorn with a few additional cereals inadvertently included during processing or from contaminants in the field (Jones & Halstead 1995). Rye is extremely rare and has only been noted at seven other sites in the research area (all Middle/Late Neolithic, Chapter 8.2.2.1). This assemblage is reminiscent of the large concentrations of einkorn found in the storage units at the Late Neolithic Serbian site of Selevać (Hopf 1974; Obradović unpublished).

The sizes of emmer and einkorn are mainly distributed within the smaller range of other Neolithic specimens. The separation between emmer and 2-grained einkorn is unusual and may suggest the latter are in fact smaller, unripe or under-developed single-grained caryopses (*cf*. Kroll 1992). Less well preserved grains assigned to emmer/einkorn appear to be part of the larger einkorn assemblage. The distribution of emmer and einkorn sizes does not follow a clear linear chronological trend. After selective pressures towards increased seed size during domestication (Fuller *et al*. 2014b; Lucas *et al*. 2012: 123-127; Purugganan & Fuller 2011: 176-79), the variation in sizes of emmer and einkorn as the crops were taken into Europe may reflect different adaptations to local conditions, or different husbandry regimes (*cf*. Dennell 1978: 150; Fuller *et al*. 2014b: 6149). Grains from another late Neolithic site (Bapska House 3, section 7.6.2) are also compared to the same assemblage, and variations in sizes are jointly discussed in the final part of this chapter (section 7.8).

7.6 Gradac, Bapska (N 45.19, E 19.26) (Burić 2009; 2011; Burić & Težak-Gregl 2009)

The Late Neolithic tell site of Gradac Bapska (hereafter, Bapska) lies in the village of Bapska, between Šarengrad and Šid on the eastern border of Croatia. It is positioned alongside a tributary of the Spačva and *c*.5.7km from the Danube. Dr. M. Burić (University of Zagreb, Department of Archaeology) began excavations at Bapska in 2006, opening new areas as well as trenches from previous excavations (Dimitrijević's old trenches; Appendix I, 1.5). A radiocarbon date was obtained from charred grains found a depth of 0.5 – 0.7 meters, placing the site within the Late Neolithic: 4680-4460 cal. BC (Burić & Težak-Gregl 2009: 89). Site reports, both unpublished and published, are not yet available from Burić's excavations.

I was sent flots from two excavation seasons. In 2013 495 litres of soil were sampled from 'floor 102': a black, burnt horizon in the southern corner of 'House 2' (M.Burić pers. comm. 16/07/15) and collected as seven different flots. Previously (date not specified) a rich deposit of burnt grain was sampled in 'House 3' (further contextual information is missing). The samples were floated using a Siraf-type flotation tank. The mesh size used was not recorded but recovered seeds indicate that a mesh no larger than 0.5mm was used. The sample from House 3 was separated into two sizes during flotation, and stored in glass jars labeled 'larger sieve' and 'fine sieve'. Heavy residues were not sorted or retained. Plant macro-remains from the two houses are described separately below, under House 2 (Bapska H2, Table 7.6a) and House 3 (Bapska H3, Table 7.6c).

7.6.1 Bapska House 2

As the flots were very large, and as is explained in Chapter 6.1.1, only sub-samples were sorted. Additional sub-samples were scanned for any new taxa and although none were found identifiable grains were recorded. Of interest is the discrepancy between the number of whole grains within fractions of the same sample, which in samples 2 and 4 varies by a factor of almost two. Whilst such differences may not skew the interpretation of grain-rich samples, particularly where one species dominates, large flots with few grains and/or seeds may be more negatively affected.

7.6.1.1 Preservation

All but two plant macro-remains were carbonised. A mineralised seed of lamb's lettuce (*Valerianella locusta* (L.) Laterr.) was found in sample 6 and a silicified seed of *Anchusa* sp. in sample 1. The charcoal was heavily comminuted and mostly smaller than two millimetres. Concentrations appeared relatively high, but may not be very accurate: due to the large number of cereal grain fragments, it was difficult to distinguish between grain and charcoal pieces of less than one millimetre. The cereal grains have a mean F.I. of 230 and a P.I. of 0.1 with a mode of 0, which defines their preservation as very bad and extremely fragmented. Table 7.6b, presented in order of ascending F.I. shows how the P.I. decreases as the F.I. increases, demonstrating that the original assemblage of grains has clearly been adversely affected by fragmentation. This correlation does not necessarily apply to the total number of grains: sample 5 with the highest number of grains does not have the lowest F.I., though sample 1 with the lowest number of grains does have the highest F.I. and lowest P.I. The majority of the larger fragments (>1mm) had smooth, sometimes bubbly scars with a 'melted' aspect, suggesting the grains were broken prior to carbonisation (Huiru Unpublished; Valamoti 2002). Though infrequent, the non-cultivated seeds were far better preserved, especially those from edible fruits and nuts. They have a mean P.I. of 2.1 and a mode of 2.3, which describes their preservation as fair.

Sample	**1**	**1**	**2**	**2**	**3**	**3**	**4**	**4**	**5**	**5**	**6**	**7**	**Totals**
Sample volume (L)	70		100		70		60		100		55	40	**495**
Total flot volume (ml)	49		91		91		76		107		82	103	**599**
Fraction sorted	¼	¼	1/8	1/8	1/8	1/8	1/8	1/8	1/16	1/16	1/8	1/16	
Sorted fraction weight (g)	8.9		10.1		9.8		9.5		7		9.5	6.5	
Charcoal >4mm		-	-	-	- -	-	- -	-	- -	-			
2-4mm	+	- -	+	- -	+	+	+	- -	+	- -	- -	+	
<2mm	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	
volume (ml)	5	5	6	6	5	5	4	4	5	5	6	4	
Estimated volume/ flot (ml)	20		48		40		32		80		48	64	**332**
Cereals													
T. monococcum, 1-grained	3		1										**4**
T. dicoccum		2	1				2				1		**6**
T. monococcum/dicoccum	8	9	14	28	42	31	29	56	44	23	24	43	**351**
Indet. glume wheat grain			7	4		2	6				1	2	**22**
Triticum sp.	6			1	2	15	2	1		1	12	8	**48**
Indet. cereal grains				11	21	10	3	23	5	6	2	2	**83**
Total grains	**17**	**11**	**23**	**44**	**65**	**58**	**42**	**80**	**49**	**30**	**40**	**55**	**514**
Preservation index mean	0.04		0.08		0.12		0.15		0.16		0.09	0.21	**0.12**
mode	0		0		0		0		0		0	0	**0**
Fragmentation index	518		383		131		168		144		188	82	**230.3**
Weight of fragments (g)	8.43		9.31		8.2		8.43		5.95		8.42	4.93	**53.67**
WGE, for flot (1 = 0.01825g)	1848		4081		3595		3695		5216		3691	4322	**26448**
Est. total grains in flot	**1904**		**4349**		**4087**		**4183**		**5848**		**4011**	**5202**	**29584**
mean/L	27.2		43.49		58.39		69.72		58.48		72.93	130.05	**59.77**
T. dicoccum sp. fork											1		**8**
Fruits and nuts													
Physalis alkakengi	1		1	2	2	1	1		1		3	3	**15**
Sambucus ebulus							1						**1**
Total	**1**		**3**		**3**		**2**		**1**		**3**	**3**	**16**
Est. Total in flot	**2**		**12**		**12**		**8**		**8**		**24**	**48**	**114**
mean/L	**0.03**		**0.12**		**0.17**		**0.13**		**0.08**		**0.43636**	**1.2**	**0.2303**
Wild/Weed seeds													
Anchusa sp.	1S												**1**
Chenopodium album									1				**1**
Caryophyllaceae							1						**1**
Lamiaceae					1								**1**
Valerianella locusta											1M		**1**
Total seeds	**1S**		**0**		**1**		**1**		**1**		**1**	**0**	**5**
Est. total seeds in flot	**2**		**0**		**4**		**4**		**8**		**8**	**0**	**26**
mean/L	0.03		0		0.06		0.07		0.08		0.15	0	**0.05**
Non-cereal P.I. mean	2		2.3		2.3		1.6		2.5		2.3	1.9	**2.13**
mode	2		3		2		2		2, 3		2	2	**2**
Est. grain:seed	952		/		1022		1046		731		501	/	
№ items/litre (ex. charcoal)	**27.3**		**43.6**		**59**		**69.9**		**60.3**		**73.7**	**132.1**	**60**
Indet. Poaceae fragments	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	
Intrusive modern seeds											P	P	

Table 7.6a: Plant macro-remains from Bapska House 2, quadrant A5, stratigraphic unit 102.

Sample	**7**	**3**	**4**	**5**	**6**	**2**	**1**	**H3**
Total grain	5202	4183	4087	5848	4011	4349	1904	32089
mean P.I.	0.21	0.12	0.15	0.16	0.09	0.08	0.04	1.6
mean F.I.	82	131	168	144	188	383	518	9.35

Table 7.6b: The preservation and fragmentation indices of samples, presented in order of ascending F.I.

7.6.1.2 The crops, gathered flora and other wild plants

Emmer and single-grained einkorn were the only cereals identified. The majority of the grains could only be identified to einkorn/emmer. The single element of chaff (emmer spikelet fork) was found in sample 5. Bladder cherry seeds are ubiquitous across the samples, and are likely to have been a gathered fruit rather than a rampant crop weed. If the latter were true one would expect other weed seeds to also be present. Dwarf elder was also noted, though only in sample 4. Both of the possible weed seeds identified to species are from edible plants (fat-hen and lamb's lettuce).

7.6.1.3 Discussion

The well preserved wild/weed and fruit seeds may not have been originally associated with the cereal grains, which are very badly preserved. Although they were all found in the same deposit, they are unlikely to have all been handled together or indeed in the same way. The grain-rich deposit in House 2 seems to represent an abundance of clean, but heavily fragmented emmer and einkorn grains. Since many grains appear to have been broken before carbonisation, the fragments may have resulted from grinding and/or cooking, to which were added other food/cereal processing wastes. The charring of a food (some sort of porridge, bulgur or *friké* - Hubbard & al Azm 1990) is also a possibility. It is not known how many burning/dumping episodes the deposit represents.

7.6.2 Bapska House 3

As is explained above (section 7.6), the flot was collected as two different size fractions. So as to avoid damaging the remains and combining them unevenly, the two parcels were sub-sampled and sorted separately.

Jar labelled:	**'Larger sieve'**	**'Fine sieve'**
Total Flot volume (ml)	263	870
Total Flot weight (g)	118	357
Fraction sorted	**1/16**	**1/32**
Charcoal >4mm		-
2-4mm	- -	+
<2mm	- -	++
volume (ml)	<1	2.5
H. vulgare ssp. *nudum*	6	1
Naked barley/emmer, puffed rounded grains	11	
Triticum d*icoccum*	367	30
T. monococcum, 1-grained	13	3
T. monococcum	1	
T. monococcum/dicoccum	43	147
Triticum sp. glume wheat		4
Total grains	**441**	**185**
Preservation index – mean	2.6	0.5
mode	3	0
Fragmentation index	0.2	18.5
Est. whole grains in flot	**7056**	**5920**
Cereal grain frags. weight	1g	10.4g
Ceralia fragments >1mm	101	2949
Ceralia fragments <1mm		4.4g, 463 in 1g
Est. frags. in flot	1616	159558
WGE (1 = 0.01825g)	877	18236
Est. total grains	**7933**	**24156**
Fallopia convolvulus		2

Table 7.6c:Plant macro-remains from sub-samples of the assemblage of burnt grains. Two additional fractions of the 'fine sieve' were sorted but the only new taxa was a single seed of fat-hen.

7.6.2.1 Preservation

All plant macro-remains were carbonised. Charcoal concentrations are low; fragments are mostly heavily comminuted and smaller than two millimetres. As expected, the two parcels produced very different cereal indices. Overall the cereal grains have a mean F.I. of 9.3 and a P.I. of 1.6 due to the large quantities of fragments in the 'fine sieve' parcel (Table 7.8a). The grains' preservation is subsequently defined as poor and highly fragmented, despite the large number of whole, well preserved caryopses. The majority of the larger fragments and grains that have split longitudinally (section 6.1.3) appear to have fresh breaks, exhibiting crisp, porous scars suggestive of post-carbonisation fragmentation (Huiru Unpublished masters; Valamoti 2002). The three non-cultivated seeds found in the 'fine sieve' fractions are fairly well preserved.

7.6.2.2 The crops, gathered flora and other wild plants

Emmer was the dominant crop (n=397). A little einkorn (n=17), possibly all of the single-grained variety, and even less naked barley (n=7) were also found. The whole emmer grains are very plump and much wider than any of the grains from Korića Han. No cereal chaff was recovered. Forty-six of the better preserved einkorn and emmer grains were measured and are plotted against the thickness and breadth of 184 other Neolithic grains, previously also used in section 7.5 (Fuller *et al.* 2017).

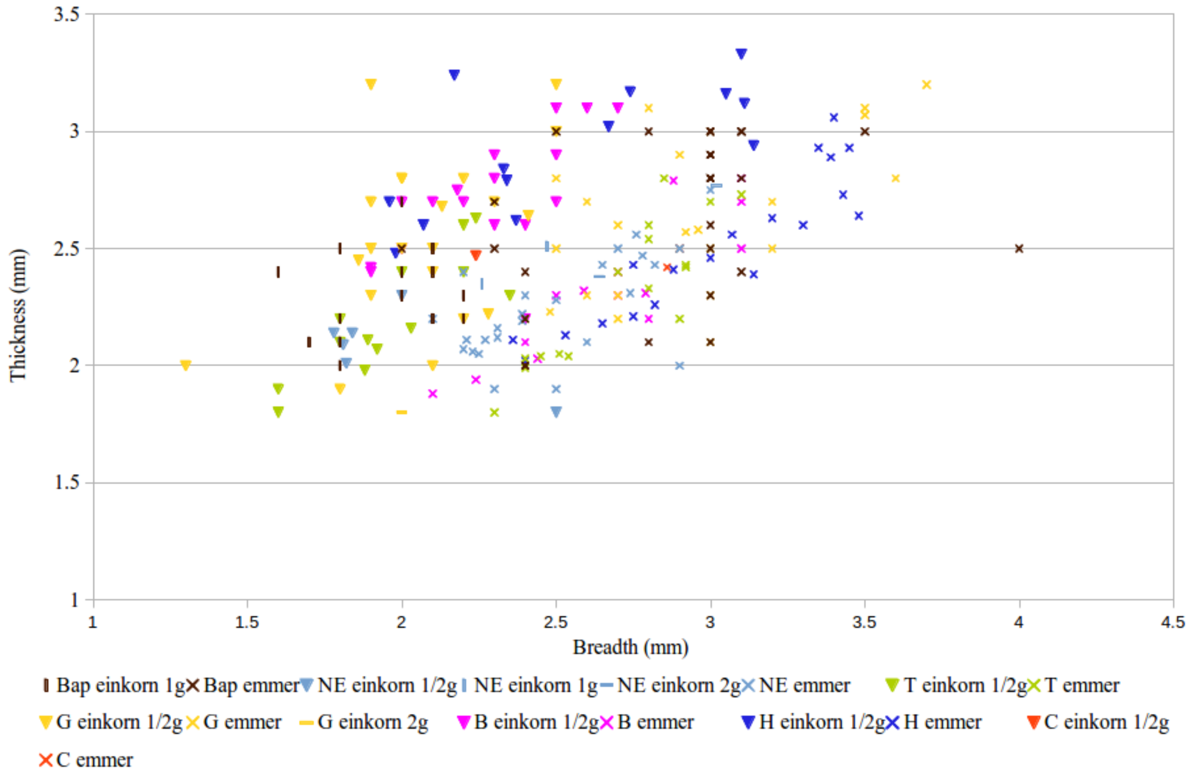


Figure 7.6: Thickness to breadth ratios of Neolithic emmer and einkorn caryopses. Grains from Bapska House 3 are represented in dark brown (Bap). NE = Syria, Iraq, Jordan and Palestine; T = Turkey; G = Greece, Cyprus, Crete and Macedonia; B = Bulgaria; H = Hungary, C = Croatia. Note that the axes start at 1mm, not 0.

Apart from three or four emmer grains, the emmer and einkorn caryopses from House 3 plot within the distribution of other emmer and einkorn sizes. The einkorn grains vary in thickness between 2mm and 2.7mm, and in breadth between 1.6mm and 2.2mm. Like those from Korića Han, they are smaller than the Hungarian and Bulgarian specimens. The Bapska emmer grains that plot within the main distribution of emmer seeds vary in thickness between 2mm and 3mm, and in breadth between 2.4mm to 3.5mm. A large outlier measures 2.5x4mm. Whilst the range in breadth of the Bapska emmer grains is broad, most of them have a breadth of 3mm or 3.1mm and cluster with the larger specimens. The range in thickness is more similar to that of the Hungarian grains. The three Bapska emmer that plot within the main distribution of einkorn grains may have been wrongly identified. Only three wild/weed seeds were found amongst the cereal grains.

7.6.2.3 Discussion

The concentration of charred grain in the corner of house 3 was clearly visible during excavations. The grains are clean and appear to have been mostly broken after carbonisation. Interestingly, grains split in half longitudinally were not seen in any of the other flots examined for this thesis. Chaff is absent and other seeds are rare. The assemblage represents a mass or store of clean emmer grains with an admixture of einkorn and a little naked barley. Although the grains were not associated with an obvious storage context, i.e. a vessel or pit, a wooden or straw/reed container might not have left any archaeobotanical remains. Whether they were burnt accidentally or not is unclear and further interpretations will depend on additional information from the excavation report (e.g. evidence for a conflagration). The samples from houses 2 and 3 were from unusual grain-rich *in situ* deposits (Hubbard & Clapham 1992, Class A and B samples, Chapter 5.1.4), and as such may not be wholly representative of routine, household activities. The near absence of weed seeds precludes any investigations into crop-husbandry practices.

Figure 7.6 suggests that the thick but narrower emmer grains that plot on the left hand side may in fact be large einkorn grains. The Bapska emmer grains tend to be larger than those from Korića Han and seem to cluster more with those from Greece, Bulgaria and Hungary. Further explanations for the possible distribution of grain sizes, including comparisons between Bapska and Korića Han grains, are examined in the final discussion of this chapter.

7.7 Hermanov Vinograd (N 45.55, E 18.63) (Los Unpublished)

The Sopot tell site of Hermanov Vinograd lies in the village of Filipović, on the outskirts of Osijek, North-eastern Croatia. It is composed of two mounds, now separated by a rail track, that were established by the river Drava in what was a marshy, hydrologically active area. The larger mound (AN6/H.V.I) is estimated to cover an area of 3400m^2, and to be 1.6m to 3.2m high. The smaller mound (AN7/H.V.II) is thought to cover an area of 630m^2, and to be *c.*1.6m deep. Large-scale rescue excavations began in 2013 in preparation for the work undertaken on the D2 southern bypass, which runs through the site. Lying adjacent to the dual carriageway, the investigated section of the site had not been built upon or farmed (since at least the 1970s) but lay covered by encroaching vegetation. Under the direction of Mr. D. Los and Mr. J. Burmaz (Kaducej ltd.) a total area of 3200m^2 was excavated. Both mounds were excavated in seven stratigraphic phases (but see below). In total sixteen structures/buildings were uncovered in H.V.I, as well as six hundred and ninety burials. Excluding a pit described as pertaining to Phase 7, the youngest phase of H.V.I was founded on the eastern side of the larger mound and is currently described as a village protected by a defensive palisade and a “moat” (Phase 6), into which several burials had been placed. Evidence of a conflagration suggests this village was burnt prior to the construction of the next habitation layer. Phases five to one lie above Phase 6, and most of the bulk soil samples taken for flotation were retrieved from Phases 3 and 2 (44 and 39 samples respectively, Table 7.7a). The smaller excavated area of H.V.II is entirely bordered by recent structures, such as cultivated gardens, railway lines and roads. Structures/buildings and burials comparable to those from the larger mound were uncovered, along with a similar range of Sopot artefacts. Phases 4 and 2 of H.V.II were the most extensively sampled for plant remains (11 and 9 samples respectively, Table 7.7d). Post-excavation work is ongoing, although, at this stage of the investigations, the sequential relationship between the two mounds remains uncertain and one cannot assume a strict contemporaneity of phases across both H.V.I and H.V.II (J.Burmaz pers. comm. 27.06.16). Plant macro-remains from the two mounds are therefore discussed separately, according to the stratigraphic phases assigned during excavations, before being discussed together in section 7.7.3. Spatial and temporal patterns in the distribution of preserved plant remains may need to be revised once the site's structures and phasing have been confirmed. The terminology adopted here, such as foundation cut, trampled surface and oven, reflects the interpretations assigned in the preliminary report. The list of sampled contexts can be found in Tables 1.11 and 1.14, Appendix I.

Ten radiocarbon dates were obtained: four from cereal grains, five from human bone and one from burnt wood. The latter, which was not identified, was retrieved from a fireplace 1.8m – 2m below the surface and its date is significantly younger than the other nine (4170-3930 cal. BC (53.2%,

±1σ), Obelić *et al.* 2004: 252). The date taken from a skeleton 1.9m below the surface (no further contextual information) places the site at 4580–4360 cal. BC (68.2%, ±1σ), (Obelić *et al.* 2004: 253). The remaining eight dates were obtained through the EUROFARM and FEPRE projects (*The Formation of Europe: Prehistoric Population Dynamics and the Roots of Socio-Cultural Diversity*). They came from cereal grains taken from samples 24, 37, 44 and 95 of H.V.I, two skeletons of unknown contexts and two from Graves 1 and 2, H.V.II, Phase 2 (also sampled for plant remains, Table 7.7e). In order to improve the precision of the results, a Bayesian model was performed in OxCal 4.2 (Bronk Ramsey 2009), using Intcal 13 (Reimer *et al*. 2013). Such an approach constrains the probability distribution of radiocarbon dates through the inclusion of robust, independent chronological data, known as prior information (Bronk Ramsey 2009). In this case robust, objective information corresponds to the stratigraphic relationship between the samples (the relative sequence of uncalibrated dates). The resulting model includes as few assumptions as possible, with a single bounded sequence. The model presents an overall good agreement (Amodel: 103.2) and is presented in Figure 1, Appendix I. The dates place the site within the Late Neolithic, with a boundary start date of 4850-4689 cal. BC (95.4%), possibly 4786-4713 cal. BC (68.2%), and a finish date of 4696-4499 cal. BC (95.4%), possibly 4674-4574 cal. BC (68.2%).

One hundred and forty-one bulk soil samples were taken and stored indoors. Spills, missing contextual information and duplicates resulted in 129 samples being used in this thesis, 96 (602.5 litres) from H.V.I and 33 (210 litres) from H.V.II. In March 2015 Dr. J. Gaastra collected them from Sisak (Croatia), and drove them to Kosjerovo where the EUROFARM team were conducting excavations (section 7.4). I floated the samples using a Siraf-type flotation tank. A 250μm mesh was used to collect the flots and a 1mm mesh retained the heavy residues. In order to avoid cross-contamination between samples, the water level in the tank was dropped after each flotation and a net was used to collect any contaminants on the surface. Both flots and heavy residues were left to dry indoors and the latter dry-sieved and sorted by the naked eye down to 2mm. Smaller fractions and all artefacts were returned to Mr. Burmaz in March 2015. All plant macro-remains are presented in Table 1.13 (H.V.I) and Table 1.16 (H.V.II), Appendix I.

7.7.1 Hermanov Vinograd I

Stratigraphic phase	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**Total**
Total samples	1	5	5	1	44	39	1	**96**
Total volume (L)	2	23	29	4	314.5	223	5	**602.5**
Total barley		10			1	1		**12**
Total einkorn					8	8		**16**
Total emmer		3			7	2		**12**
Total 'new' type						1		**1**
Total free-threshing		7						**7**
Total grains (incl. indet. grains)	**1**	**39**	**5**	**1**	**143**	**63**	**6**	**258**
mean/L	0.50	1.70	0.17	0.25	0.45	0.28	1.2	**0.43**
Preservation index mean	1	1.3	0.9	0	0.6	0.6	0.7	**0.6**
mode	1	2	0	0	0	0	1	**0**
Fragmentation index	0	0	2	0	2.1	0	0	**1.1**
Samples with grains	100%	40%	60%	100%	66%	54%	100%	**60%**
Total einkorn glume base		2	6	2	648	132		**790**
Total emmer glume base					110	59	3	**172**
Total 'new' type glume base					21	3		**24**
Total glume bases (incl. Indet.)	**0**	**5**	**7**	**10**	**2080**	**614**	**7**	**2723**
mean/L	0	0.22	0.24	2.56	6.61	2.75	1.4	**4.52**
Glume base : grain ratio	0	0.13	1.4	10	14.55	9.75	1.17	**10.55**
Samples with glume bases	0%	40%	40%	100%	75%	72%	100%	**68%**
Total pulses	**0**	**3**	**0**	**0**	**12**	**3**	**0**	**18**
mean/L	/	0.13	/	/	0.04	0.01	/	**0.03**
Samples with pulses	0%	20%	0%	0%	14%	8%	0%	**10%**
Total fruits/nuts	**0**	**2**	**0**	**0**	**59**	**6**	**11**	**78**
mean/L	/	0.09	/	/	0.19	0.03	2.2	**0.13**
Samples with fruits/nuts	0%	20%	0%	0%	30%	15%	100%	**22%**
Total wild/weed seeds	**20**	**42**	**2**	**0**	**531**	**464**	**1**	**1060**
mean/L	10	1.83	0.07	/	1.68	2.08	0.2	**1.76**
Non-cereal P.I. mean	1	1	1.5	/	1.3	1.4	1.6	**1.4**
mode	1	0	1, 2	/	1	1, 2	1	**1**
Samples with wild/weed seeds	100%	40%	20%	0%	66%	82%	100%	**69%**
Grain : seed ratio	0.05	0.93	2.5	/	0.27	0.14	6	**0.24**
Grain/Seed density (ex. chaff)	**1**	**3.4**	**0.2**	**0.2**	**0.24**	**2.4**	**9.3**	**2.3**
№ items / litre (excl. charcoal)	**1**	**3.6**	**0.5**	**2.2**	**9.1**	**5.8**	**11**	**6.89**

Table 7.7a: Summary results from the analysis of flots from Hermanov Vinograd I.

7.7.1.1 Preservation

Carbonisation was the dominant form of preservation. Mineralisation also occurred, exemplified by 31 seeds, some of which are edible (bladder cherry, elder and opium poppy (*Papaver somniferum* L.)). Charcoal was present in all samples but was mostly heavily comminuted, with an average volume per flot of 2.4ml. The largest quantity of 84ml came from a 'canal' in the second oldest occupation level (stratigraphic Phase 6, context 1274). Plant macro-remains were not recovered from the heavy residues, demonstrating that efficient flotation. The caryopses are mostly fragmented with few traces of preserved epidermis; those that are whole are distorted and often puffed. Not all phases were equally sampled (volume varies by phase between two and 314.5 litres), and the correlation between sample volumes and their sums of cereal grain is weak (Pearson's r = 0.08). Indeed, grain/seed density (excludes charcoal and chaff) is highest in Phases 1 and 6 which were not the most heavily sampled, suggesting that factors other than overall soil volume influenced the recovery of plant remains. One such factor is the location of samples (Table 7.7b).

Overall the cereal grains have a mean F.I. of 1.1 and a P.I. of 0.6 with a mode of 0, which defines the preservation of cereal grains as very bad and low to moderately fragmented. The samples' F.I., P.I. and total number of cereal grains are plotted in Figure 7.7a, by ascending F.I. followed by P.I. The first nine samples on Figure 7.7a have a P.I. of 0 and no F.I. because all of the grains are fragmented. The following 41 samples have an F.I. of 0, indicating that none of the grains are fragmented. The P.I. gradually rises, seemingly independently to the total number of grains. The remaining eight samples have higher F.I. and P.I., indicating highly fragmented assemblages, with no apparent correlation between either index and the number of grains. Figures 7.7b and 7.7c represent the same charts made for the more densely sampled Phases 3 and 2, and both confirm the lack of any correlation between either index and the number of grains. When split by stratigraphic phase (Table 7.7a, Figure 7.7d) it becomes clear that fragmented grains were only recovered from Phases 3 and 5. The former was most heavily sampled and generated the highest number of cereal grains (n=143), whilst only five samples and five grains were obtained from Phase 5. The P.I. by phase falls below average (0.6) in Phase 4 where the single grain in the single sample has a P.I. of 0, and above average in Phase 6 where 39 grains have a mean P.I. of 1.3. Overall, the concentration of cereal grains is low: sixty percent (n=58) of samples contained cereal grains (Table 7.7a), with an average of 0.4 grains per litre of sediment or 2.2 grains per sample, and a range of 1-31 grains per sample.

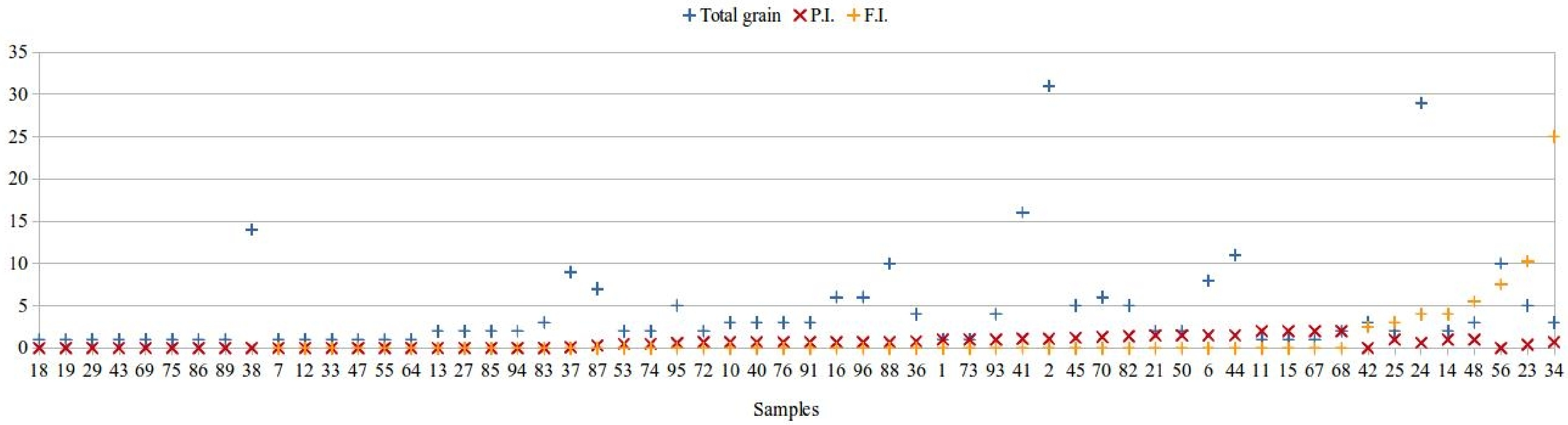


Figure 7.7a: Total grain, preservation and fragmentation indices by sample (H.V.I). Plotted by ascending F.I.

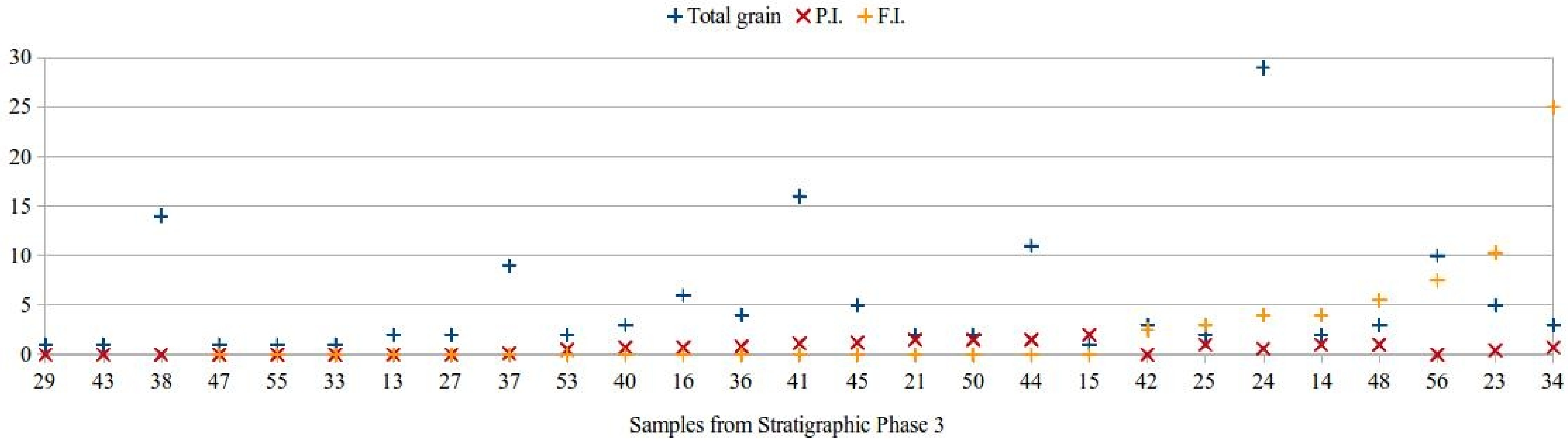


Figure 7.7b: Total grain, preservation and fragmentation indices by sample from Phase 3 (H.V.I). Plotted by ascending F.I.

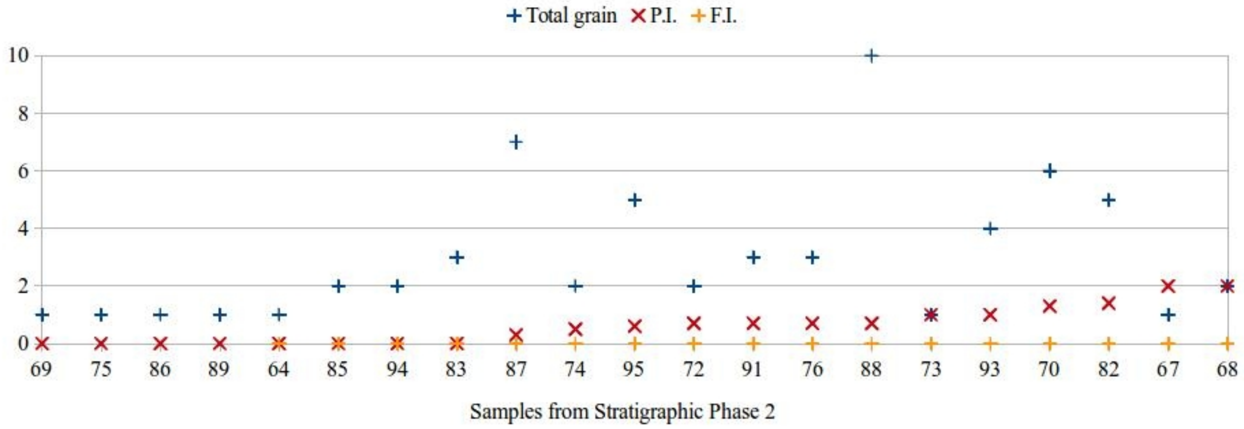


Figure 7.7c: Total grain, preservation and fragmentation indices by sample from Phase 2 (H.V.I).

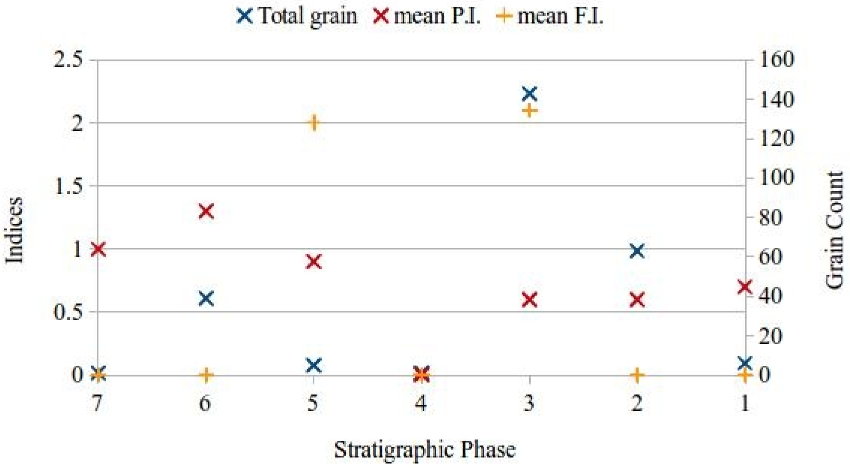


Figure 7.7d: Total grain, preservation and fragmentation indices by stratigraphic phase (H.V.I).

The non-cultivated seeds are only slightly better preserved than the cereal grains. They have a mean P.I. of 1.4 (mode of 1), which describes their preservation as poor. Mean cereal P.I., mean non-cereal P.I. and grain/seed density are plotted on a dual axis graph, Figure 7.7e, in order of ascending grain/seed density. The cereal P.I. varies between 0 and 2, whereas the non-cereal P.I. rises above 2 for three samples. The indices fluctuate independently of each other and the grain/seed density. Figures 7.7f and 7.7g represent the same charts made for the more densely sampled Phases 3 and 2, and both confirm the lack of any correlation between indices and the grain/seed density. When split by stratigraphic phase (Table 7.7a, Figure 7.7h), the lack of correlation between the three values remains evident, even if one excludes Phases 1, 4 and 7 represented by single samples. Therefore, the total number of grains and seeds does not appear to be a direct reflection of preservation conditions. The far great number of glume bases to grains supports this conclusion, as the former tend to be more sensitive to carbonisation (Boardman & Jones 1990). It is difficult to establish the extent to which assemblages have been detrimentally affected by pre- or post-depositional processes, as the level of preservation seems to vary between features and phases. This pattern illustrates the importance of sampling broadly as the distribution of charred plant macro-remains may not be even or predictable (Table 7.7b).

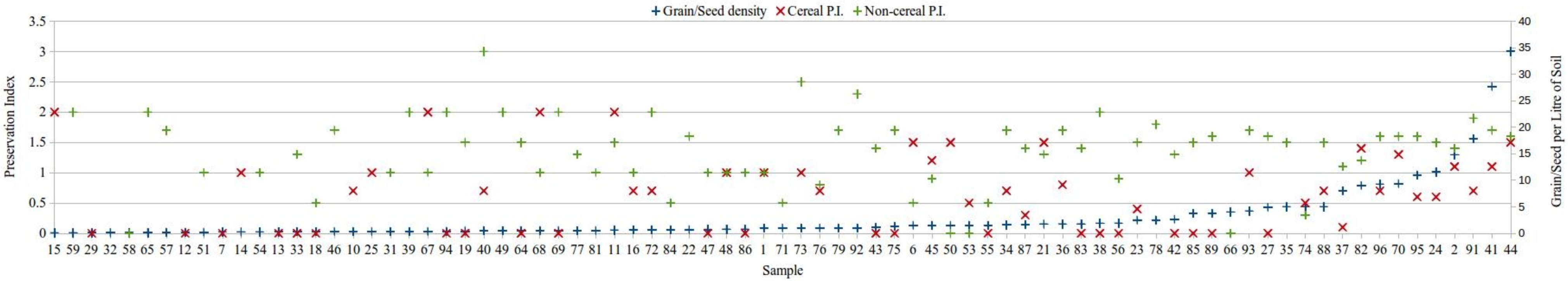


Figure 7.7e: Grain/seed density and preservation indices by sample (H.V.I). Plotted by ascending grain/seed density.

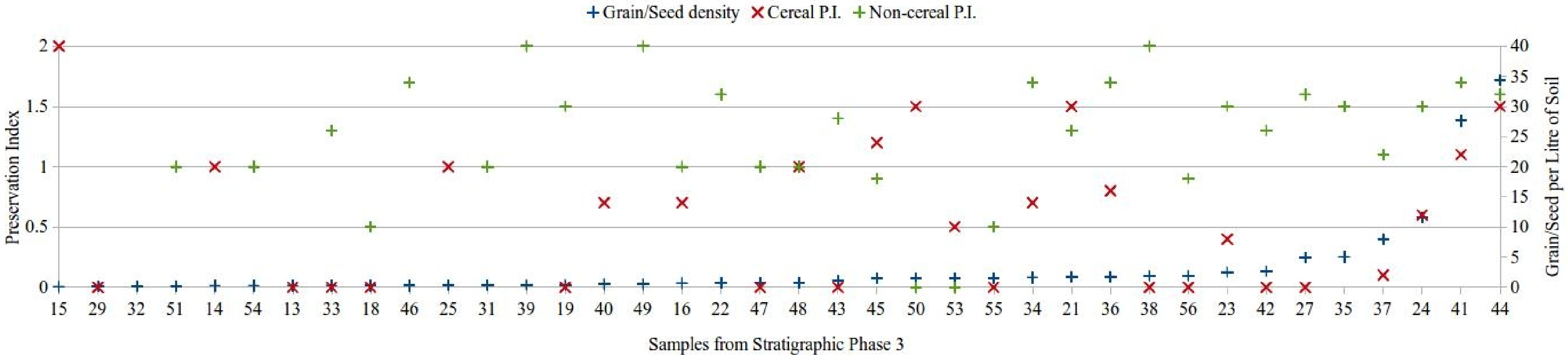


Figure 7.7f: Grain/seed density and preservation indices by sample from Phase 3 (H.V.I).Plotted by ascending grain/seed density.

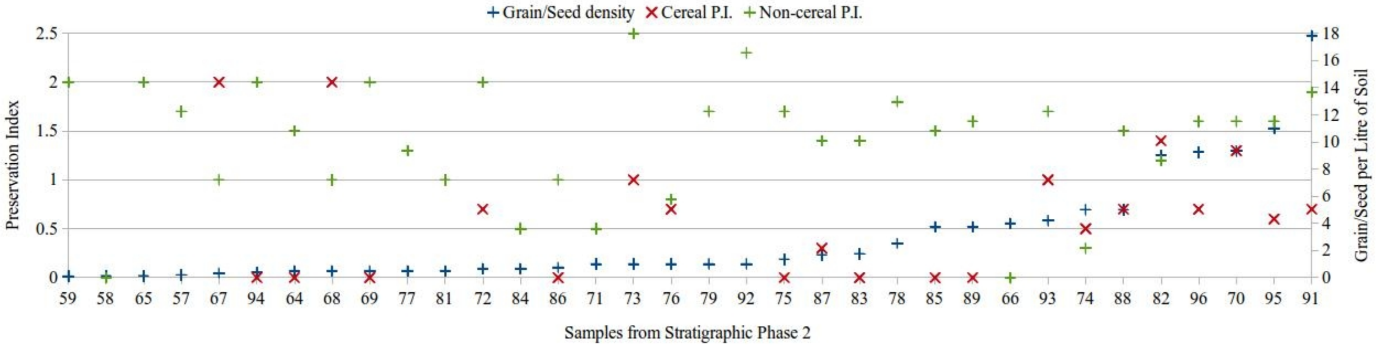


Figure 7.7g: Grain/seed density and preservation indices by sample from Phase 2 (H.V.I).Plotted by ascending grain/seed density.

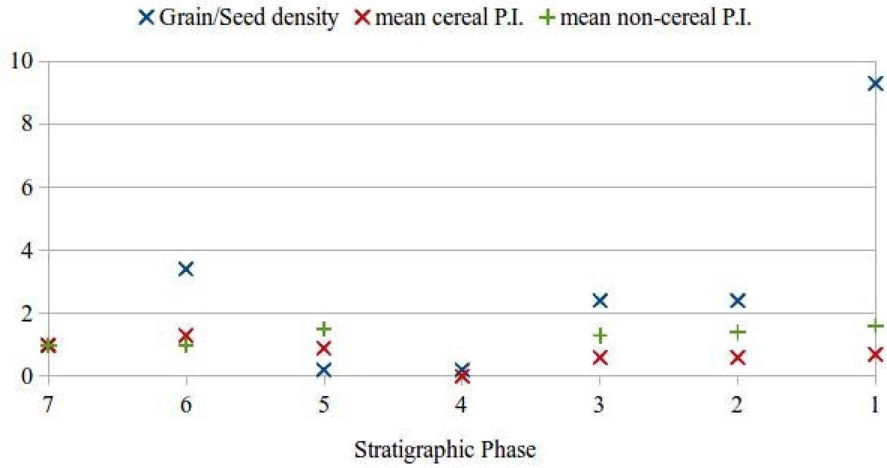


Figure 7.7h: Grain/seed density and preservation indices by stratigraphic phase (H.V.I).

7.7.1.2 Distribution

Table 7.7b, where the plant remains are presented by phase and feature type, suggests that plant macro-remains were not predominantly found in ovens and fireplaces but from pits, foundation cuts and ditches. Cereal processing by-products (chaff and weed seeds) were more numerous than food products (grain, pulses and edible fruits and nuts) (Table 7.7a). Thirty-four percent (n=26) of the fruits and nuts came from a foundation-cut in Structure 6, Phase 3, which contained 33 bladder cherry seeds. Comparing finds from Phases 2 and 3, from which most samples were obtained, the largest sum of cereal grains and glume bases came from pits and foundation cuts. The pattern for wild plant seeds is less clear, but they appear most abundant in pits, trampled surfaces and post-holes. Pulses, fruits and nuts are rare and randomly distributed. It appears that whilst some plant remains may were intentionally discarded into pits, many have accumulated in dips and crevices. As with most archaeobotanical samples, this pattern suggests that the composition of assemblages could originate from various events, determined more by the post-carbonisation events that led to their final deposition than by the human actions which affected their original plant associations. Consequently, assemblages are discussed by structures and phases rather than individual samples.

Stratigraphic phase	**7**	**6**											**5a&5**										
Number of samples	**1**	**2**					**2**					**1**	**2**					**2**					**1**
Feature type	4	7					1					2	1					6					3
Description	Pit	Moat, Canal					2 Trampled surfaces/Floors					P-hole	2 Trampled surfaces					Grave 1					F.cut
Total soil volume (L)	2	9					8					8	5					19					5
Total charcoal (ml)	3.5	84	**Mean**	**Median**	**Range**	**%**	0.5	**Mean**	**Median**	**Range**	**%**	0.5	0.5	**Mean**	**Median**	**Range**	**%**	0.5	**Mean**	**Median**	**Range**	**%**	0.5
Total grains	1	31	15.5	15.5	0 – 31	50%	0	0	0	0	100%	8	1	0.5	0.5	0 – 1	50%	3	1.5	1.5	0 – 3	50%	1
Total glume bases	0	3	1.5	1.5	0 – 3	50%	2	1	1	0 – 2	50%	0	4	2	2	0 – 4	50%	3	1.5	1.5	0 – 3	50%	0
Glume base:grain	0	0.1	/	/	/	50%	N/A				100%	0	4	2	2	0 – 4	50%	1	1	1	1	50%	0
Total pulses	0	3	1.5	1.5	0 – 3	50%	0	0	0	0	100%	0	0	0	0	0	100%	0	0	0	0	100%	0
Total fruits and nuts	0	2	1	1	0 – 2	50%	0	0	0	0	100%	0	0	0	0	0	100%	0	0	0	0	100%	0
Total wild seed	1	38	19	19	0 – 38	50%	0	0	0	0	100%	4	0	0	0	0	100%	0	0	0	0	100%	2
Grain:seed ratio	1	0.8	/	/	/	50%	N/A				100%	2	N/A				100%	N/A				100%	0.5
Grain/Seed density	1	8.2	7.1	7.1	0-14.2	50%	0	0	0	0	100%	1.5	0.2	0.2	0.2	0 – 0.3	50%	0.2	0.2	0.2	0 – 0.3	50%	0.6
№ items / litre*	1	8.6	7.4	7.4	0-14.8	50%	0.3	0.3	0.3	0 – 0.5	50%	1.5	1	0.7	0.7	0 – 1.3	50%	0.3	0.4	0.4	0 – 0.7	50%	0.6

Stratigraphic phase	**4**	**3**																			
Number of samples	**1**	**9**					**3**					**2**					**6**				
Feature type	5	1					5					6					7				
Description	Fire	9 Trampled surfaces					2 Fires, 1 Oven					Grave 2					4 Unknown, 2 from a Ditch/Fence				
Total soil volume (L)	5	56.5					22					32					24				
Total charcoal (ml)	0.5	16.5	**Mean**	**Median**	**Range**	**%**	1.5	**Mean**	**Median**	**Range**	**%**	20	**Mean**	**Median**	**Range**	**%**	6	**Mean**	**Median**	**Range**	**%**
Total grains	1	43	4.8	2	0 – 14	33%	2	0.7	0	0 – 2	33%	4	2	2	1 – 3	50%	5	0.8	0	0 – 3	33%
Total glume bases	10	162	18	3	0 – 81	33%	0	0	0	0	100%	79	39.5	39.5	30-49	50%	41	6.8	2.5	0 – 24	33%
Glume base:grain	10	3.8	4.3	2.2	0.5 –16	22%	0	0	0	0	100%	19.8	29.5	29.5	10-49	50%	8.2	6	6	0 – 12	17%
Total pulses	0	5	0.6	0	0 – 2	33%	0	0	0	0	100%	4	2	2	0 – 4	50%	0	0	0	0	100%
Total fruits and nuts	0	0	0	0	0	100%	0	0	0	0	100%	8	4	4	1 – 7	50%	1	0.2	0	0 – 1	17%
Total wild seed	0	205	22.8	0	0 – 193	11%	0	0	0	0	100%	13	7.5	7.5	3 – 10	50%	5	0.8	1	0 – 2	67%
Grain:seed ratio	N/A	0.2	0.7	0.8	0.1-1.3	22%	N/A				100%	0.3	0.2	/	/	100%	1	0.8	0.8	0 – 2	33%
Grain/Seed density	0.2	4.5	5.1	0.4	0 – 34	22%	0.1	0.1	0	0 – 0.3	33%	0.7	0.8	0.8	0.3–1.3	50%	1.8	0.5	0.4	0 – 1.5	50%
№ items / litre*	2.2	6.6	8.5	1.2	0 –47.5	22%	0.1	0.1	0	0 – 0.3	33%	3.3	3.3	3.3	3.2-3.4	50%	8.7	2.8	0.9	0.3-14	33%

Table 7.7b: Plant macro-remains by phase and feature type (H.V.I). See below for key.

Stratigraphic phase	**3**														
Number of samples	**2**					**12**					**10**				
Feature type	2					4					3				
Description	2 post-holes					10 Pits					10 Foundation cuts				
Total soil volume (L)	17					99					64				
Total charcoal (ml)	12	**Mean**	**Median**	**Range**	**%**	23.5	**Mean**	**Median**	**Range**	**%**	28.5	**Mean**	**Median**	**Range**	**%**
Total grains	1	0.5	0.5	0 – 1	50%	46	3.8	0.5	0 – 29	25%	42	4.2	2.5	0 – 16	30%
Total glume bases	22	11	11	7 – 15	50%	1183	98.6	5	0-745	17%	593	59.3	17	0 - 336	20%
Glume base:grain	22	7	7	7	50%	25.7	24.3	25.7	0 -47.5	33%	14.1	13.9	13.4	3.4-28	40%
Total pulses	0	0	0	0	100%	3	0.25	0	0 – 2	17%	0	0	0	0	100%
Total fruits and nuts	0	0	0	0	100%	14	1.2	0.5	0 – 5	17%	39	3.9	0.5	0 – 33	10%
Total wild seed	7	3.5	3.5	3 – 4	50%	104	8.7	2	0 – 48	25%	197	19.7	7.5	1 – 149	10%
Grain:seed ratio	0.1	0.2	0.2	0 – 0.3	50%	0.4	0.6	0.4	0 – 3	17%	0.2	0.6	0.3	0 – 2	30%
Grain/Seed density	0.5	0.5	0.5	0.3-0.7	50%	1.7	1.8	0.5	0–11	33%	4.3	4.5	1.6	0.3-28	20%
№ items / litre*	2.3	2.3	2.3	2.3-2.3	100%	13.7	16.6	0.8	0–118	33%	13.7	15.9	6.6	3.2-84	20%

Stratigraphic phase	**2**																					**1**
Number of samples	**10**					**2**					**1**	**10**					**16**					1
Feature type	1					5					7	3					2					4
Description	10 Trampled surfaces/Floors					1 Oven					?	10 Foundation cuts					16 Post-holes					Pit
Total soil volume (L)	84					15					1	46					77					4
Total charcoal (ml)	10.5	**Mean**	**Median**	**Range**	**%**	0.5	**Mean**	**Median**	**Range**	**%**	1	6	**Mean**	**Median**	**Range**	**%**	20	**Mean**	**Median**	**Range**	**%**	5
Total grains	9	0.9	0	0 – 5	40%	0	0	0	0	100%	0	16	1.6	2.5	0 – 6	40%	38	2.4	1.5	0 – 10	38%	6
Total glume bases	86	8.6	1	0 – 74	10%	0	0	0	0	100%	4	292	29.2	5	0–242	10%	232	14.5	7	0 – 73	25%	7
Glume base:grain	9.6	4.6	1.3	0.5-15	10%		/			100%	N/A	18.3	1.8	1	0-40.3	10%	6.1	7	7.9	1 –24.3	30%	1.2
Total pulses	0	0	0	0	100%	0	0	0	0	100%	0	1	0.1	0	0 – 1	10%	2	0.1	0	0 – 1	20%	0
Total fruits and nuts	0	0	0	0	100%	0	0	0	0	100%	0	2	0.2	0	0 – 1	20%	4	0.3	0	0 – 1	25%	11
Total wild seed	149	14.9	1	0 – 138	10%	0	0	0	0	100%	4	76	7.6	5.5	1 – 49	10%	235	14.7	8.5	0 – 104	19%	20
Grain:seed ratio	0.06	0.3	0	0 – 1	30%		/			100%	0	0.2	0.4	0.3	0 – 1	40%	0.2	0.5	0.2	0 – 0.5	27%	0.3
Grain/Seed density	1.9	1.3	0.2	0 – 11	10%	0	0	0	0	100%	4	2.1	2.1	3.8	0.5-9.3	30%	3.6	3.2	1	0 –17.8	38%	9.3
№ items / litre*	3	2.1	0.5	0.1-17	10%	0	0	0	0	100%	8	9.1	8.5	6.8	1 -53.3	20%	7.9	7.7	5.8	0 – 31	25%	11

Table 7.7b continued. Key: 1 – floor/ground surface; 2 – post-hole; 3 – foundation cut; 4 – pit; 5 – oven/hearth/fire; 6 – Grave; 7 – other/unknown. % percentage of samples with the value of the mean or above. excludes charcoal but includes all chaff and indeterminate food/parenchyma fragments. The latter have greatly increased the density in the post-holes of Stratigraphic Phase 3.

7.7.1.3 The crops, gathered flora and other wild plants

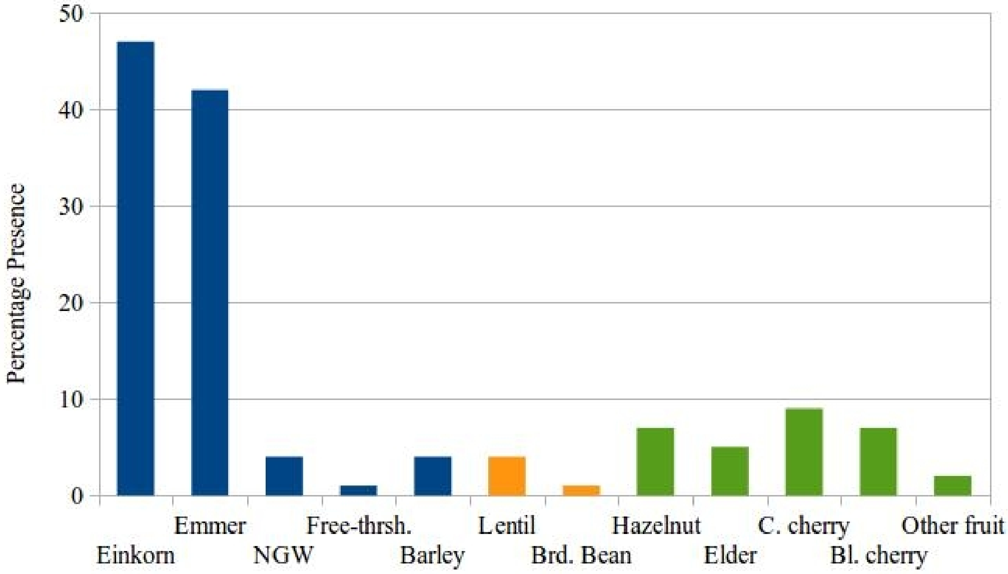


Figure 7.7i: Percentage presence (ubiquity across 96 samples) of crops, fruits and nuts (H.V.I).

- *Crops*

Einkorn (n=453 grain and chaff items) and emmer (n=135 grain and chaff items) are the major crops represented in the samples, occurring in 47% (n=45) and 42% (n=40) of samples respectively (Figure 7.7i). An additional three cereals were found, but they occur in few samples and are not numerous: the 'new' glume wheat (one grain and 23 glume bases within four samples), barley (13 grains, including six of hulled barley, across four samples), and an oval-shaped free-threshing wheat (seven grains, including smaller tail grains, from the 'canal' sample). Fifty-one percent (n=41) of samples with both grains and cereal chaff had glume base to grain ratios of two or higher, representing the by-products of dehusking spikelets of hulled wheats (based on the highest ratio of two glumes to every grain for single-grained einkorn). The number of grains specifically identified to emmer (n=12) or einkorn (n=16) is very low and so glume base to grain ratios by species was not attempted. Samples with glume base to grain ratios of less than two never had more than eight grains per sample, except for the sample from the canal that had 31 caryopses, three glume bases and 38 wild plant seeds. Pulses were infrequent: five lentils were found in four samples, a single broad bean (*Vicia faba* L.) came from the canal sample and an additional 12 indeterminate large legumes were recovered from eight samples.

- *Edible fruits and nuts*

Wild fruits and nuts were infrequent. The most frequently occurring taxa was cornelian cherry, found as ten fruit-stones in nine samples. Bladder cherry had the highest count of seeds: 54 across seven samples. Thirty-three of those seeds were found in a sample from stratigraphic Phase 3, with nothing else but two goosefoot seeds (*C. album* and *Chenopodium* sp.). Another eight seeds, found in Grave 2, are mineralised, possibly as a result of having been buried within an organic-rich medium. 'Other fruits' listed in Figure 7.7i consist of strawberry and hawthorn (*Crataegus monogyna* Jacq.) found as single seeds.

- *'Weed' seeds*

The most ubiquitous and numerous seeds were of fat-hen and *Chenopodium* sp. (probably poorly preserved fat-hen seeds). The 459 fat-hen seeds were distributed across 50% (n=48) of the samples. The larger assemblages of fat-hen (over 40 seeds, found in 5 samples) were all found in grain-poor and chaff-rich assemblages, where the glume base to grain ratios are not lower than 7.4. This association suggests that fat-hen was an arable weed rather than a gathered or cultivated plant. Other frequent seeds were large grass seeds (77 in 30% (n=29) of samples) and barnyard millet (*Echinocloa crus-galli* (L.) Beauv: 101 in 8% (n=8) of samples). Most taxa however, only occurred as one or two specimens in a limited number of samples. A total of three seeds were found in Phases 7, 5 and 4. Phases 6, 3 and 2 had at least 40 seeds each from a minimum number of 18, 22 and 15 species respectively (Table 7.7c), and are discussed below. Contextual descriptions are presented by phase, followed by a discussion of the ecological characteristics of taxa (Table 1.12, Appendix I).

Hermanov Vinograd I – wild/weed seeds (40 taxa)	**Phase 6** (5 samples)		**Phase 3** (44 samples)		**Phase 2** (39 samples)	
	Ubiquity	Total	Ubiquity	Total	Ubiquity	Total
cf. *Agrostemma githago*					2.5%	1
Aphanes/Alchemilla spp.	20%	1				
Apium graveolens	20%	1				
Artemisia sp.					5.1%	3
Asteraceae			2.3%	1		
Atriplex sp.	20%	1	2.3%	1	2.5%	1
Avena sp.						
Brassicaceae					2.5%	1
Carex cf. *muricata*			2.3%	1		
Carex cf. *nigra*					2.5%	1
Carex cf. *sylvatica*	20%	1	2.3%	1		
Carex spp.	20%	2				
Cerastium sp.						
Chenopodium album	20%	3	55%	201	56%	253
Chenopodium sp.	20%	1	36%	162	38%	143
Echinocloa crus-galli	20%	1	2.3%	76	15%	24
Euphorbia peplus	20%	1				
Fallopia convolvulus	20%	1	4.5%	2		
Galeopsis/Stachys sp.			2.3%	1		
Galium aparine						
Hyoscyamus niger			4.5%	2		
Lolium sp.			2.7%	1		
Lolium/Festuca sp.			14%	9	2.5%	1
Montia cf. *fontana* ssp. *Chondrosperma*			2.3%	1		
P.somniferum/dubium			2.3%	1		
Papaver somniferum			2.3%	1		
Persicaria lapathifolia	20%	2				
Phleum sp.						
Physalis/Solanum sp.			4.5%	2	2.5%	1
Plantago lanceolata	20%	1				
Poa sp.	20%	2	2.3%	4		
Polygonum aviculare	20%	4	2.3%	2	2.5%	1
Polygonum sp.	20%	2	2.3%	1		
Potentilla sp.					2.5%	1
Potentilla/Fragaria sp.						
Ranunculus bulbosus/acris/repens					5.1%	2
Rumex acetosella	20%	1				
Rumex sp.	20%	1	2.3%	1	2.5%	1
Large Poaceae (wild)	20%	2	14%	18	13%	6
Small Poaceae (wild)			4.5%	2		
Total	**18 taxa**	**28**	**22 taxa**	**491**	**15 taxa**	**440**
Total (incl. indeterminate seeds)		**42**		**531**		**464**
Total (excl. *C.album*)	**17 taxa**	**39**	**21 taxa**	**330**	**14 taxa**	**211**
Total (excl. *Chenopodium* sp.)	**16 taxa**	**38**	**20 taxa**	**168**	**13 taxa**	**68**

Table 7.7c: Wild/Weed taxa from Phases 6, 3 and 2 (H.V.I).

Forty-one seeds were retrieved from stratigraphic Phase 6 and 39% (n=16) were identified to species. Sixty-five percent (n=26) of the taxa are represented as single seeds; the best represented taxa is knotgrass (*Polygonum aviculare* L., 4 seeds). Ninety percent (n=37) of the seeds were retrieved from the 'canal', context 1274, of which 34% (n=13) were mineralised. These point to an organic rich deposit, perhaps even cess, though the seeds need not have been ingested (Chapter 5.1.1). Some of the more recognisable edible seeds include wild celery (*Apium graveolens* L.) and opium poppy (Figure 2, Appendix I). Only two seeds of opium poppy were found and so it is here considered an arable weed rather than a crop. They, along with the single seed from H.V.II represent the earliest finds of that species in the western Balkans. Radiocarbon dated cereal grains from H.V.I sample 37 (from which a mineralised poppy seed was retrieved) lend supportive evidence for a Late Neolithic date (4117-4552 cal. BC, 95.4%). Its presence in the Pannonian Plain during the Late Neolithic is further discussed in Chapter 9.3.

Five hundred and thirty-one seeds were retrieved from stratigraphic Phase 3 and 56% (n=297) were identified to species. Seeds were quite common in pits though mainly distributed on trampled surfaces and within foundation cuts (Table 7.7b). It seems most were not intentionally discarded into specific refuse areas, but swept aside, either intentionally or through the regular passings of humans and/or animals. Fifty-two percent (n=12) of the taxa are represented as single seeds; the best represented taxa are fat-hen, *Chenopodium* sp., followed by barnyard millet and large grasses (Table 7.7c). The latter are the most ubiquitous after fat-hen and *Chenopodium* sp., and may represent the most common BFH weed seeds removed during the final stages of processing. Phase 3 contained 75% (n=76) of all barnyard millet seeds, concentrated in a sample from Structure 7, which also contained a large quantity of glume bases (n=336) and fat-hen seeds (n=46). The barnyard millet seeds still retained their lemma and palea, and vary in size between 0.7x0.6mm to 1.2x1.6mm, representing a mixture of charred hulled mature and immature seeds.

Four hundred and sixty-four seeds were retrieved from stratigraphic Phase 2, and 59% (n=274) were identified to species. They were mostly retrieved from trampled surfaces and post-holes, suggesting that, just as in Phase 3, cereal processing waste had not been intentionally discarded into specific refuse areas. Sixty-four percent (n=9) of the taxa are represented as single seeds; the best represented taxa are fat-hen, followed by *Chenopodium* sp., barnyard millet and indeterminate grasses (Table 7.7c). Similarly to Phase 3, half of the barnyard millet seeds were in one of the post-holes from Structure 7, which also contained many glume bases (n=73, glume base:grain is 24.3) and fat-hen seeds (n=61). The large grass seeds are well distributed, but never as more than two seeds per sample. As was noted for Phase 3, they were amongst the more ubiquitous weeds.

Most of the wild species found in Phases 6, 3 and 2 grow well in disturbed habitats such as arable fields (Table 1.12, Appendix I). The only exceptions are the sedges (*Carex* sp.*)* which are usually associated with damp woodlands, pastures or wetlands (but see Chapter 5.4.3). The species for which information on soil moisture requirements was available suggest that whilst some fields may have been damper than others, cultivated soils were never dry. *Euphorbia peplus* L., found in the 'canal' sample (Phase 6), is an indicator of moist but well aerated soils in damp climates (Hanf 1983: 307). The pH preferences of weeds suggest that neutral to alkaline soils were preferentially used. However, two species are indicative of weakly acidic soils: *Rumex acetosella* L. from Phase 6 and *Hyoscyamus niger* L. from Phase 3. The majority of the taxa from all three phases grow well on soils of medium texture. Light (higher sand content) and heavy (higher clay content) soils are both represented by three species. Only one species from the three phases is categorised as 'low' (growing to 30cm or less), which suggests that cereal crops were not commonly harvested at ground level. The season in which the weed species set seed suggests harvesting took place in the late summer and/or autumn (as all identified seeds were ripe, other than some of barnyard millet).

In order to investigate the intensity of the husbandry regimes the life cycle, fertility requirements and flowering onset and duration of the wild taxa were recorded (Tables 1.12 and 1.15, Appendix I). Figures 7.7j to 7.7m show the relative proportions of taxa with these attributes by sub-site (mounds I and II) and phase. They should, however, be interpreted with caution as they are based on a low number of species, most of which have unknown ecological attributions. Nevertheless, the number of species between phases is comparable and the figures enable a visual comparison between chronological phases and between mounds I and II.

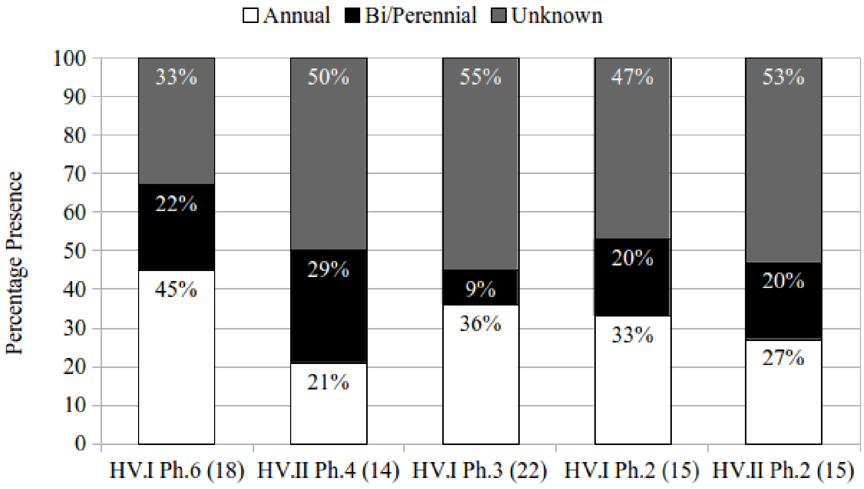


Figure 7.7j: Relative proportions of annual and perennial wild/weed taxa.

Figure 7.7j illustrates how H.V.I Phase 6 had the highest proportion of annuals, whilst the highest proportion of perennials was found in H.V.II Phase 4. Phases 2 of both mounds had the same proportion of perennials and twice as many as in Phase 3 of H.V.I. A large proportion of perennials are from open habitats and are an indication of regular disturbance (Chapter 5.4.5). Two of the four perennials in Phase 4 are hemicryptophytes (*Lychnis flos-cuculi* L. and *Plantago lanceolata* L.) and so could have benefited from shallow ploughing. Indeed *P. lanceolata* thrives in disturbed habitats and is often used as an indicator of anthropogenic disturbance (e.g. Roberts *et al*. 2011; Willis 1994). It is worth noting that, as Chenopodiaceae and barnyard millet seeds are the most abundant, the proportion of annuals would significantly increase if graphs were based on the percentage of seeds rather than taxa, particularly in Phases 2 and 3 of H.V.I. However, such an approach would be biased by the productivity (seeds per plant) of species.

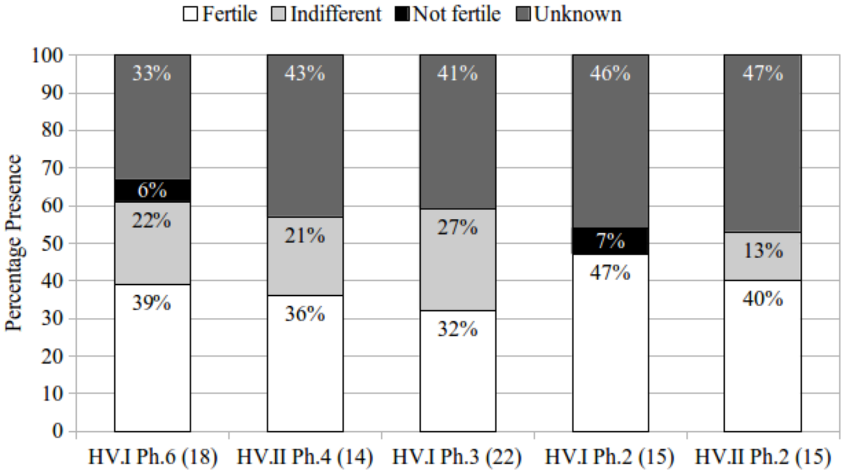


Figure 7.7k: Relative proportions of soil fertility levels, as indicated by the wild/weed taxa.

Notwithstanding taxa of unknown fertility requirements, nitrophilous plants represent less than 50% of the species per phase and are in similar proportion to plants that can grow successfully on both fertile and less fertile soils. Two species indicative of poor soils were found: *R. acetosella* L. in Phase 6 and *Carex* cf. *nigra* (L). Reichard in Phase 2 of H.V.I. The latter phase, however, also had the highest proportion of nitrophiles (47%, n=7) and no plants indifferent to fertility levels.

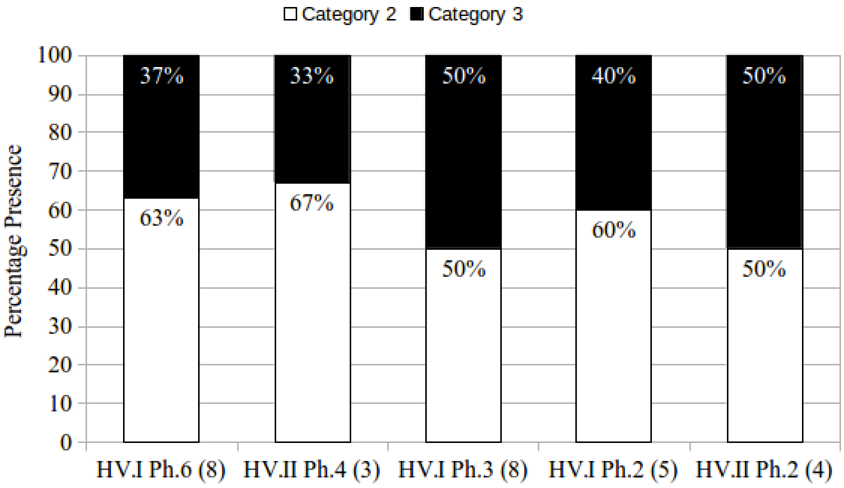


Figure 7.7l: Relative proportions of flowering onset and duration categories of annuals (after Bogaard *et al*. 2001).

Figure 7.7l shows that all annuals either flower for one to five months late in the year (category 2) or have long flowering periods that stretch from the spring into the summer (>5 months, category 3). Category 2 is associated with spring-sowing and/or high levels of disturbance, whilst category 3 can be indicative of both autumn and spring-sowing (Chapter 5.4.7). Apart from Phase 3 of H.V.I (where 'small' and 'big' seeds occur in similar proportions), more than half of the wild/weed seed assemblages are made up of 'small' seeds which could be indicative of a bias towards spring germinating plants in cleaning by-products (though not necessarily associated with Category 2; Chapter 5.4.10). However, the processing stages identified from richer samples (sections 7.7.1.4 and 7.7.2.4) indicate that by-products from various stages may be mixed, and biases for or against sowing time cannot be evaluated without further, detailed analysis of crop-processing stages (*cf.* Bogaard *et al*. 2005). None of the annual species that produce 'big' seeds germinate specifically in the autumn; *Galium aparine* L. can germinate in both autumn and spring, whilst all the others germinate in the spring (Table 1.12 and 1.15, Appendix I). The species with long flowering periods have permanent seed banks which, along with the ability to flower over several months, would have enabled them to survive periods of disturbance. The high proportion of these species, along with that of hemicryptophyte perennials and those that can regenerate from seed are suggestive of a high level of disturbance (e.g. Jones *et al*. 2000b).

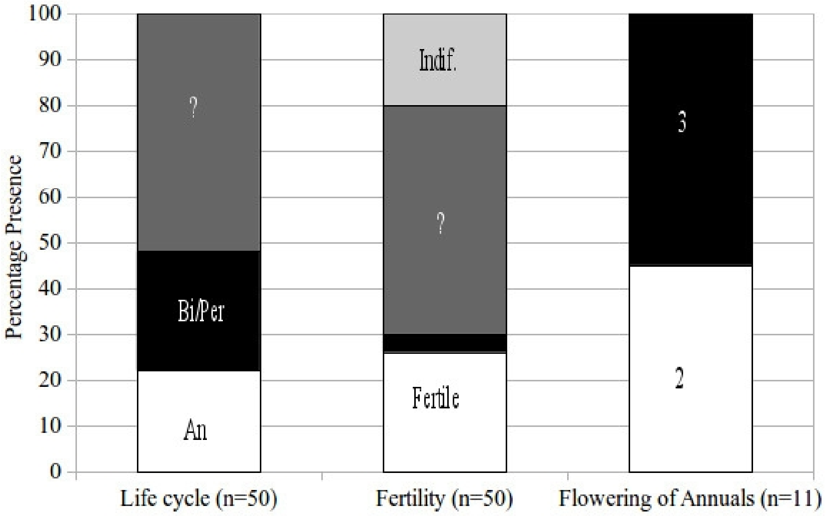


Figure 7.7m: Relative proportions of the biological and ecological characteristics of all wild/weed taxa.

When all of the wild/weed taxa are presented as a single assemblage (n=50), it becomes clear that the majority of taxa have unknown life cycles (52%, n=26) and fertility requirements (50%, n=25). Annuals and biennials/perennials occurred in similar quantities (22%, n=11 and 26%, n=13 respectively). The same is true for taxa that prefer fertile soils and those that are indifferent to fertility levels (26%, n=13 and 20%, n=10 respectively). Only 4% (n=2) are indicators of poor soils.

Taxa with flowering onset and length categories 2 and 3 also occurred in similar quantities (45%, n=22 and 55%, n=28 respectively). This graph corroborates those above plotted by phase in illustrating how much information is missing for interpreting the intensity of cultivation regimes. Nevertheless, the graphs suggest that annuals were only significantly more frequent than perennials in Phase 3, and that flowering categories of annuals indicative of spring sowing and/or disturbed arable conditions (unpredictable and intensive disruptions to the vegetation) predominate in all assemblages.

7.7.1.4 Exceptional assemblages

Whilst the plant macro-remains are generally sparsely distributed, five areas in Phase 3 and two areas in Phase 2 stand out for having an abundance of glume bases and relatively high proportions of wild/weed seeds: the large pit defined as Structure 8, another pit (context 702), Structure 5, Structure 12 and Structure 7(III) (all Phase 3); Structure 7(IV) and the undefined context 250 (both Phase 2). The emmer and einkorn glume base to grain ratio varies between 5.6 and 47.5, and the cereal grain to wild/weed seed ratios are mostly less than one (sample 53 from Structure 12 has a ratio of 2). These ratios are typical of chaff- and seed-rich glume wheat processing by-products. All samples contained both emmer and einkorn; exact proportions are difficult to establish due to the significant number of grains and chaff that could not be specifically identified. The wild plant seed assemblage is dominated by free and heavy seeds (SFH (70% FHH (n=650) and 30% BFH (n=279)) found amongst numerous glume bases, pointing to by-products of the last stages of the processing of glume wheats: de-husking, fine sieving and hand-sorting waste (Figure 5.1). Further sample by sample crop-processing analyses would provide greater detail but few samples contained more than 50 crops items and 30 seeds.

7.7.2 Hermanov Vinograd II

Stratigraphic phase	**4**	**3**	**2**	**1**	**?**	**Total**
Total samples	11	6	9	2	5	**33**
Total volume (L)	72	33	56	12	31	**210**
Total einkorn	2	34	5		3	**44**
Total emmer	11	61	1		4	**77**
Total 'new' type	1	1	2			**4**
Total grains (incl. indet. grains)	**58**	**244**	**35**	**2**	**15**	**354**
mean/L	0.81	0.48	0.63	0.17	0.48	**1.68**
Preservation index mean	0.6	0.6	0.9	0	1.9	**0.9**
mode	0	0	0	0	2	**0**
Fragmentation index	0	0	1.2	N/A	0	**0.3**
Samples with grains	82%	80%	89%	100%	80%	**85%**
Total einkorn glume base	22	17	10	10	5	**64**
Total emmer glume base	23	4	12	21	11	**71**
Total 'new' type glume base			1	51		**52**
Total glume bases (incl. Indet.)	**120**	**47**	**45**	**298**	**48**	**558**
mean/L	1.67	1.42	0.8	24.83	1.55	**2.66**
Glume base : grain ratio	2.07	2.94	1.29	149.00	3.20	**1.58**
Samples with glume bases	82%	50%	55%	100%	80%	**70%**
Total pulses	**12**	**4**	**49**	**0**	**4**	**69**
mean/L	0.17	0.12	0.88	0	0.13	**0.33**
Samples with pulses	45%	50%	56%	0%	40%	**45%**
Total fruits/nuts	**14**	**4**	**11**	**1**	**3**	**33**
mean/L	0.19	0.12	0.2	0.08	0.1	**0.16**
Samples with fruits/nuts	45%	50%	56%	50%	40%	**48%**
Total wild/weed seeds	**46**	**26**	**45**	**15**	**16**	**148**
mean/L	0.64	0.79	0.80	1.25	0.52	**0.70**
Non-cereal P.I. mean	1.8	1.7	1.6	1.8	1.5	**1.6**
mode	2	2	2	2, 3	1, 2	**2**
Samples with wild/weed seeds	91%	100%	89%	100%	40%	**91%**
Grain : seed ratio	1.26	0.62	0.78	0.13	0.94	**2.39**
Grain/Seed density (ex. chaff)	**1.8**	**7.8**	**2.5**	**1.5**	**1.2**	**2.9**
№ items / litre (excl. charcoal)	**3.5**	**9**	**3.6**	**27.8**	**2.8**	**5.8**

Table 7.7d: Summary results from the analysis of flots from Hermanov Vinograd II.

7.7.2.1 Preservation

Carbonisation was the dominant form of preservation. Mineralisation also occurred, exemplified by three seeds (opium poppy, common verbena (*Verbena officinalis* L.) and a possible bladder cherry seed). Charcoal was present in all samples with an average of 7.5ml/flot, which is about three times higher than the average found at H.V.I. Nevertheless, larger volumes of charcoal were an exception as 82% (n=27) of the samples contained three or less millilitres of finely comminuted fragments. Of those with higher quantities of charcoal only one came from a hearth (sample 10 with 15ml and only two other plant remains), and only one was associated with a large concentration of charred plant remains (sample 13 with 70ml charcoal). Charcoal fragments and other plant macro-remains were not recovered from the heavy residues. The caryopses are mostly fragmented with few traces of preserved epidermis; those that are whole are distorted and often puffed. Not all phases were equally sampled (total volume by phase varies between 12 and 72 litres), and the correlation between sample volumes and number of cereal grain is very weak (Pearson's r = 0.007). As is also the case with H.V.I, the variation in the number of grains per sample is therefore not a reflection of the volume sampled.

Overall the cereal grains have a mean F.I. of 0.3 and a P.I. of 0.9 with a mode of 0, which defines the preservation of cereal grains as very bad but with little fragmentation. The samples' F.I., P.I. and total number of cereal grains are plotted in Figures 7.7n by sample and 7.7o by phase. Sample 13 contained an unusually high number of cereal grains (n=228, 38grains/L) and is excluded from the graphs. The samples and stratigraphic phases vary between containing only grain fragments (Phase 1) to only whole grains (Phases 3 and 4). The degree of fragmentation decreases between the highest and lowest excavation levels, which may represent greater levels of surface disturbances.

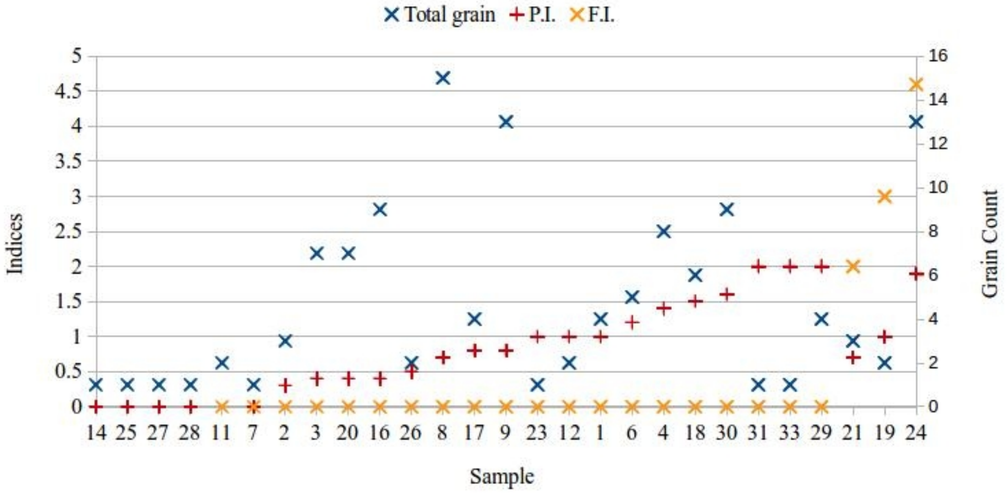


Figure 7.7n: Total grain, preservation and fragmentation indices by sample (H.V.II). Plotted by ascending F.I.

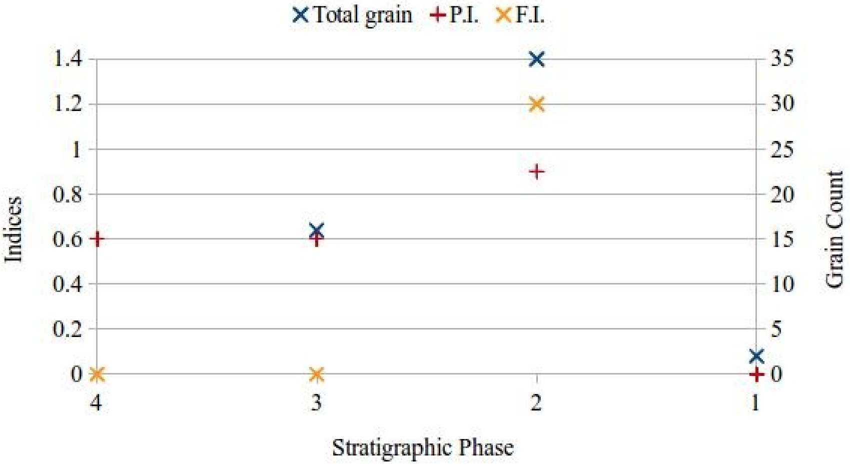


Figure 7.7o: Total grain, preservation and fragmentation indices by stratigraphic phase (H.V.II).

The non-cultivated seeds are better preserved than the cereal grains. They have a mean P.I. of 1.6 (mode of 2), which describes their preservation as poor to fair. Mean cereal P.I., mean non-cereal P.I. and grain/seed density (excludes chaff and charcoal) are plotted in Figures 7.7p by sample, and 7.7q by phase. Sample 13 is excluded. The cereal P.I. of individual samples varies between 0 and 2, and is only greater than the non-cereal P.I. in seven samples. The latter varies between 0 and 3. The two samples with the highest non-cereal P.I. had well preserved single wild plant seeds. The two samples with the lowest non-cereal P.I. had single fragments of a wild grass seed. The highest grain/seed density is seen in stratigraphic Phase 2, and results from an unusually high concentration of pulses recovered from sample 24. The indices seem to fluctuate independently of each other and the grain/seed density. The lack of a positive correlation between the cereal- and non-cereal P.I. may reflect the different taphonomical pathways of grains and wild/weed seeds.

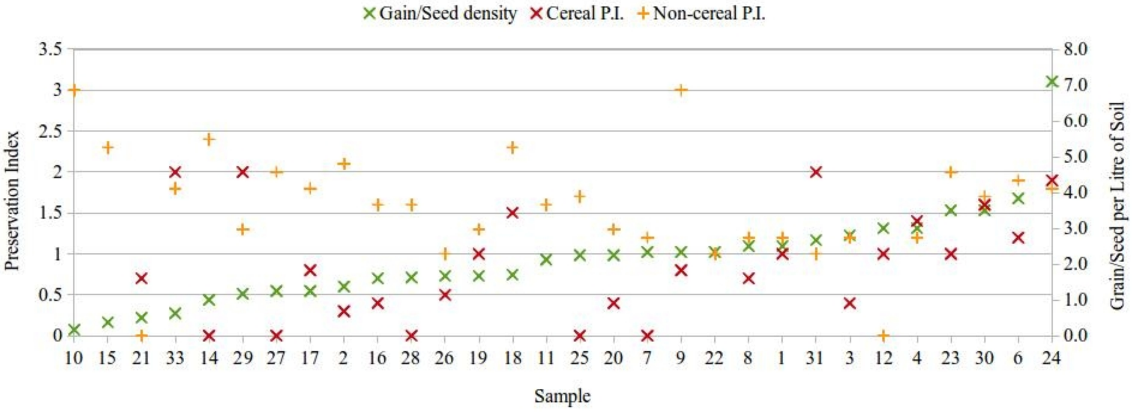


Figure 7.7p: Grain/seed density and preservation indices by sample (H.V.II). Plotted by ascending grain/seed density.

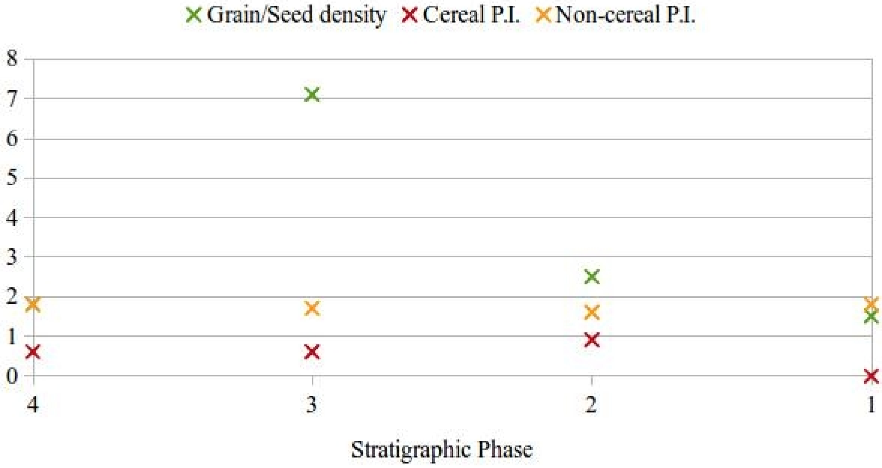


Figure 7.7q: Grain/seed density and preservation indices by phase (H.V.II).

7.7.2.2 Distribution

Table 7.7e, where the plant remains are presented by phase and feature type, suggests that plant remains were relatively evenly distributed across all feature types, except for the two graves which contained far fewer remains. As is mentioned above, sample 13 from a post-hole (the only post-hole sampled) in Phase 2 contained an unusually large number of cereal grains. Two other samples stand out as having large concentrations of cereal chaff and pulses but these single samples cannot exemplify a trend by feature type: sample 28 from the hearth in Structure 4, Phase 1, had 290 glume bases, and sample 24 from the floor in Structure 4(II), Phase 2, had 29 pulses. The remainder 30 samples had similarly low concentrations of plant remains and there is no apparent spatial or diachronic pattern in the distribution of plant parts. Interpretations of individual samples are not attempted, but rather descriptions and discussions are made by structures and phases.

Stratigraphic phase	**4**											**3**						
Number of samples	8					2					1	1	4					1
Feature type	4					1					5	4	1					2
Description	3 Pits					2 Floors					Hearth	Pit	4 Floors					P-hole
Total soil volume (L)	52					14					6	10	23					6
Total charcoal (ml)	66.5	**Mean**	**Median**	**Range**	**%**	1	**Mean**	**Median**	**Range**	**%**	15	1.5	3.5	**Mean**	**Median**	**Range**	**%**	70
Total grains	43	5.4	1.1	0 – 15	38%	15	7.5	7.5	2 – 13	50%	0	9	7	1.8	0.8	0 – 4	50%	228
Total glume bases	100	12.5	17.1	0 – 31	50%	19	9.5	9.5	3 – 16	50%	1	29	1	0.3	0	0 – 1	25%	17
Glume base:grain	1.9	2.5	1.8	0 – 7.8	43%	1.3	4.1	4.1	0.2 – 8	50%	N/A	3.2	0.1	1.1	0	0 – 3.2	25%	0.1
Total pulses	19	2.4	0.5	0 – 4	38%	0				100%	0	2	2	0.5	0	0 – 2	25%	1
Total fruits and nuts	9	1.1	1.3	0 – 4	13%	5	2.5	/	0 – 5	50%	1	1	1	0.3	0	0 – 1	25%	2
Total wild seed	36	4.5	1.3	0 – 11	50%	9	4.5	4.5	1 – 9	50%	1	2	12	3	4	1 – 5	75%	12
Grain:seed ratio	1.2	1.4	1.3	0.2–5	57%	1.7	6.7	/	0.3–13	50%	0	4.5	0.6	0.9	0.8	0 – 2	50%	19
Grain/Seed density	2.1	2.1	0.5	0 – 3	50%	2.1	2.1	2.1	1.9-2.3	50%	0.2	1.2	1	1.4	0.7	0.4 – 3	25%	40.3
№ items / litre*	4	4.8	3.9	0 – 9.5	38%	3.4	3.4	3.4	2.8-3.9	50%	0.3	6.7	1	1.4	0.8	0.5 – 3	25%	43.2

Stratigraphic phase	**2**																**1**	
Number of samples	2					4					2					1	1	1
Feature type	4					1					6					7	1	5
Description	2 Pits					4 Floors					2 Graves					?	Floor	Hearth
Total soil volume (L)	14					29					11					2	4	8
Total charcoal (ml)	3	**Mean**	**Median**	**Range**	**%**	3.5	**Mean**	**Median**	**Range**	**%**	1	**Mean**	**Median**	**Range**	**%**	0.5	0.5	2
Total grains	9	4.5	4.5	2 – 7	50%	22	5.5	4	1 – 13	50%	3	1.5	1.5	0 – 3	50%	1	1	1
Total glume bases	11	5.5	5.5	3 – 8	50%	28	7	3.5	0 – 21	50%	0				100%	6	8	290
Glume base:grain	1.2	2.2	2.2	0.4 –4	50%	1.3	5.4	0.3	0 – 21	25%	0				100%	6	8	290
Total pulses	15	7.5	7.5	3 – 12	50%	73	18.3	16.5	6 – 29	50%	0				100%	0	0	0
Total fruits and nuts	4	2	2	3 – 1	50%	7	1.8	2	0 – 3	50%	0				100%	0	1	0
Total wild seed	12	6	6	4 – 8	50%	19	4.8	3.5	0 – 12	50%	8	4	4	1 – 7	50%	6	3	12
Grain:seed ratio	0.8	0.6	/	0.5-0.9	50%	1.2	1.1	1.1	0.2 – 2	67%	0.4	1.5	1.5	0 – 3	50%	0.2	0.3	0.08
Grain/Seed density	2.9	1.3	1.3	1.2-2.3	50%	4.2	1.6	1.2	0.7–4	25%	1	1.4	1.4	0.5-2.3	50%	3.5	1.3	1.6
№ items / litre*	3.6	2.8	2.8	2.6 - 3	100%	5.1	3.9	3.2	1.3 – 8	25%	2.5	2.5	2.5	2.3-2.6	50%	6.5	3.3	39.8

Table 7.7e: Plant macro-remains by phase and feature type (H.V.II). Key: 1 – floor/ground surface; 2 – post-hole; 3 – foundation cut; 4 – pit; 5 – oven/hearth/fire; 6 – Grave; 7 – other/unknown. % percentage of samples with the value of the mean or above. excludes charcoal but includes all chaff and indeterminate food/parenchyma fragments. The latter have greatly increased the density in the graves of Stratigraphic Phase 2.

7.7.2.3 The crops, gathered flora and other wild plants

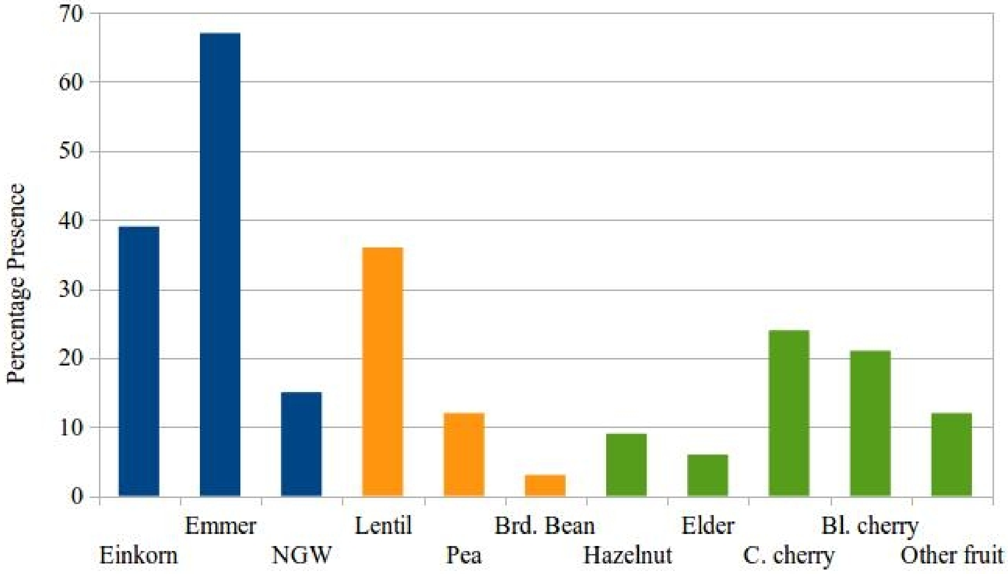


Figure 7.7r: Percentage presence (ubiquity across 33 samples) of crops, fruits and nuts (H.V.II).

- *Crops*

Einkorn (n=80 grain and chaff items) and emmer (n=131 grain and chaff items) are the major crops in the samples, occurring in 39% (n=13) and 67% (n=22) of samples respectively (Figure 7.7r). An additional cereal was found: 'new' glume wheat with a ubiquity score of 15% (n=5). It was found as four grains, 36 glume bases and eight spikelet forks. Eighty-five percent (n=28) of samples contained cereal grains (n=354, Table 7.7d), with an average of 1.7 grains per litre of sediment or 10.7 grains per sample, and a range of 1-228 grains. Excluding sample 13 reduces the average to 3.9 grains/sample or 0.6 grains/litre (range 1-15 grains), which demonstrates that, overall, there is a low concentration of cereal grains across the site. Seventy percent (n=23) of samples contained glume bases (n= 558), with an average of 2.7 per litre of sediment or 17 glume bases per sample, and a range of 1-290. Forty-six percent (n=13) of samples with grains had glume base to grain ratios of two or higher, representing the processing by-products of hulled wheats (based on the highest ratio of two glumes to every grain for single-grained einkorn). Sample 28 from the hearth in Structure 4, stratigraphic Phase 1, had an exceptionally high count of glume bases: 290 and only one grain (excluding this sample, the range for glume bases per sample is 0-21). When samples 13 and 28 are excluded, the overall glume base to grain ratio increases to 2.1, demonstrating that overall more cereal processing by-products were recovered than clean grain. Lentils were the most frequent pulse, pea and broad bean were also found, along with one possible common vetch (*Vicia sativa* L.) and two possible bitter vetches (*V. ervilia* (L.) Willd.). Both types were found in the pulse-rich sample. Indeterminate large legumes were mostly present as individual finds, though eight whole specimens were counted in the pulse-rich sample.

- *Edible fruits and nuts*

Cornelian cherry (n=9) and bladder cherry (n=14) were the most frequently occurring fruit stones/seeds. 'Other fruits' in Figure 7.7r consist of two strawberry seeds and one *Prunus s*p. stone.

- *'Weed' seeds*

Fat-hen seeds were not as numerous as in H.V.I but were still the most common and ubiquitous seeds (26 across 36% (n=12) of samples). *Chenopodium* sp. seeds (n=19) were found in 30% (n=10) of samples. Other common seeds were large grass seeds (n=14 across 36% of samples) followed by *Physalis/Solanum* (n=10 across 27% (n=9) of samples). Most taxa occurred as one or two specimens in a limited number of samples. Phases 4 and 2 were the only ones to contain more than 40 seeds, with a minimum number of 14 and 15 taxa respectively, and so only these are discussed (Table 7.7f). Comparisons between phases can be found above with results from H.V.I.

Forty-six seeds were retrieved from Phase 4 and 37% (n=17) were identified to species. The majority were retrieved from the three pits, along with most of the chaff recovered from Phase 4 (Table 7.7e). The hearth only contained one seed and nine seeds were recovered from the two floors. Seventy-seven percent (n=10) of the taxa are represented as single seeds; the best represented taxa are fat-hen (n=13), *Chenopodium* sp. (n=4), and *Physalis/Solanum*, (n=4, including one mineralised).

Forty-five seeds were retrieved from Phase 2 and 33% (n=15) were identified to species. They were mostly retrieved from four floors and two pits, along with most of the chaff (Table 7.7e). The graves contained very few plant remains. Thirty-six percent (n=5) of the wild/weed taxa are represented as single seeds. The best represented taxa is *H. niger* (n=5), followed by equal proportions of *Chenopodium* sp., barnyard millet and *Physalis/Solanum* (4 seeds each).

Most of the wild species recovered from Phases 4 and 2 grow well in disturbed habitats (Table 1.15, Appendix I). The species for which information on soil requirements was available suggest that cultivation was mostly upon moist to damp soils of medium texture and neutral to alkaline pH. Only common verbena (found as a mineralised seed in Phase 4) prefers dry soils. Light textured soils are represented by one species in Phase 2, and heavy soils by two taxa. Phase 2 also contained two taxa indicative of weakly acidic soils. All taxa could have reached a height of at least 30cm, suggesting that crops were not harvested at ground level. The season in which the taxa set seed indicates that harvesting took place in the late summer and/or autumn. The soil preferences, harvesting height and harvesting season compare favourably with those identified from the 'weeds' of H.V.I.

Hermanov Vinograd II – wild/weed seeds (29 taxa)	**Phase 4** (11 samples)		**Phase 2** (9 samples)	
	Ubiquity	Total	Ubiquity	Total
Agrostis spp. (1mm long)				
Aphanes/Alchemilla sp.			11%	2
Atriplex sp.				
Brassica/Sinapis sp.			22%	2
Chenopodium album	45%	13	22%	3
Chenopodium sp.	18%	4	33%	4
Echinocloa crus-galli			11%	4
Fallopia convolvulus				
Galium aparine	9.1%	1		
Hyoscyamus niger			33%	5
Juncus sp.				
Lolium/Festuca sp.				
Lychnis flos-cuculi	9.1%	1		
Medicago sp.	9.1%	1	11%	2
Medium Poaceae (wild)				
P. somniferum/dubium			11%	1
Papaver somniferum				
Phleum sp.	9.1%	1		
Physalis/Solanum sp.	36%	4	33%	4
Plantago lanceolata	9.1%	1	11%	1
Poa sp.	9.1%	1		
Polygonum spp.	18%	2	11%	2
Potentilla/Fragaria sp.			11%	1
Rumex sp.	9.1%	1		
Large Poaceae (wild)	9.1%	1		
Small Poaceae (wild)	9.1%	1	22%	2
Trifolium/Medicago sp.			11%	1
cf. *Urtica dioica*			11%	1
Verbena officinalis	9.1%	1		
Total	**14 taxa**	**33**	**15 taxa**	**35**
Total (incl. Indet. seeds)		**46**		**45**
Total (excluding *C. album*)	**13 taxa**	**33**	**14 taxa**	**42**
Total (excl. *Chenopodium* sp.)	**12 taxa**	**29**	**13 taxa**	**38**

Table 7.7f: Wild/Weed taxa from Phases 4 and 2, (H.V.II).

7.7.2.4 Exceptional assemblages

The three assemblages with unusual compositions originate from Phases 1, 2 and 3. The hearth in Phase 1 contained 290 glume bases, predominantly pertaining to the 'new' glume wheat (n=51). A single indeterminate cereal grain was also found, along with 12 wild plant seeds and some amorphous lumps of charred organic matter, possibly burnt bread/food. Chaff appears to have been used as kindling or fuel in this hearth/oven. The presence of free and heavy seeds, as well as the lack of any straw or awns (though both are more combustible than glume bases), suggests that only the final by-product of cereal processing was used. Phase 2 contained a relatively large quantity of pulses, namely lentils, embedded in the floor of Structure 4(II) (sample 24, n=29). These were associated with 13 highly fragmented cereal grains and seven glume bases. Bladder cherry, cornelian cherry and 12 wild plant seeds were also recovered. The assemblage appears to contain waste/spills from crop processing, cooking and/or consumption. The 228 grains from the post-hole in Phase 3 are a mix of emmer (n=58) and einkorn (n=34). Other finds comprise of 17 glume bases, two fruits and 12 wild plant seeds. The assemblage is the only one from the whole of Hermanov Vinograd to contain a significant quantity of grain (the next largest quantity by sample being 31), a low glume base to grain ratio (0.1) and a high grain to wild/weed seed ratio (19).

7.7.3 Discussion of results from H.V.I and H.V.II

Both mounds mainly used the same restricted range of cereals: einkorn, emmer and the 'new' glume wheat, as well as lentil and broad bean. Common and bitter vetch, found at H.V.II, may also have been cultivated. At least eight fruits and nuts were identified. They were found in greater numbers than the pulses (111 compared to 87), and attest to the importance of gathering during the Late Neolithic (Chapter 5.3.3.2). Fat-hen seeds are the most ubiquitous and numerous wild plant seeds found at both mounds. It was either a prolific weed or (also) collected and handled on site as a food.

The overall preservation of cereal grains is poor despite a low mean fragmentation index. Only at the smaller mound does the level of fragmentation increase in higher stratigraphical levels, suggesting that activities on the site's surface (natural and/or anthropogenic) may have affected the preservation of the archaeological record. The weak correlations between the number of grains and volumes sampled suggest that there is an uneven distribution of grains across both mounds, and that larger concentrations of cereal grains would not be obtained from randomly selected larger samples. Eighty-nine percent (n=115) of samples contained at least one grain, seed or piece of chaff. Richer samples, with above average densities of crop remains and/or wild plant seeds, are rare. The absence of any correlation between the seed densities and preservation indices indicates that the assemblages of seeds and grains have not been overly distorted by adverse preservation conditions. The vast majority of plant remains were carbonised whilst the few mineralised ones may point to culinary ingredients, or simply high levels of decaying organic residues as must have accumulated on long-lived farming sites (Chapter 5.1.1).

On the whole glume bases and free, heavy weed seeds predominate, suggesting that most remains are burnt waste from the final stages of cereal processing which took place within and/or around the site structures. Concentrations of plant remains were relatively high in pits, but also in samples from trampled surfaces, foundation cuts and post-holes, and it seems that burnt waste from routine activities was generally not carefully or intentionally disposed off in specifically designated areas. Analysis of the zoological remains also showed that most bones had not been systematically disposed off into refuse areas, but were found scattered across the site and had gnaw marks from dogs and rodents (Gaastra Unpublished_a). The cereal grain and glume base densities at the two mounds differ: the site densities for H.V.I are 0.4 grains/Litre and 4.5 glume bases/Litre; those for H.V. II are 1.7 grains/Litre and 2.7 glume bases/Litre. Whilst it may be unreasonable to suggest that one mound acted more as 'producer' and the other as 'consumer', the denser concentration of wheat chaff on the bigger mound could suggest that cereal de-husking was more frequently performed there than on the smaller mound (*cf*. Chapter 5.3.3.1; Fuller *et al*. 2014; Fuller & Stevens 2009). The presence of pulses within crop processing waste (supposing the assemblage originated from a single activity) can be explained if crop rotation was practised, and/or the same threshing floor was used for cereals and pulses (Jones & Halstead 1995: 111). It is also possible that cereals and pulses were sown together, as has been attested in present-day Asturias where peas and/or broad beans are often sown with spelt or emmer (Peña-Chocarro 1996: 134; 1999: 39).

The possible weed seeds, though not numerous, suggest that the husbandry regime adopted during all analysed phases did not vary significantly. Cultivation was mainly practised upon soils of medium texture and neutral to alkaline pH, though lighter and heavier soils, of more alkaline and weakly acid pH, may also have been used. Both autumn and spring-sowing appears to have been practised, perhaps reflecting the cultivation of both cereals and pulses. Although the signature for spring-sowing appears stronger (Figure 7.7l), flowering Category 2 taxa are also known to thrive in intensively managed autumn-sown crops (Jones *et al*. 1999, 2005). Soils were maintained moist or damp, most likely naturally considering the high precipitation levels in the Pannonian Basin (Figure 2.5b). The proportion of nitrophilous weeds is not high, suggesting that soils were not fertilised, or at least not evenly or intensively. Some level of fertility may have been maintained within a rotation system that included periods of fallow, as may be indicated by the proportion of perennials and annuals capable of enduring repeated episodes of disturbance. The relatively high proportion of perennials throughout the phases suggests weeds were not uprooted by hand or a deep mechanical action. Cereals were seemingly harvested in the late summer or autumn. The harvesting height does not appear to have changed much between phases as the majority of taxa grew to at least 30cm. The distance below the ear at which the cereal was cut is impossible to tell but it seems some stubble was either cut separately, ploughed or left to be eaten by herbivores.

7.8 Final Discussion

7.8.1 Preservation of plant remains

A total of ten sites were sampled for this thesis. They are all located within the northern area of the western Balkans (Figure 7.1) and, apart from Korića Han, were situated on flat plains with high water-tables within landscapes dissected by active river systems. Not all the samples were obtained from secure Neolithic contexts, and not all sites contained sufficient plant remains to justify interpretations in terms of human behaviour. The sums of plant remains and the mean preservation and fragmentation indices recorded from the seven sites with reliable contexts are presented in Table 7.8a. The results vary significantly between sites, and the only apparent pattern is that the tell sites had higher densities of plant remains than the open sites. The density of plant remains between AtII and Potporanj, for example, varies by a factor of ten, which reflects a trend evident between Early and later Neolithic sites (though not without exceptions - *cf*. Filipović 2014; Chapter 4.1.4). This difference however, probably relates to the discrepancy in the longevity and density of occupations between site types, rather than differences in the contribution or importance of cereal farming to the inhabitant's diet (*contra* Greenfield 2014; Greenfield & Jongsma 2008; Gyulai 2012).

The correlation between the total number of items per litre (excluding charcoal) and the total volume sampled by site is weak (Pearson's r = -0.1), as is the correlation between the total number of cereal grains and the volume sampled by site (Pearson's r = 0.01 excluding sites with unknown sampled volumes, and r =-0.48 when Bapska H2 is also excluded). These results corroborate those from individual sites where the correlations between the number of grains and sample volume were weak. Theoretically, the more one samples, the more one is likely to recover a representative sub-sample of preserved plant remains (*sensu* Jacomet & Brombacher 2005). Therefore, at sites where plant remains are unevenly and sparsely distributed, it is particularly important to sample as widely and intensively as possible.

The correlations between the total number of grains and the mean preservation and fragmentation indices by site are quite weak (Pearson's r = 0.38 and 0.54 respectively), indicating that the overall levels of preservation have not adversely affected the number of grains. The same results were obtained when these relationships were explored by sample: strong correlations were not evident, other than at Bapska H2. Instead, these variations may have been caused by differences in the frequency of cereal processing and in the use/discard of processing waste (whether it was burnt and/or discarded within the sampled areas). Only at Tăşnad Sere and Bapska H2 were the identifications of grains affected by detrimental pre- or post-depositional processes.

	T.Sere	**At II**	**Potporanj**	**Kočićevo**	**K.Han**	**Bap. H2**	**Bap. H3**	**H.V. I**	**H.V. II**
Site type	Open	Open	Tell	Open	Tell	Tell	Tell	Tell	Tell
Neolithic Phase	Early	Early	Middle	Mid/Late	Mid/Late	Late	Late	Late	Late
Cultural attribution	Çris	Starčevo	Vinča B	Sopot	Vinča C/D	Vinča C&D / Sopot		Sopot	
Total samples	165	10	11	21	1	7	1	96	33
Total volumes (L)	1645	100	110	115	?	495	?	602.5	210
Total cereal grains	45	163	609	79	23573	29584	32089	258	354
mean/L	0.03	1.63	5.5	0.7	/	59.8	/	0.4	1.7
range/sample	0 – 4	5 – 36	6 – 265	0 – 24	/	1904-5848	/	0 – 31	0 – 228
Total glume bases	62	35	1484	141	16	16	0	2723	558
mean/L	0.04	0.35	13.5	1.2	/	0.03	/	4.5	2.7
range/sample	0 – 8	0 – 9	7 – 954	0 – 111	/	0 – 8	/	0 – 745	0 – 290
Gl.base:grain	1.4	0.2	2.4	1.8	0.0007	0.0005	/	10.6	1.6
range	0 – 7	0 – 1.5	0.3 – 16.7	0 – 9.3	/	0 – 0.004	/	0 – 49	0 – 290
T. pulses/fruit/nuts	15^	11	139	4	16	114	0	96	102
mean/L	0.009	0.11	1.3	0.003	/	0.2	/	0.2	0.5
range/sample	0 – 6^	0 – 3	1 – 42	0 – 2	/	2 – 48	/	0 – 33	0 – 31
Total 'weed' seeds	139*	10	336	24	24	26	48	1060	148
mean/L	0.08	0.1	3.1	0.2	/	0.05	/	1.8	0.7
range	0 – 11	0 – 3	7 – 129	0 – 5	/	0 – 8	/	0 – 149	0 – 12
Grain:'weed' seed	0.3*	16.3	1.8	3.3	982	1138	669	0.2	2.4
range	0 – 2	6 – 18	1 – 5.6	0 – 24	/	501 – 1046	/	0 – 3.5	0 – 19
$^+$№ items / litre	0.2*	2.3	23.5	3.2	/	60	/	6.9	5.8
range	0 – 1.2	0.6 – 4.7	2.2 – 106.1	0 – 31.2	/	27.3– 132	/	0 – 118	0 – 43.3
Cereal P.I. mean	♦0.2	0.6	1.2	0.8	2.4	0.1	1.6	0.6	0.9
mode	0	0	1	1	2	0	0	0	0
range	0 – 2	0.3 – 0.8	0.4 – 2.2	0 – 1.4	0 – 3	0.04 – 0.2	0 – 3	0 – 1.5	0 – 1.9
Cereal F.I. mean	♦4.4	4.2	2.7	1.8	2.9	230	9.35	1.1	0.3
range	0 – 11	1.6 – 7.2	0 – 10.5	0 – 4.8	/	82 – 518	/	0 – 25	0 – 4.6
Non-c. P.I. mean	♦0.6	0.9	1.6	0.9	2.5	2.1	1.7	1.4	1.6
mode	0	1	2	1	2, 3	2	2	1	2
range	0 – 2	0 – 2	1 – 1.9	0 – 2	2 – 3	1.6 – 2.5	1 – 2	0 – 2.5	0 – 2.4

Table 7.8a: Summary data for the nine sites with secure contexts. Key: ♦only representative of flots sorted by the author; ^ includes 6 nut shells from a single sample; *excludes the sample with >153 wild/weed seeds $^+$excludes charcoal

7.8.2 Distribution of plant remains

Samples from the buried soils excavated by the EUROFARM team had very few plant remains, and indeed results from Kočićevo and Hermanov Vinograd suggest these small artefacts often end up in negative features. The difference in the density of plant remains between the two Early Neolithic settlements (0.2/L at Tăşnad Sere and 2.3/L at AtII) may equate to the location of samples: negative features within a structure were sampled at AtII, whereas the samples from Tăşnad-Sere came from an occupational layer. Almost the same number of cereal grains were found in the Potporanj house as in the whole of Hermanov Vinograd. Results from the zoological analysis indicate that the Potporanj inhabitants were not lacking in meat, and hunted more as a mark of social status than necessity (Gaastra Unpublished_b; see also Orton 2012). Cereals also seem to have been plentiful. Assemblages with the highest number of grains were recovered from single samples/deposits (Bapska and Koriča Han), where grain was clearly visible during excavations. These rich deposits of clean grain are not the most informative on past agricultural husbandry regimes, and should not deflect from broader sampling efforts which are far more likely to retrieve evidence of routine activities and cultivation practices (*cf*. Filipović & Marić 2013).

7.8.3 The cereals

The most numerous and ubiquitous cereals were single-grained einkorn and emmer. Although they were nearly always found together, either one or the other dominates in the dense assemblages of clean grain. As is mentioned above, emmer and einkorn make for unlikely maslins due to variations in their growth habits. They may have been processed or cooked in the same areas, which could explain some contamination. On the other hand, if they *were* grown as a maslin, one would expect the ecologically more resilient species to dominate (Jones & Halstead 1995: 109). This scenario could account for the predominance of one glume wheat in the large assemblages of clean but mixed grain from Bapska H2 and Korića Han. Barley was found at five sites (Tăşnad-Sere, AtII, Kočićevo, Korića Han and Bapska H2), though never in large quantities. The largest number of grains were recovered from Korića Han where they constitute no more than 19% (n=169) of the otherwise einkorn dominated assemblage. The barley from Korića Han is of the naked 2-row variety. Naked barley was also found at Bapska H3. Hulled grains were identified at AtII and Kočićevo. Free-threshing wheat was even rarer, occurring as one grain in Kočićevo and one rachis node in Potporanj. Barley and free-threshing wheat are quite rare on Neolithic sites in Serbia and eastern Croatia, and are more usually considered crop contaminants (Chapter 4.1.2.2 & 4.1.4). However, evidence for their use cannot be directly compared with that for hulled cereals as free-threshing chaff is removed during threshing and is therefore less likely to become charred during household activities (Table 5.2). It is also possible that barley was not commonly de-husked and consumed but rather used hulled as animal feed and/or in fermented beverages (*cf*. Filipović 2014: 201). The 'new' glume wheat was found at Hermanov Vinograd (76 glume bases), and at Potporanj and AtII where possible grains were recovered. Finds from the latter site suggest that the 'new' glume wheat was present in northern Serbia from the Early Neolithic (see Bogaard *et al*. 2007). The spatial and diachronic presence of cereal types across the western Balkans is discussed in further detail in Chapter 9.

The breadth and thickness of 46 and 70 of the better preserved caryopses from Bapska H3 and Korića Han respectively, were plotted against measurements from 184 charred domesticated Neolithic emmer and einkorn grains from the Near East (n=36), Turkey (n=31), Bulgaria (n=36), Hungary (n=32), Croatia (n=2), Greece (n=35), Cyprus (n=9), Crete (n=2) and Macedonia (n=1) (the latter four form the 'G' group) (Fuller *et al.* 2017; Figures 7.5 and 7.6). On average, emmer grains from Bapska H3 are slightly larger than those from Korića Han (Table 7.8b). The grains appear to represent crops of clean emmer and/or einkorn burnt in single events, and demonstrate that a broad range of sizes can be found within a cereal plot.

	Korića Han		**Bapska House 3**	
	Thickness	Breadth	Thickness	Breadth
Emmer	2.2mm	2.5mm	2.7mm	2.9mm
Einkorn, 1-grained	2.2mm	2mm	2.3mm	1.9mm

Table 7.8b: Mean thickness and breadth of emmer and single-grained einkorn grains

The range of sizes potentially present in single harvests suggests that comparing the mean breadth and thickness of cereal grains between cultural groups or ecological areas may be more meaningful than plotting individual grains (particularly as the effects of cereal processing on the selection of grains (by size) are not always evident or uniform (*cf*. Dennell 1974; 1978: 149-50)). The separation between emmer and einkorn is less distinct when grain sizes are plotted individually (Figure 7.8). Emmer grains from Bapska are larger than those from Korića Han, and are more comparable to those from Hungary (3x2.5mm) and the 'G' group (3x2.6mm). Korića Han emmer sizes compare well to Near Eastern ones (2.5x2.2mm), whereas Turkish ones (2.7x2.3mm) are closer to those from Bulgaria (2.7x2.4mm). Bapska einkorn are slightly thicker and narrower than those from Korića Han, and both are distributed towards the smaller end of the graph, along with Turkish einkorn (2x2.2mm). These three groups of einkorn are of a similar thickness to those from the Near East (2.2x2.2mm), despite having narrower breadths. Emmer and einkorn from Korića Han and einkorn from Bapska House 3 date to the first half of the fourth millennium BC but mostly cluster with the older, smaller grains. In summary, domesticated emmer and einkorn have distinctive shapes, but the variation in grain sizes does not follow a chronological trend (dates of assemblages can be found in section 7.5.2). Rather, variation by geography is evident, seemingly reflecting adaptations to local natural and anthropogenic conditions.

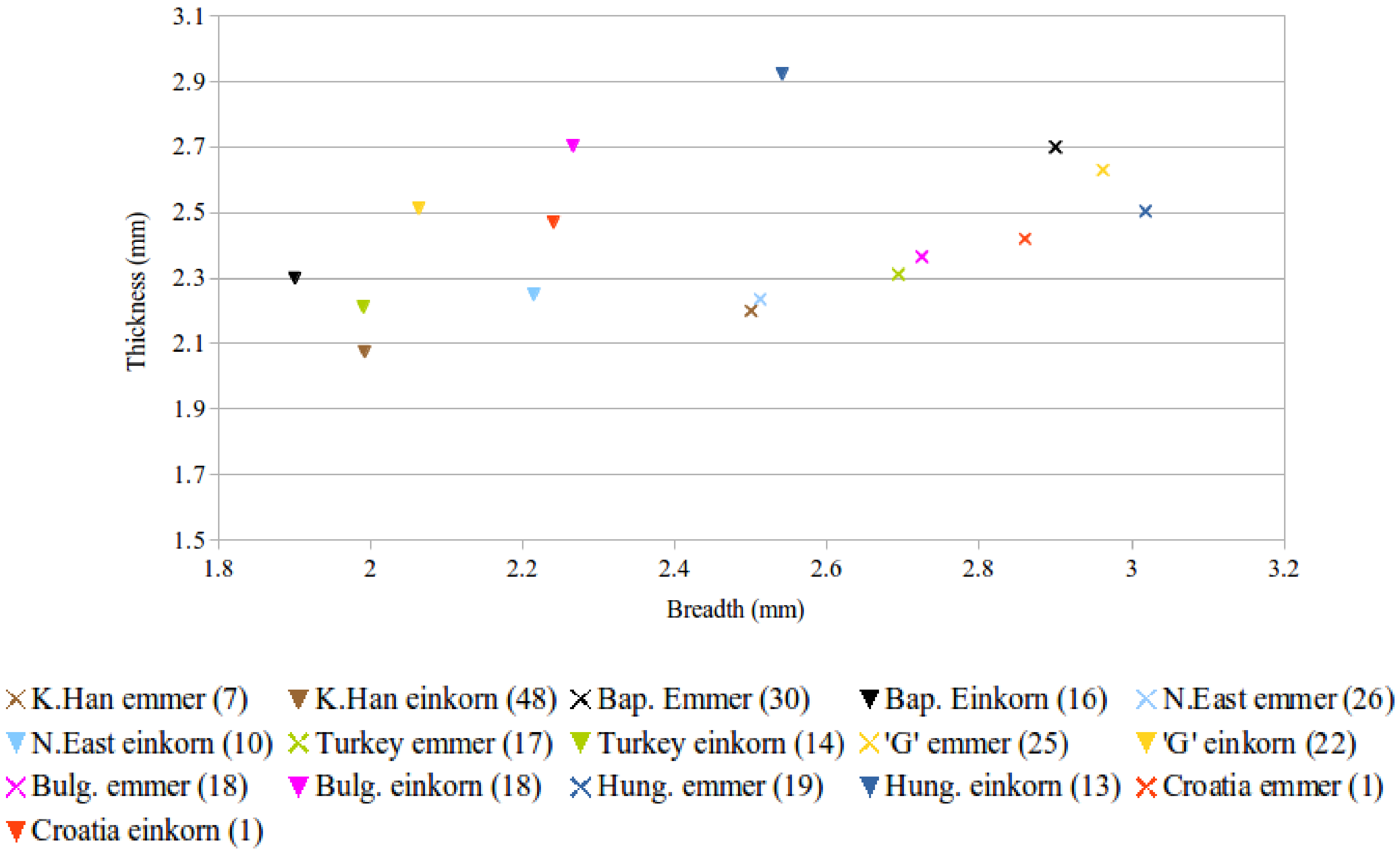


Figure 7.8: Mean breadth and thickness of Neolithic emmer (crosses) and einkorn (triangles; all varieties included). Note that the axes do not start at zero.

Only the final stages of crop-processing are evident from the assemblages. The glume base to grain ratios (excluding Bapska and Korića Han) suggest that, overall, waste from de-husking and further sieving/sorting predominate in the assemblages. The frequency and ubiquity of this waste suggest it was regularly produced by routine activities (Fuller & Stevens 2009: 40; Chapter 5.1.3.2). Glume wheats therefore appear to have been stored hulled rather than as clean, naked grains. The relatively low presence of weed seeds, and high grain to seed ratios could suggest that fields were regularly weeded (but see section 7.8.6), that cereals were harvested in such a way that avoided most weeds (e.g. ear plucking), or that coarse and fine sieving of spikelets prior to storage was very efficient. In the latter case glume bases and grain-sized weed seeds would predominate in the final by-products, as is seen at Potporanj. Hermanov Vinograd.I differs from the other sites in having more weed seeds than grains, most of which are small, free and heavy. Waste from fine-sieving was therefore also present at H.V.I. Cereals seem to have been stored as spikelets prior to fine-sieving at Hermanov Vinograd and Kočićevo, and possibly in a semi-clean state (spikelets after fine sieving) at Potporanj. The large deposits of clean grain from Bapska and Korića Han are difficult to interpret (*cf*. Dennell 1972: 151), but may have been held in organic vessels, such as baskets. The very fragmented assemblage from Bapska H2 probably represents cooking/grinding residues.

There is no clear evidence for storage receptacles at any of the sites sampled. Storage facilities should maintain cereals dry and very well ventilated, or in an oxygen-free environment. The availability and effectiveness of such facilities will determine how long cereals can be stored. Evidence from other Vinča sites show that cereals were stored in underground pits, clay-lined bins, possible granaries, ceramic vessels including large pithoi, and possibly organic containers such as hanging baskets (Borojević 2006: 132; Filipović & Obradović unpublished; Obradović unpublished; Spasić & Živanović 2015; Tripković 2011: Fig.2). Glume wheats are thought to have stored better hulled as clean or semi-cleaned spikelets, particularly in areas of wetter climates, producing chaff-rich assemblages if burnt (*cf*. Hillman 1981: 138, 1984a: Fig.3). This practice assumes a degree of communal labour to process the crop *en masse* in a short time span between harvest and storage, after which further de-husking can be done piece-meal as and when grain is required for consumption (Stevens 2003: Fig.7). The earlier stages of crop-processing of glume wheats are more labour intensive, and Steven's study of crop-processing practices at Iron Age and Roman sites along the Thames Valley, England, led him to suggest that the stage at which glume wheat spikelets were stored depended upon the “ability to organise large numbers of people for agricultural purposes.” (Stevens 2003: 72). Sigaut (1988: 10-11) notes that in the 18th century AD hermetically sealed underground pits were still used to store grain across Europe, including Hungary and the Balkans. The exclusion of oxygen stops any germination, insect infestations and bacterial or fungi infection, allowing the grain to be stored over several months even if the crop was not properly dried (Sigaut 1988: 11). Charred adult wheat weevils (*Sitophilus granarius* L.) were found amongst the Neolithic einkorn grains in the storage feature at Selevać, and are a reminder of how detrimental insect infestations could be (Obradović 2016). In certain cases a hermetic seal can be achieved naturally when the external layer of grains, exposed to variations of temperature and humidity, forms a hard protective crust (Sigaut 1988: 12). Another method of increasing storage length is to parboil the grains to render them biologically inert (Sigaut 1988: 5). This method is obviously unsuitable for grains destined for recipes that require fermentation, such as those for beer and leavened bread. Storage can also relate to the sowing method: broadcast sowing uses much more grain than sowing in rows or dibbling, requiring larger storage containers for the hulled seed crop. Therefore, the processing stage at which cereals are stored will not only depend upon local climatic conditions, available labour during the harvest season and the types of storage facilities, but also on the intended final use of cereals (culinary or otherwise).

Tăşnad Sere and AtII had the lowest densities of glume wheat chaff (0.04/L and 0.35/L respectively). Glume wheats may not have been de-husked in the areas sampled at AtII and Tăşnad Sere, or chaff was not burnt. SKC pottery was tempered with cereal chaff (Manson 1995), and chaff was added to clay and mud for the construction of houses throughout the Neolithic (Borojević 2006: 125-127). Indeed I noticed that most of the burnt clay and 'plaster' fragments in the heavy residues from Hermanov Vinograd contained chaff impressions. The architect Ginder (1996) published the methodology used in building the traditional Voyvodina (region of northern Serbia) mud (*pisé*) houses constructed in the 1960s and 70s (cited in Borojević 2006: 126). On the basis of Ginder's calculations Borojević (2006: 126) calculated that between 130 to 200 litres of straw was required to construct a $1m^3$ daub wall at the Late Neolithic (Vinča C) site of Opovo (30km North-West of Belgrade at the southern limit of the Pannonian Plain; site 108, Figure 8.2). It is not known whether building work was a seasonal activity, though it has been suggested that constructions took place during late spring when the clay was still naturally soft (Borojević 2006: 127). Either way, some chaff, particularly straw, was most likely retained for construction purposes. The addition of straw into the very fabric of the settlements, not to mention its probable role as an animal winter feed, is an indication of how cereal cultivation was more than just an important food source but formed an integral part of the settlements' identities and livelihoods.

7.8.4 Other crops

Pulses were not as numerous or as common as cereal remains and were found at only four sites. Lentils were found at three sites: Korića Han (n=1), Potporanj (n=40) and Hermanov Vinograd (n=45). Pea was identified at H.V.II (n=5) and Kočićevo (n=1). Hermanov Vinograd also contained three broad beans, one possible common vetch and two possible bitter vetches, as well as 29 indeterminate large pulses. The processing of pulses is very similar to that of free-threshing cereals (Butler 1999: 36; Hillman 1981: Fig.6; 1984: Fig.2; Jones 1984: Fig.1). They do not require to be parched in order to release a clean seed and this may be why they are often found in much lower proportions than glume wheats. They can be an important source of protein for humans, a rich source of nutrients for animals, and can improve the soil when used as a green manure or as part of a crop rotation system (Butler 1999: 33-34; Palmer 1998b: 38-39). Pea and broad bean are more tolerant to cooler conditions than lentil, which is particularly susceptible to frost damage (Butler 1999: 35; Eddowes 1976: 220, 230; Hillman 1981: 146; Saxena 1981: 115-16). Bitter vetch may also have been grown for human consumption, as is attested by the “the large number of bitter vetch seeds in the storage/food preparation area of the burnt House 01/06 at Vinča – Belo Brdo” (Filipović & Obradović 2013: 43; see also Filipović 2014: 201).

7.8.5 Edible fruits and nuts

The only sites not to contain edible wild fruits and nuts were Bapska and Korića Han from which single deposits of clean cereal grain were sampled. Eight taxa were identified and there is no perceptible diachronic difference in the range or representation of wild fruits and nuts (but see Figure 8.25). As is discussed in Chapter 5.3.3.2 gathered wild plants were an important and integral part of the Neolithic diet, and it is interesting to note that they were not simply picked and eaten '*al fresco*', as one might pick black berries whilst on a walk, but brought into dwellings and eaten with farmed foods.

7.8.6 Wild/weed seeds

Seeds of some common arable weeds, such as those of goosefoots, cleavers and black bindweed, are edible whilst other taxa have useful/edible leaves and/or roots. Some sedge seeds are edible and the straw has a number of uses (such as kindle, basketry, matting, roofing, etc.), which could indicate yet another provenance for the charred seeds. Nevertheless, most of the wild/weed seeds were recovered from crop-rich samples and it is assumed that they grew within the cereal fields, even if some were possibly eaten or used in medicinal concoctions (e.g. Tardío & Pardo-de-Santayana 2014; Redžić 2006). The reconstruction of cultivation practices by examining the ecological requirements of wild/weed taxa was only attempted with the larger assemblages from Hermanov Vinograd. It seems that emmer, einkorn and the 'new' glume wheat where cultivated under similar conditions throughout the phases of occupation. Moist soils of medium texture and neutral to alkaline pH were preferentially used. Fertility levels do not seem to have been intensively increased, as is indicated by the low proportion of nitrophiles. The proportion of hemicryptophyte perennials and annuals with persistent seed banks and long flowering periods is relatively high, suggesting a high level of disturbance. This could suggest that fields were hoed but that roots were not collected and removed (as perennials remained and were able to set seed; *cf*. Hillman 1981: 145-6). The range of weeds from Hermanov Vinograd point to both autumn- and spring-sowing, though possible biases in the weed assemblages introduced during cop-processing need to be further assessed. Such an approach will be adopted for the final site report/publication once the stratigraphy and contextual descriptions have been confirmed. Evidence for autumn-sowing is present at Potporanj, where the predominance of twining weeds could indicate that cereal plants were uprooted (*cf*. Hilmann 1981: 148; 1984: 26). At Hermanov Vinograd cereals appear to have been harvested during the late summer or early autumn at a height no lower than 30cm above the ground. Harvesting the useful straw separately to the ears would have been more time consuming. It is possible that cereals were tall or varied in height (*cf*. Reynolds 1981: 113), and that *c*.30cm was a suitable height for the harvesting method (e.g. using a sickle). There are a number of reasons why stubble may have been left behind, such as for grazing animals, and to maintain soil fertility, structure and humidity (Peterson 1965: 239-240).

CHAPTER 8

Results from the Analyses of the Literature Survey on Neolithic Archaeobotanical Data in the Research Area

This chapter pools all the known records of plant macro-remains (excluding charcoal) from the research area in order to describe spatial and diachronic patterns in the cultivation of crops and use of edible wild plants. It begins with a presentation of the sites used in this study, and the type of information available for each one. The chapter is then organised by plant category (crops, edible fruits and nuts and wild/weed taxa), and results from both the Early and Middle/Late Neolithic are presented sequentially within each section. The full lists of taxa by site can be found in Tables 2.4 to 2.11, Appendix II. Early Neolithic (*c*.6100-5400 cal. BC) plant remains are analysed by catchment area, i.e., they are split between the inland and coastal neolithisation routes. The inland area is further sub-divided into the Continental and Pannonian bioregions (Figure 8.1; Chapter 2.4). Records from Greece and Bulgaria are included in order to explore the possible origins of the crop packages in the western Balkans; the full list of taxa by site can be found in Table 2.6, Appendix II, along with references to site reports. Middle/Late Neolithic (*c*.5400-4500 cal. BC) plant remains are analysed by catchment area, bioregion and cultural attribution. Sites in the Alpine bioregion of BiH are grouped with Continental ones. Although the cultural groups of the Middle/Late Neolithic in Hungary (LBK, Tisza, Lengyel, etc) are not the focus of this thesis, their sites are included as a geographical and ecological comparison; they cover the same geographical area as Hungarian SKC sites and are in the same bioregion as sites further south on the Pannonian Plain. Results are compared and interpreted in the following chapter.

Early Neolithic sites

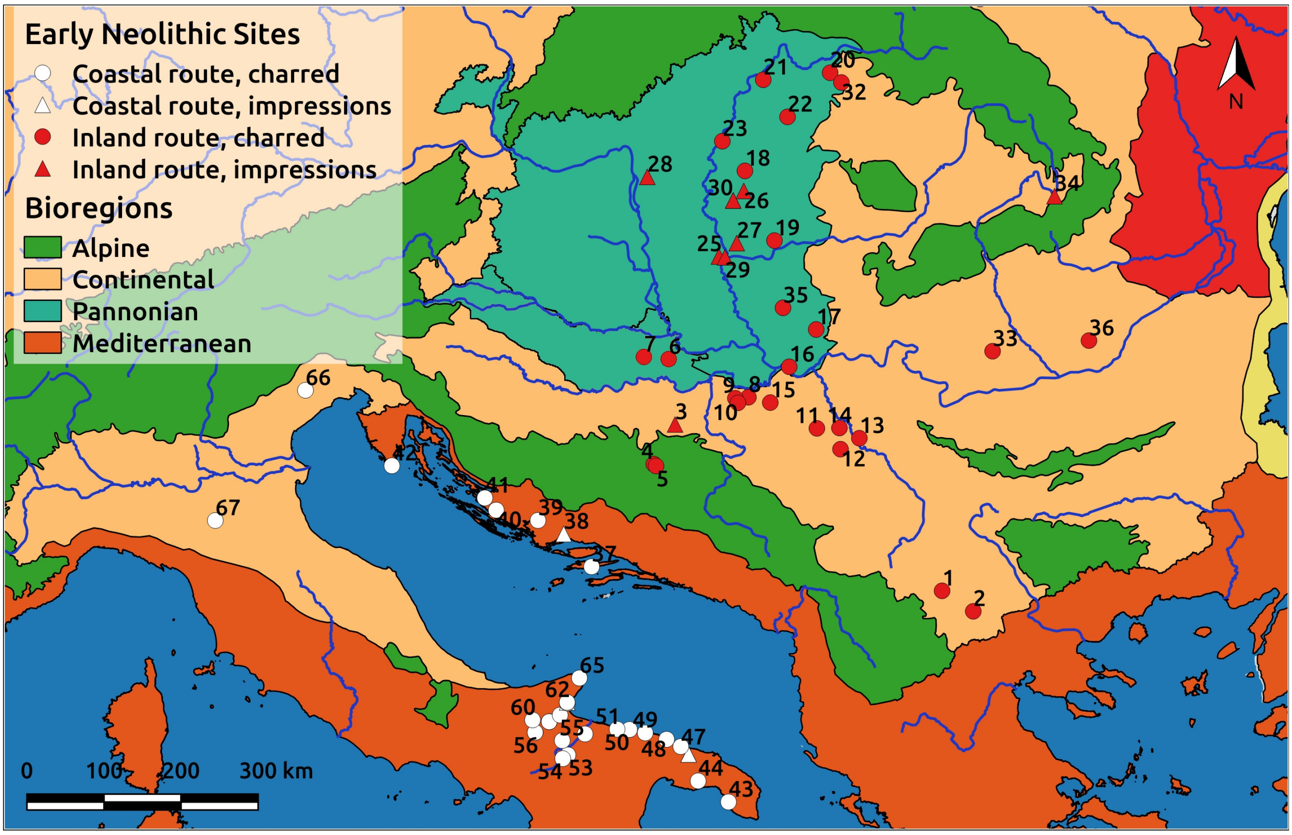


Figure 8.1: Distribution of Early Neolithic sites with records of plant-macro remains. Corresponding site names are listed in Table 8.1. Not all labels are visible but numbers mostly follow sequentially.

Inland SKC sites		Bioregion	Site type	14C range (cal. BC)	Main Preservation	Sampling Grade	№ samples	Volume	Treatment of sample	Context info.	ID	Min № taxa
FYRM	1.Anza	Continental	Open		Charred	2	64		Flotation and wet sieving	√		18
	2.Vršnik	Continental	Open		Charred	2			Flotation			4
BiH	3.Gornja Tuzla	Continental	Open	5700–5400	Impressions		0					1
	4.Kakanj	Con/Alpine	Open		Charred	2	4		Flotation			7
	5.Obre I	Con/Alpine	Open	6000-5300	Charred	2	23		Machine fl.			7
Croatia – Slavonia	6.Sopot	Pannonian	Open	6000-5800	Charred	3 / 4	4	*c.*44	Machine fl. 250µm mesh	√	√	13
	7.Tomašanci-Palača	Pannonian	Open	5700-5300	Charred	3 / 4	37	*c.*407	Machine fl, 1mm mesh	√	√	17
Serbia	8.Mesarci	Continental	Open		Charred	1	1			√		2
	9.Zablaće	Continental	Open		Charred	1	1			√		1
	10.Belotić	Continental	Open		Charred	1	1			√		3
	11.Divostin	Continental	Open	6100-5800	Charred	1	1			√		1
	12.Blagotin	Continental	Open		Charred	3	max	2L each	Flotation	√	√	13
	13.Drenovać	Continental	Open		Charred	3 / 4	50	450	500µm mesh Flotation	√		18
	14.Međurec	Continental	Open		Charred	2 / 3	10	30	Flotation	√		9
	15.Jaričište 1, Mali Borak	Continental	Open		Charred	1			Flotation			6
	16.Starčevo-Grad	Pannonian	Open	6000-5400	Charred	2 / 3	3	10L each	Flotation	√		13
	17.At	Pannonian	Open		Charred	3	10	10L each	Machine fl, 500µm mesh	√	√	13
Hungary	18.Ecsegfalva	Pannonian	Open	5800-5700	Charred	3 / 4	max	4756.7	Machine fl. 300Mm mesh	√	√	34
	19.Battonya-Basarága	Pannonian	Open	6000-5300	Charred	1	1					2
	20.Méhtelek-Nádas	Pannonian	Open	6000-5300	Charred	1	1		Flotation?			1
	21.Ibrány-Nagyerdő	Pannonian	Open	6000-5300	Charred	2	45		Flotation	√	√	7
	22.Berettyóújfalu-Nagy	Pannonian	Open	6000-5300	Charred	1	12		Flotation			33
	23.Tiszaszőlős-Domaháza	Pannonian	Open	6000-5800	Charred	1	111	20kg each	Flotation			21
	24.T.Domaháza (transitional phase)	Pannonian	Open	5800-5600	Charred	1	71		Flotation			18
	25.Röske-Ludvár	Pannonian	Open	6000-5300	Impressions		0					2
	26.Győmaendröd	Pannonian	Open	6000-5300	Impressions		0					1
	27.Hódmezővásárhely-G.–Kovácstanya	Pannonian	Open	6000-5300	Impressions		0					1
	28.Kéthely-Falu	Pannonian	Open	6000-5300	Impressions		0					1
	29.Szeged–Gyálarét	Pannonian	Open	6000-5300	Impressions		0					4
	30.Szarvas	Pannonian	Open	6000-5300	Impressions		0					1
	31.Szarvas–Szappanos	Pannonian	Open	6000-5300	Impressions		0					2
Romania	32.Tăşnad Sere	Pannonian	Open		Charred	3	190	10L each	Bucket fl. 250µm mesh	√	√	6
	33.Circea	Continental	Open		Charred	1			Flotation			6
	34.Hărman	Continental	Open		Impressions		0					1
	35.Foeni-Salaş	Pannonian	Open		Charred	3	max		Flotation	√	√	17
	36.Măgura-Buduiasca	Continental	Open	5800-5600	Charred	3	max	1257	Machine fl, 300µm mesh	√		23

Table 8.1: Early Neolithic sites with plant macro-remains from the research area. Sampling grade is after Fuller & Weber 2005 (Chapter 5.1.4); Max – all excavated contexts sampled; ID notes sites for which identification procedures are published; Number of samples refers to those with published datasets, not necessarily the total taken. Empty cells represent unknown/unavailable information. References to site reports are listed with Tables 2.4 and 2.5, Appendix II.

Table 8.1 continued.

Coastal Impress Ware sites		Bioregion	Site type	14C range (cal. BC)	Main Preservation	Sampling Grade	№ samples	Volume sampled	Treatment of sample	Context info.	ID	Min № of taxa
Croatia – Adriatic	37.Grapčeva cave	Coastal	Cave		Charred	3	3	3L each	Machine fl, 425µm mesh	√		0
	38.Krćina cave	Coastal	Cave		Impressions		0					1
	39.Pokrovnic	Coastal	Open	5900-5300	Charred	3 / 4	26	3310	Flotation, 250µm mesh	√		23
	40.Tinj-Podlivade	Coastal	Open	5800-5100	Charred	1	14					11
	41.Crno Vrilo	Coastal	Open		Charred	1						4
	42.Kargadur-Ližnjan	Coastal	Open		Charred	1						7
South Italy	43.Torre Sabea	Coastal	Open	6200-5600	Charred	3			Sieving			9
	44.Terragne	Coastal	Open	5900-5600	Charred	1						7
	45.Fontanelle	Coastal	Open	6200-5600	Impressions	Haphazard						4
	46.Grotta S'Angelo	Coastal	Cave	5800-5400	Impressions	Haphazard						2
	47.Torre Canne	Coastal	Open	6200-5600	Charred	1						10
	48.Grotta della Mura	Coastal	Cave	6200-5600	Charred	1						2
	49.Scamuso	Coastal	Open	6200-5600	Charred	1						15
	50.Titolo	Coastal	Open	6200-5600	Charred	1						2
	51.Pulo di Molfetta	Coastal	Open	6200-5600	Charred	1						17
	52.Canosa	Coastal	Open	6200-5600	Charred	1						4
	53.Sito 3 Lago di Rendina	Coastal	Open		Charred	1	40					7
	54.Rendina	Coastal	Open	5900-5500	Charred	1			Dry sieving, 500µm mesh			8
	55.Lagnano da Piede	Coastal	Open	6200-5600	Charred	2						6
	56.Monte Calvello	Coastal	Open	6200-5600	Charred	3 / 4						9
	57.Monte San Vincenzo	Coastal	Open	6200-5600	Charred	3						13
	58.Foggia ex-Ippodromo	Coastal	Open	6200-5600	Charred	3	22	195	Flotation, 500µm mesh	√	√	12
	59.Villa Comunale di Foggia	Coastal	Open	6200-5600	Charred	2			Wet sieving			4
	60.Rippa Tetta	Coastal	Open	6200-5600	Charred	1						4
	61.Coppa Nevigata	Coastal	Open	6200-5600	Charred	2 / 3	*c*.8			√		30
	62.Monte Aquilone	Coastal	Open	6200-5600	Impressions							1
	63.Masseria Candelaro	Coastal	Open	6200-5600	Charred	1						4
	64.Masseria Valente	Coastal	Open	6200-5600	Charred	1						1
	65.Defensola A	Coastal	Open	6200-5600	Charred	1						2
N.Italy	66.Fiorano	Coa/Con	Open	5600-5400	Charred	1						1
	67.Valler	Coa/Con	Open	5600-5300	Charred	1	7		Wet-sieving, 500µm mesh			7

Early Neolithic sites – Plant macro-remain categories		Cereal gr./chaff	Cereal grains	Cereal chaff	Other crops	Edible nuts/fruits	Wild seeds			Presence only	Total counts
							B	S	?		
FYROM	1.Anza		▨	▨	▨	▨	▨	▨			▨
	2.Vršnik		▨							▨	
BiH	3.Gornja Tuzla ░	▨									▨
	4.Kakanj		▨		▨	▨	▨			▨	
	5.Obre I		▨		▨	▨	▨			▨	
Slavonia	6.Sopot		▨	▨	▨	▨	▨	▨			▨
	7.Tomašanci-Palača		▨	▨	▨	▨	▨	▨			▨
Serbia	8.Mesarci		▨	▨						▨	
	9.Zablaće		▨							▨	
	10.Belotić		▨							▨	
	11.Divostin		▨								▨
	12.Blagotin		▨		▨	▨		▨	▨		▨
	13.Drenovać		▨	▨	▨	▨	▨	▨		▨	
	14.Međurec	▨			▨	▨	▨	▨		▨	
	15.Jaričište 1, Mali Borak		▨		▨	▨			▨		▨
	16.Starčevo-Grad		▨	▨		▨	▨	▨			▨
	17.At		▨	▨		▨	▨	▨			▨
Hungary	18.Ecsegfalva		▨	▨	▨	▨	▨	▨			▨
	19.Battonya-Basarága			▨		▨					▨
	20.Méhtelek-Nádas					▨				▨	
	21.Ibrány-Nagyerdő		▨		▨	▨	▨		▨	▨	▨
	22.Berettyóújfalu-Nagy		▨	▨	▨	▨	▨	▨		▨	▨
	23.Tiszaszőlős-Domaháza		▨		▨	▨	▨	▨			▨
	24.T.Domaháza (transitional phase)		▨		▨	▨	▨	▨			▨
	25.Röske-Ludvár ░		▨	▨							▨
	26.Győmaendröd ░			▨							▨
	27.Hódmezővásárhely-G.–Kovácstanya ░		▨	▨						▨	
	28.Kéthely-Falu ░			▨						▨	
	29.Szeged–Gyálarét ░		▨	▨			▨				▨
	30.Szarvas ░		▨							▨	
	31.Szarvas–Szappanos ░		▨							▨	
Romania	32.Tăşnad Sere		▨	▨		▨		▨	▨		▨
	33.Circea	▨			▨					▨	
	34.Hărman ░	▨			▨					▨	
	35.Foeni-Salaş	▨	▨		▨		▨	▨			▨
	36. Măgura-Buduiasca		▨	▨	▨	▨	▨	▨			▨
Croatia – Adriatic	37.Grapčeva cave										
	38.Krćina cave ░		▨							▨	
	39.Pokrovnic		▨	▨	▨	▨	▨	▨		▨	
	40.Tinj-Podlivade		▨	▨			▨	▨			▨
	41.Crno Vrilo	▨						▨		▨	
	42.Kargadur-Ližnjan	▨				▨				▨	
South Italy	43.Torre Sabea		▨	▨	▨		▨	▨			▨
	44.Terragne	▨	▨		▨						▨
	45.Fontanelle ░		▨	▨							▨
	46.Grotta S'Angelo ░		▨								▨
	47.Torre Canne		▨	▨	▨	▨	▨		▨		▨
	48.Grotta della Mura	▨	▨								▨
	49.Scamuso		▨		▨	▨	▨	▨			▨
	50.Titolo	▨	▨								▨
	51.Pulo di Molfetta		▨	▨		▨	▨	▨		▨	
	52.Canosa	▨	▨								▨
	53.Sito 3 Lago di Rendina		▨		▨				▨	▨	
	54.Rendina		▨		▨						▨
	55.Lagnano da Piede		▨	▨	▨						▨
	56.Monte Calvello		▨	▨	▨						▨
	57.Monte San Vincenzo		▨	▨	▨		▨	▨			▨
	58.Foggia ex-Ippodromo		▨	▨	▨		▨	▨			▨
	59.Villa Comunale di Foggia		▨		▨						▨
	60.Rippa Tetta		▨	▨							▨
	61.Coppa Nevigata		▨	▨	▨	▨	▨	▨			▨
	62.Monte Aquilone ░		▨								▨
	63.Masseria Candelaro		▨						▨		▨
	64.Masseria Valente			▨							▨
	65.Defensola A	▨	▨							▨	
N.Italy	66.Fiorano					▨				▨	
	67.Valler	▨	▨			▨	▨			▨	

Table 8.2: Plant categories by site. Shaded sites are those with impressions. Other taxa are pulses and crops. Wild/weed seeds are separated by size: B ≥ cereal grain, S < grain (as defined in Chapter 6.4).

Middle/Late Neolithic sites

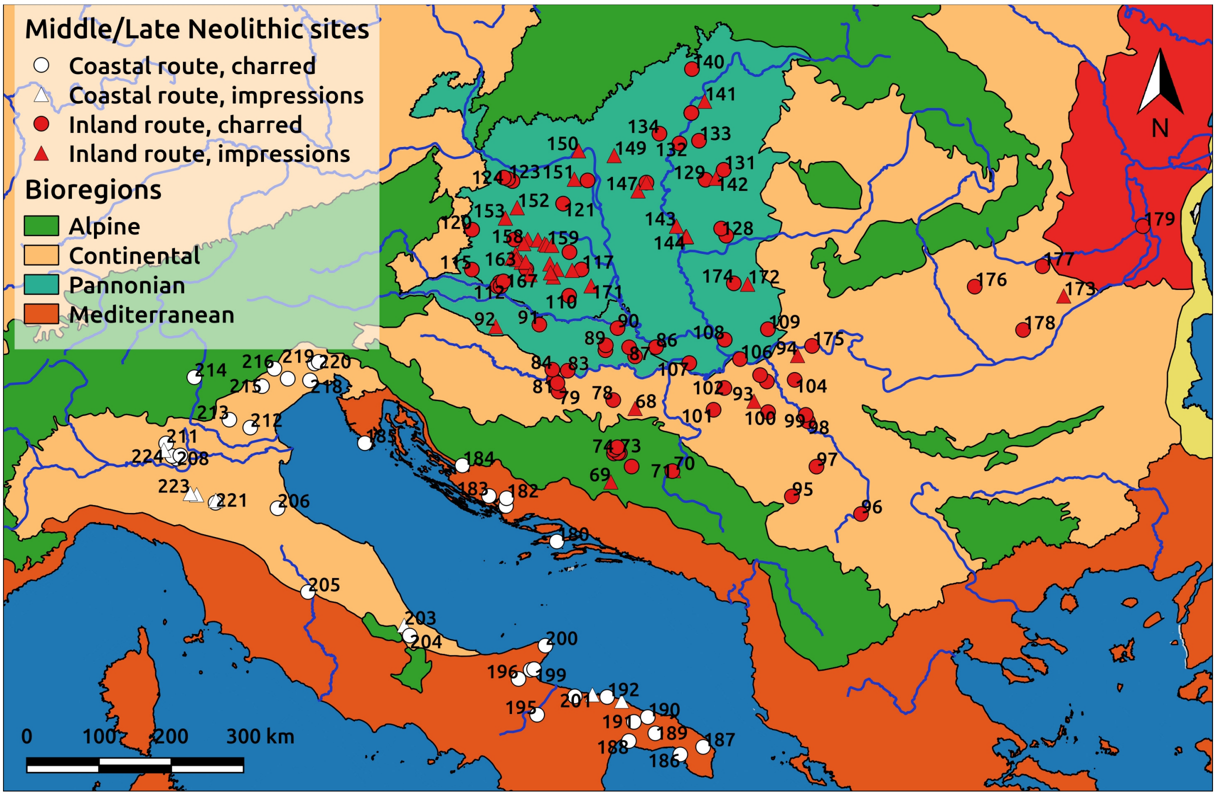


Figure 8.2: Distribution of Middle/Late Neolithic sites with records of plant-macro remains. Corresponding site names are listed in Table 8.3. Not all labels are visible but numbers mostly follow sequentially.

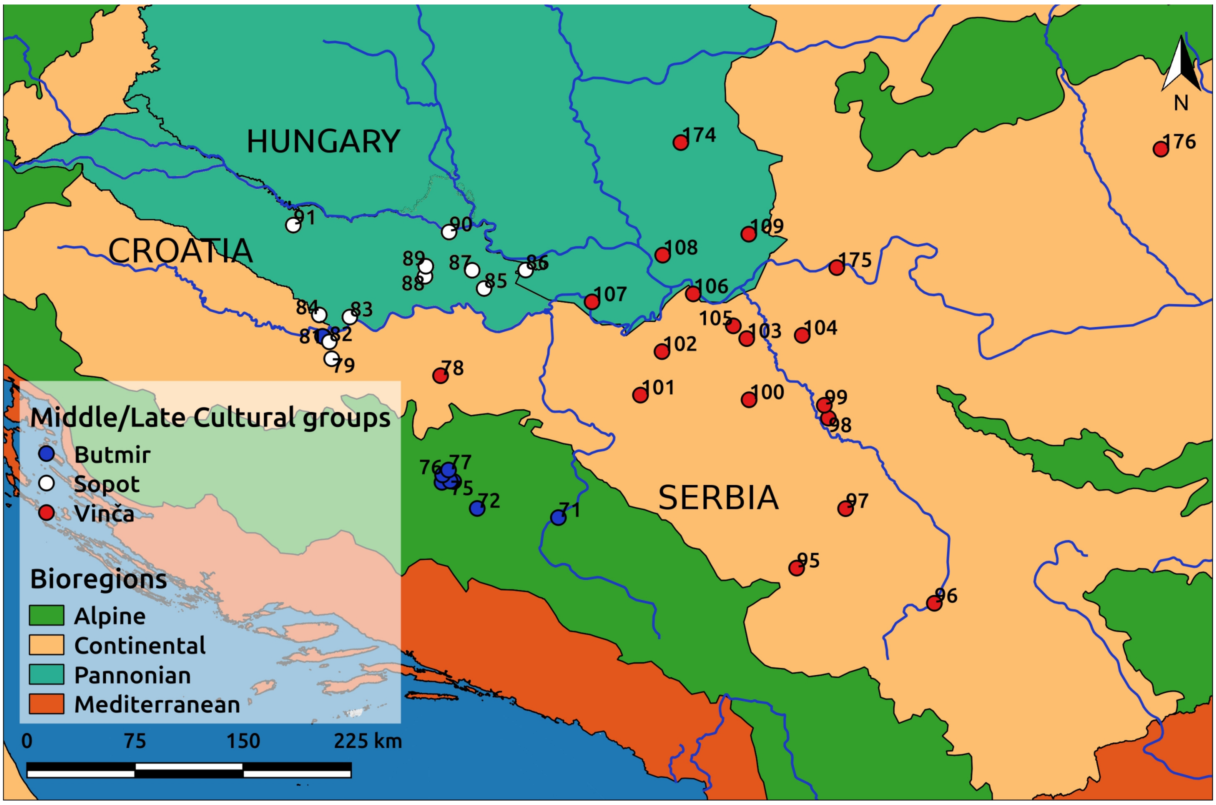


Figure 8.3: The location of Vinča, Sopot and Butmir sites, distributed within the inland catchment area.

Inland Middle/Late Neolithic sites		Bioregion	Cultural attribution	Site type	14C range (cal. BC)	Main Preserv.	Samp. Grade	№ samples	Vol. (L)	Treatment of sample	Ctext info.	ID	Min № taxa
BiH	68.Gornja Tuzla (1)	Continental	Butmir	Open	4700-4300	Imp.							2
	69.Lisičići	Alpine	Butmir	Open		Imp.							3
	70.Lug (Goražde)	Alpine	Butmir	Open		Imp.							5
	71.Jagnilo	Alpine	Butmir	Open		Charred	1	185		Machine fl.			54
	72.Butmir	Alpine	Butmir	Tell	4930-4550	Charred	3			Flotation			10
	73.Donje Moštre	Alpine	Butmir	Open	4670-4260	Charred	3	47		Machine fl.			25
	74.Kundruci	Alpine	Butmir	Open	4930-4700	Charred	3	29		Machine fl.			10
	75.Okolište	Alpine	Butmir	Tell	5230-4480	Charred	3 / 4	1564		Machine fl.	√		88
	76.Zagrebnice	Alpine	Butmir	Open	5600-4600	Charred	3	28		Machine fl.			22
	77.Obre II (5)	Alpine	Butmir	Open	5130-4530	Charred	1	14		Machine fl.	√		9
	78.Korića Han	Continental	Vinča	Tell		Charred	4	1				√	8
	79.Kosjerovo*	Continental	Sopot	Open	5230-4440	Charred	2	26	412	Machine fl, 250µm mesh	√	√	14
	80.Laminski Jaružani	Continental	Butmir	Open		Charred	2	2	144	Machine fl, 300µm mesh	√	√	6
	81.Laminski Jaružani-Njiva	Continental	Butmir	Open		Charred	2	2	56	Machine fl, 300µm mesh	√	√	4
	82.Kočićevo*	Continental	Sopot	Open	5200-4700	Charred	2 / 3	16	90.5	Flotation, 300µm mesh	√	√	16
Croatia – Slavonia	83.Ravnjaš-Nova Kapela	Pannonian	Sopot	Tell		Charred	3	71	781	Bucket fl, 250µm mesh	√	√	17
	84.Slavća	Pannonian	Sopot	Tell	4990-4200	Charred	3	28	264	Bucket fl, 250µm mesh	√	√	17
	85.Otok	Pannonian	Sopot	Tell	4540-4040	Charred	1	1			√		1
	86.Bapska	Pannonian	Sopot	Tell	4680-4460	Charred	4	8	495	Machine fl, <500µm mesh	√	√	11
	87.Sopot (6)	Pannonian	Sopot	Open	5050-3940	Charred	3	144	2842	Machine fl, 250µm mesh	√	√	33
	88.Ivandvor—Šuma Gaj	Pannonian	Sopot	Open	5050-4490	Charred	3	14	154	Machine fl, 1mm mesh	√	√	2
	89.Tomašanci-Palača (7)	Pannonian	Sopot	Open	4300-3900	Charred	2	1	11	Machine fl, 1mm mesh	√	√	2
	90.Hermanov Vinograd I&II	Pannonian	Sopot	Tell	4980-4410	Charred	3	129	812.5	Machine fl, 250µm mesh	√	√	58
	91.Virovitika-Brekinja	Pannonian	Sopot	Open	5400-5200	Charred	2 / 3	5	55	Machine fl, 1mm mesh	√	√	3
	92.Brezovljani	Pannonian	Sopot	Open	4900-4600	Imp.							1
Serbia	93.Vinča-Kragujevac	Continental	Vinča	Open	5480-4530	Imp.							1
	94.Predionica	Continental	Vinča	Open	5400-5000	Imp.							2
	95.Valač	Continental	Vinča	Open	4900-4680	Charred	1	1		Hand picked?			1
	96.Pavlovac-Gumnište	Continental	Vinča		5500-4500	Charred	3	100		Machine fl.	√		9
	97.Pločnik	Continental	Vinča	Open	5300-5000	Charred	3 / 4			Machine fl.			53
	98.Drenovać (13)	Continental	Vinča	Tell		Charred	3 / 4	94		Machine fl.			25
	99.Motel-Slatina	Continental	Vinča	Tell		Charred	1	2					4
	100.Divostin (11)	Continental	Vinča	Open	5000-4500	Charred	1	1			√		2
	101.Petnica	Continental	Vinča	Open	5000-4700	Charred	1	1		Hand picked?			4
	102.Jaričište 1, Mali Borak (15)	Continental	Vinča	Open	5300-5200	Charred	1						5
	103.Medvednjak	Continental	Vinča		5200-4850	Charred	1	1		Hand picked?			3
	104.Belovode	Continental	Vinča	Tell	5500-5000	Charred	3 / 4			Machine fl.			49
	105.Selevac	Continental	Vinča	Tell	5500-4500	Charred	3 / 4	47		Flotation & wet-sieving			24
	106.Vinča-Belo Brdo	Pannonian	Vinča	Tell	5600-4500	Charred	3 / 4	>82		Machine fl, 300µm mesh	√		46
	107.Gomolava	Pannonian	Vinča	Tell		Charred	3 / 4	41	*c*.50		√	√	36
	108.Opovo	Pannonian	Vinča	Open	5000-4500	Charred	3	265	2916	Flotation & sieving, 1mm mesh	√		21
	109.Potporanj	Pannonian	Vinča	Tell	5230-5000	Charred	3	11	110	Machine fl, 500µm mesh	√	√	27

Table 8.3: Middle/Late Neolithic sites with plant macro-remains from the research area. Sampling grade is after Fuller & Weber 2005 (Chapter 5.1.4); Max – all excavated contexts sampled; ID notes sites for which identification procedures are published; Number of samples refers to those with published datasets, not necessarily the total taken; Imp – impressions. * only data from 'trustworthy' contexts (see Chapter 7.7). Empty cells represent unknown/unavailable information.

Table 8.3 continued

Inland Middle/Late Neolithic sites		Bioregion	Cultural attribution	Site type	14C range (cal. BC)	Main Preserv.	Samp. Grade	№ samples	Vol. (L)	Treatment of sample	Ctext info.	ID	Min № taxa
Hungary	110. Ludas, Varjú dűlő	Pannonian	LBK	Open	5300-4700	Charred	1	71		Flotation			7
	111. Becsehely-Újmajori tábla	Pannonian		Open	5300-4700	Ch & Imp.	1			Flotation			2
	112. Becsehely-Bükkalji dűlő	Pannonian		Open	5300-4700	Charred	1	1		Flotation			1
	113. Petrivente	Pannonian	LBK	Open	5300-4700	Charred	1	4		Flotation			4
	114. Sormás-Mántai dűlő	Pannonian		Open	5300-4700	Charred	1	1					1
	115. Szentgyörgyvölgy-Pityerdomb	Pannonian	LBK	Open	5620-5410	Charred	3	5	20.5	Flotation	√		8
	116. Marcali-Lókpuszta	Pannonian	LBK	Open	5300-4700	Charred	1	1		Flotation			2
	117. Lengyel	Pannonian	Lengyel	Open	4700-4300	Charred	1	14		Flotation			22
	118. Pári-Altäcker dűlő	Pannonian	LBK	Open	5300-4700	Ch & Imp.	1	1		Flotation			8
	119. Sümeg-Mogyorósdomb	Pannonian		Open	4700-4300	Charred	1	1		Hand picked?			1
	120. Szombathely – Aranypatak	Pannonian	LBK	Open	5300-4700	Charred	1	10		Flotation			9
	121. Moha-Homokbánya	Pannonian	Lengyel	Open	4700-4300	Charred	1	1		Hand picked?			1
	122. Börcs-Paphomlok	Pannonian	Lengyel	Open	4700-4300	Charred	1	5		Flotation			2
	123. Mosonszentmiklós-Pálmajor	Pannonian	LBK/Lengyel	Open	5300-4300	Charred	1	10		Flotation			3
	124. Lébény-Billedomb	Pannonian		Open	4700-4300	Charred	1	2		Flotation			2
	125. Törökbálint Dulácska	Pannonian	LBK	Open	5300-4700	Charred	1	16		Flotation			9
	126. Abony 49	Pannonian	Szakálhát	Open	5300-4700	Charred	1	2		Flotation			3
	127. Battonya-Parázstanya	Pannonian	Tisza	Open	4400-4200	Charred	1	51		Flotation			13
	128. Battonya-Vertán major	Pannonian	Tisza/Herpaly	Open	4700-4300	Charred	1			Flotation			7
	129. Dévaványa-Réhelyi gát	Pannonian	Szakálhát	Open	5300-4700	Ch & Imp.	1	4		Flotation			6
	130. Berettyóújfalu-Herpály	Pannonian	Tisza/Herpaly	Open	4700-4300	Charred	1	1		Hand picked?			2
	131. Berettyóújfalu-Szilhalom	Pannonian	Tisza/Herpaly	Open	4700-4300	Charred	1	6		Flotation			7
	132. Tisza.-Domaháza (23/24)	Pannonian	LBK	Open	5300-4700	Charred	1	104		Flotation			17
	133. Tiszapolgár-Csőszhalom	Pannonian	LBK/Herpaly	Open	4700-4300	Charred	1	37		Flotation			72
	134. Füzesaboy-Gubakút	Pannonian	LBK	Open	5300-4700	Charred	1	38		Flotation			3
	135. Polgár 6	Pannonian		Open	4700-4300	Charred	1	34		Flotation			47
	136. Polgár 7	Pannonian		Open	4700-4300	Charred	1	1		Flotation			14
	137. Polgár 10/11	Pannonian		Open	4700-4300	Charred	1	52		Flotation			5
	138. Polgár 31	Pannonian		Open	5300-4700	Charred	1	171		Flotation			72
	139. Polgár 34	Pannonian		Open	5300-4700	Charred	1	1		Flotation			1
	140. Regéc	Pannonian	LBK	Open	5300-4700	Charred	1	42		Flotation			4
	141. Tiszavasvár-Keresztfal	Pannonian	LBK	Open	5300-4700	Imp.							2
	142. Szeghalom-Kovácshalom	Pannonian	Tisza	Open	4700-4300	Imp.							2
	143. Szegvár-Tűzköves	Pannonian	Tisza	Open	4700-4300	Imp.							1
	144. Hódmezővásárhely-Cukortania	Pannonian	Tisza	Open	4700-4300	Imp.							1
	145. Hód.-Kökénydomb	Pannonian	Tisza	Open	4700-4300	Imp.							2
	146. Hódmezővásárhely-Kotacpart	Pannonian	Tisza	Open	4700-4300	Imp.							1
	147. Cegléd 4	Pannonian	Szakálhát	Open	5300-4700	Imp.							1
	148. Abony 8	Pannonian	Szakálhát	Open	5300-4700	Imp.							1
	149. Aszód-Papi földek	Pannonian	Lengyel	Open	4700-4300	Imp.							4
	150. Szob-Kilenec	Pannonian	LBK	Open	5300-4700	Imp.							1
	151. Bicske-Galagonyás	Pannonian	LBK	Open	5300-4700	Imp.							5
	152. Pápa-Vaszar	Pannonian	LBK	Open	5300-4700	Imp.							2
	153. Adorjánháza-Kenderáztató	Pannonian	LBK	Open	5300-4700	Imp.							3
	154. Hegyesd-Ágói dűlő	Pannonian	LBK	Open	5300-4700	Imp.							1
	155. Zánka-Vasúti bevágás	Pannonian	LBK	Open	5300-4700	Imp. & ch.	1						11
	156. Balatonszárszó-Gönye dűlő	Pannonian	LBK	Open	5300-4700	Imp.							1
	157. Balatonszentgyörgy	Pannonian	LBK	Open	5300-4700	Imp.							3
	158. Tapolca-Plébániakert	Pannonian	LBK	Open	5300-4700	Imp.							4
	159. Szólád-Hadúti dűlő	Pannonian	LBK	Open	5300-4700	Imp.							4
	160. Pusztaszemes-Majorság	Pannonian	LBK	Open	5300-4700	Imp.							1
	161. Keszthely-Zsidi út	Pannonian	LBK	Open	5300-4700	Imp.							1
	162. Alsópáhok-Kátyánalja dűlő	Pannonian	LBK	Open	5300-4700	Imp.							2
	163. Fenékpuszta-Vámház	Pannonian	LBK	Open	5300-4700	Imp.							2
	164. Kéthely-Sziget	Pannonian	LBK	Open	5300-4700	Imp.							4
	165. Mernye-Szentmiklós	Pannonian	LBK	Open	5300-4700	Imp.							1
	166. Magyaratád	Pannonian	LBK	Open	5300-4700	Imp.							6
	167. Szenyér-Mesztegnyő	Pannonian	LBK	Open	5300-4700	Imp.							7
	168. Dombóvár-Gunaras	Pannonian	LBK	Open	5300-4700	Imp.							2
	169. Kaposvár-Kisapáti dűlő	Pannonian	LBK	Open	5300-4700	Imp.							3
	170. Kaposvár-Villanytelep	Pannonian	LBK	Open	5300-4700	Imp.							1
	171. Zengővárkony	Pannonian	Lengyel	Open	4700-4300	Imp.							4
Romania	172. Parţa	Pannonian	Vinča–Turdas	Tell		Imp.							3
	173. Gradistea Ulmilor	Continental	Dudešti-Boian	Tell		Imp.							3
	174. Uivar	Pannonian	Vinča-Turdas	Tell		Charred	3	286	2860	Wet-sieving, 500µm mesh	√	√	73
	175. Liubcova	Continental	Vinča-Turdas	Tell		Charred	1						8
	176. Tell Laceni	Continental	Vinča-Turdas	Tell		Charred	1						11
	177. Vladiceasca	Continental	Dudešti-Boian			Charred	1						6
	178. Măgura-Buduiasca (36)	Continental	Dudešti-Boian	Open	5340-5080	Charred	3	Max	847	Machine fl, 300µm mesh	√		21
	179. Tell Hirsova	Steppic	Dudešti-Boian	Tell	5300-5570	Charred	1						4

Table 8.3 continued

Coastal Middle/Late Neolithic sites		Bioregion	Cultural attribution	Site type	14C range (cal. BC)	Main Preserv.	Samp. Grade	№ sam-ples	Vol. (L.)	Treatment of sample	Ctext info.	ID	Min № taxa
Croatia – Adriatic	180.Grapčeva cave	Coastal	Danilo-Hvar	Cave	4340-4900	Charred	3	11	33	Machine fl, 425µm mesh	√		12
	181.Danilo	Coastal	Danilo-Hvar	Open	5300-4800	Charred	3	44	11120	Machine fl.	√	√	27
	182.Pokrovnic	Coastal	Danilo-Hvar	Open	5500-4900	Charred	3	28	3765	Machine fl.	√	√	25
	183.Čista Mala Velištak	Coastal	Danilo-Hvar	Open	4900-4700	Charred	3	52	571.5	Bucket fl, 250µm mesh	√	√	30
	184.Turska Peć	Coastal	Danilo-Hvar	Cave		Charred	3 / 4	22	304	Bucket fl, 250µm mesh	√	√	30
	185.Gromače-Brijuni	Coastal	Danilo-Vlaška	Open		Charred	1						4
South Italy	186.Serra Cicora	Coastal	Danilo	Open	4800-4300	Charred	1						4
	187.Carpignano Salentino	Coastal	Danilo	Open	4800-4300	Charred	2	4	16	Flotation, 500µm mesh	√	√	4
	188.Capo Rondinella	Coastal	Danilo	Open	5600-4800	Charred	1						8
	189.Oria Sant'Anna	Coastal	Danilo	Open	5600-4800	Charred	1						8
	190.Grotta S'Angelo (46)	Coastal	Danilo	Cave	5600-4800	Ch & Imp.	1						9
	191.San Domenico	Coastal	Danilo	Open	5600-4800	Charred	1						5
	192.Scamuso (49)	Coastal	Danilo	Open	5600-4300	Charred	1						15
	193.Grotta della Tartaruga	Coastal	Danilo	Cave	4800-4300	Charred	1						7
	194.Grotta Santa Croce	Coastal	Danilo	Cave	5600-4800	Charred	1						8
	195.Olivento di Lavello	Coastal	Danilo	Open		Charred	1			Flotation			4
	196.Passo di Corvo	Coastal	Impressed W.	Open	5600-4800	Ch & Imp.	1			Flotation			9
	197.Masseria Candelaro (63)	Coastal	Danilo	Open	5600-4800	Charred	1						10
	198.Masseria Fontanarosa Uliveto	Coastal	Danilo	Open	5600-4800	Charred	1			Flotation, 1mm mesh			5
	199.Masseria Santa Tecchia	Coastal	Impressed Ware	Open	5600-4800	Charred	1						5
	200.Defensola A (65)	Coastal	Danilo	Open	5600-4800	Charred	1						3
	201.Palese	Coastal	Danilo	Open	5000-4500	Imp.							2
	202.Le Macchie	Coastal	Danilo	Open	5000-4500	Imp.							6
Central Italy	203.Ripoli	Coa/Con		Open	4700-4200	Imp.							2
	204.Catignano	Coa/Con		Open	4600-4900	Charred	1						20
	205.San Marco Gubbio	Coa/Con	Impressed Ware	Open	5400-4600	Charred	1						19
N.Italy	206.Forli - via Navicella	Coa/Con	VBQ	Open	5000-4000	Charred	3	10	50	Flotation	√	√	10
	207.Spilamberto – via Macchioni	Coa/Con	VBQ	Open	4100-3500	Charred	3	14	70	Flotation	√	√	21
	208.Rivarolo Mantovano	Coa/Con	VBQ	Open	4500-3500	Charred	1			Flotation			6
	209.Vhó di Piadena	Coa/Con	VBQ	Open	5100-4500	Charred	2						5
	210.Casatico di Marcaria	Coa/Con	VBQ	Open	4500-3500	Charred	1						3
	211.Isorella	Coa/Con	VBQ	Open	4900-4500	Charred	2	8		Wet-sieving			4
	212.Maserà	Coa/Con	VBQ	Open	4500-4370	Charred	1			Flotation			12
	213.Fimon Molino Casarotto	Coa/Con	VBQ	Open	4500-4000	Ch & WL	1			Wet-sieving			3
	214.Vela in Trento	Alpine	VBQ	Open	4500-4300	Charred	Total			Machine fl.	√		23
	215.Lugo di Romagna	Coa/Con	VBQ	Open	5600-4500	Charred	1						17
	216.Palù di Livenza	Coa/Con	VBQ	Open	5000-4000	Ch & WL	1			Wet-sieving, 500µm mesh			23
	217.Fagnignola	Coa/Con	VBQ	Open	5600-4800	Charred		11		Wet-sieving, 500µm mesh			6
	218.Piancada	Coa/Con	VBQ	Open	5500-4700	Charred	1						15
	219.Sammardenchia	Coa/Con	VBQ	Open	5600-4500	Charred	1	>150		Machine fl.			34
	220.Pavia di Udine	Coa/Con	VBQ	Open	5100-4500	Charred	1						13
	221.Savignano	Coa/Con	VBQ	Open	4900-4500	Imp.							1
	222.Chiozza	Coa/Con	VBQ	Open	5400-4500	Imp.							1
	223.Albinea	Coa/Con	VBQ	Open	4700-4500	Imp.							1
	224.Ostiano – Dugali Alti	Coa/Con	VBQ	Open	5100-4500	Imp.							2

Inland Middle/Late Neolithic sites Plant macro-remain categories		Cereal gr./chaff	Cereal grains	Cereal chaff	Other crops	Edible nuts/fruits	Wild seeds			Presence only	Total counts
							B	S	?		
BiH	68.Gornja Tuzla (1)			■						■	
	69.Lisičići		■	■							■
	70.Lug (Goražde)		■	■							■
	71.Jagnilo		■	■	■	■	■	■			■
	72.Butmir		■		■	■		■		■	
	73.Donje Moštre		■	■	■	■	■	■			■
	74.Kundruci		■	■	■	■		■			■
	75.Okolište		■	■	■	■	■	■			■
	76.Zagrebnice		■	■	■	■	■	■			■
	77.Obre II (5)		■		■		■			■	
	78.Korića Han		■	■	■		■				■
	79.Kosjerovo*		■	■		■		■			■
	80.Laminci Jaružani		■	■	■	■	■	■			■
	81.Laminci Jaružani-Njiva			■		■		■			■
	82.Kočićevo*		■	■	■	■		■			■
Croatia – Slavonia	83.Ravnjaš-Nova Kapela		■	■	■	■	■	■			■
	84.Slavća		■	■	■	■	■	■			■
	85.Otok		■								■
	86.Bapska		■	■		■	■	■			■
	87.Sopot (6)		■	■	■	■	■	■			■
	88.Ivandvor—Šuma Gaj		■	■	■				■		■
	89.Tomašanci-Palača (7)					■			■		■
	90.Hermanov Vinograd I&II		■	■	■	■	■	■			■
	91.Virovitika-Brekinja		■		■				■		■
	92.Brezovljani			■							■
Serbia	93.Vinča-Kragujevac			■							■
	94.Predionica		■	■						■	
	95.Valač				■					■	
	96.Pavlovac-Gumnište*	■			■					■	
	97.Pločnik		■	■	■	■	■	■			■
	98.Drenovać (13)*	■	■		■	■	■	■		■	
	99.Motel-Slatina		■							■	
	100.Divostin (11)		■		■						■
	101.Petnica		■							■	
	102.Jaričište 1, Mali Borak (15)		■		■	■			■	■	
	103.Medvednjak	■	■							■	
	104.Belovode		■	■	■	■	■	■			■
	105.Selevac		■	■	■	■	■	■			■
	106.Vinča-Belo brdo		■	■	■	■	■	■		■	
	107.Gomolava		■	■	■	■	■	■			■
	108.Opovo		■	■	■	■	■	■			■
	109.Potporanj		■	■	■	■	■	■			■

Table 8.4: Plant categories by site. Shaded sites are those with impressions. Other taxa are pulses and crops. Wild/weed seeds are separated by size: B ≥ cereal grain, S < grain (as defined in Chapter 6.4). *the plant remains are currently being examined by Ms. Đ. Obradović for her doctoral thesis and are not yet fully published.

Table 8.4 continued

Inland Middle/Late Neolithic sites Plant macro-remain categories		Cereal gr./chaff	Cereal grains	Cereal chaff	Other crops	Edible nuts/fruits	Wild seeds			Presence only	Total counts
							B	S	?		
	110. Ludas, Varjú dűlő		■	■		■	■	■			■
	111. Becsehely-Újmajori tábla		■								■
	112. Becsehely-Bükkalji dűlő				■						■
	113. Petrivente		■	■		■		■			■
	114. Sormás-Mántai dűlő		■								■
	115. Szentgyörgyvölgy-Pityerdomb		■	■	■			■	■		■
	116. Marcali-Lókpuszta		■								■
	117. Lengyel		■	■	■	■	■	■		■	
	118. Pári-Altäcker dűlő		■	■		■	■	■			■
	119. Sümeg-Mogyorósdomb					■					■
	120. Szombathely – Aranypatak		■		■	■	■	■			■
	121. Moha-Homokbánya					■					■
	122. Börcs-Paphomlok		■								■
	123. Mosonszentmiklós-Pálmajor		■		■			■	■		
	124. Lébény-Billedomb		■						■		■
	125. Törökbálint Dulácska		■	■	■		■	■			■
	126. Abony 49		■					■	■		■
	127. Battonya-Parázstanya		■	■	■	■	■	■			■
	128. Battonya-Vertán major		■			■		■	■		■
	129. Dévaványa-Réhelyi gát		■		■		■	■			■
	130. Berettyóújfalu-Herpály				■						■
	131. Berettyóújfalu-Szilhalom		■		■	■			■		■
	132. Tiszaszőlős-Domaháza (23&24)		■		■	■	■	■			■
	133. Tiszapolgár-Csőszhalom		■	■	■	■	■	■			■
	134. Füzesaboy-Gubakút		■	■			■				■
	135. Polgár 6		■	■	■	■	■	■			■
	136. Polgár 7		■	■		■	■	■			■
	137. Polgár 10/11		■	■			■	■			■
	138. Polgár 31		■	■	■	■	■	■			■
	139. Polgár 34								■		
	140. Regéc		■					■			■
	141. Tiszavasvár-Keresztfal		■								■
	142. Szeghalom-Kovácshalom			■						■	
	143. Szegvár-Tűzköves			■							■
	144. Hódmezővásárhely-Cukortania		■							■	
	145. Hód.-Kökénydomb		■						■	■	
	146. Hódmezővásárhely-Kotacpart									*T.latifolia* leaf	
	147. Cegléd 4		■								■
	148. Abony 8		■								■
	149. Aszód-Papi földek		■	■							■
	150. Szob-Kilenec		■								■
	151. Bicske-Galagonyás		■				■	■			■
	152. Pápa-Vaszar		■	■						■	
	153. Adorjánháza-Kenderáztató		■	■						■	
	154. Hegyesd-Ágói dűlő		■	■							■
	155. Zánka-Vasúti bevágás		■	■			■				■
	156. Balatonszárszó-Gönye dűlő			■						■	
	157. Balatonszentgyörgy		■	■						■	
	158. Tapolca-Plébániakert		■	■							■
	159. Szólád-Hadúti dűlő		■	■							■
	160. Pusztaszemes-Majorság									*P.australis* leaf	
	161. Keszthely-Zsidi út		■							■	
	162. Alsópáhok-Kátyánalja dűlő			■						■	
	163. Fenékpuszta-Vámház		■	■							■
	164. Kéthely-Sziget		■			■					■
	165. Mernye-Szentmiklós		■	■							■
	166. Magyaratád		■	■		■	■				■
	167. Szenyér-Mesztegnyő		■	■			■	■			■
	168. Dombóvár-Gunaras			■	■						■
	169. Kaposvár-Kisapáti dűlő		■	■						■	
	170. Kaposvár-Villanytelep			■						■	
	171. Zengővárkony		■			■				■	
Romania	172. Parţa	■									■
	173. Gradistea Ulmilor	■									■
	174. Uivar		■	■	■	■	■	■			■
	175. Liubcova		■		■			■		■	
	176. Tell Laceni		■	■	■	■	■	■		■	
	177. Vladiceasca		■		■					■	
	178. Măgura-Buduiasca (36)		■	■	■	■	■	■			■
	179. Tell Hirsova	■								■	

Table 8.4 continued

Coastal Middle/Late Neolithic sites Plant-macro remain categories		**Cereal gr./chaff**	**Cereal grains**	**Cereal chaff**	**Other crops**	**Edible nuts/fruits**	**Wild seeds**			**Presence only**	**Total counts**
							B	**S**	**?**		
Croatia – Adriatic	180.Grapčeva cave		▨		▨	▨		▨	▨		▨
	181.Danilo		▨	▨	▨	▨	▨	▨			▨
	182.Pokrovnic		▨	▨	▨	▨	▨	▨		▨	
	183.Čista Mala Velištak		▨	▨	▨	▨	▨	▨			▨
	184.Turska Peć		▨	▨	▨	▨	▨	▨			▨
	185.Gromače-Brijuni	▨				▨	▨			▨	
South Italy	186.Serra Cicora	▨									▨
	187.Carpignano Salentino		▨			▨		▨		▨	
	188.Capo Rondinella	▨	▨		▨						▨
	189.Oria Sant'Anna	▨	▨		▨						▨
	190.Grotta S'Angelo (46)		▨		▨						▨
	191.San Domenico	▨	▨								▨
	192.Scamuso (49)		▨		▨	▨	▨	▨			▨
	193.Grotta della Tartaruga	▨	▨		▨						▨
	194.Grotte Santa Croce	▨	▨		▨ *Vicia* sp.		▨				▨
	195.Olivento di Lavello		▨		▨					▨	
	196.Passo di Corvo		▨		▨						▨
	197.Masseria Candelaro (63)		▨	▨	▨				▨		▨
	198.Masseria Fontanarosa Uliveto		▨	▨					▨		▨
	199.Masseria Santa Tecchia		▨	▨					▨		▨
	200.Defensola A (65)	▨	▨								▨
	201.Palese		▨							▨	
	202.Le Macchie	▨	▨					▨	▨		▨
Central Italy	203.Ripoli		▨								▨
	204.Catignano		▨	▨	▨	▨	▨	▨		▨	
	205.San Marco Gubbio		▨	▨	▨	▨		▨	▨		▨
N.Italy	206.Forli - via Navicella		▨			▨		▨	▨		▨
	207.Spilamberto – via Macchioni		▨		▨	▨	▨	▨			▨
	208.Rivarolo Mantovano	▨				▨				▨	
	209.Vhó di Piadena		▨			▨					▨
	210.Casatico di Marcaria					▨				▨	
	211.Isorella		▨			▨				▨	
	212.Maserà	▨			▨	▨				▨	
	213.Fimon Molino Casarotto					▨				▨	
	214.Vela in Trento		▨	▨	▨	▨	▨	▨			▨
	215.Lugo di Romagna	▨			▨	▨				▨	
	216.Palù di Livenza	▨			▨	▨		▨		▨	
	217.Fagnignola	▨	▨			▨				▨	
	218.Piancada		▨	▨	▨	▨				▨	
	219.Sammardenchia		▨	▨	▨	▨	▨	▨		▨	
	220.Pavia di Udine		▨	▨	▨	▨				▨	
	221.Savignano	▨								▨	
	222.Chiozza	▨									▨
	223.Albinea	▨									▨
	224.Ostiano – Dugali Alti		▨			▨				▨	

8.1 Archaeobotanical Reports

Sixty-six Early Neolithic sites (sites 23 and 24 are Early Neolithic phases of the same site) and 157 Middle/Late sites contained records of plant macro-remains (Published and/or available online; Tables 8.1 and 8.3). The Early sites were all open, flat settlements except for three caves along the Adriatic coast (sites 37, 38, 48; site 37 is excluded from further analyses as it did not contain any plant remains). Thirteen sites (20%) only contained plant impressions of plant remains. The same level of detail was not recorded for Greek and Bulgarian sites and so these were not included in the tables. All except for Franchthi cave were open-air settlements, and most were occupied continuously throughout the Neolithic and even into the Chalcolithic. All plant remains were retrieved via flotation, although the mesh size is not always specified. Indeed, the three sites (sites 4, 5, 67) with only large 'weed' seeds only had one or two seeds from samples of unknown contexts floated with an unknown mesh size. Table 8.5 shows that although fewer sites were sampled in Bulgaria, there is a bigger range of taxa from these sites than in the research area. The median is almost three times that of the study areas, being affected by Kovačevo, Karanovo, Slatina and Kapitan Dimitrievo where 54 to 84 taxa were recovered. The values for Greece are more similar to those from the inland research area, although only half as many sites were sampled.

	Bulgaria	**Greece & Knossos**	**Coastal route**	**Inland route**
N° sites	18	13	26	26
N° taxa – mean	27	14	8	12
median	20	10	7	7
mode	6, 18, 55	8	4	13
range	4 – 84	8 – 28	1 – 30	1 – 33

Table 8.5: Summary statistics of Early Neolithic sites with charred plant remains from the research area, Greece and Bulgaria. Based on the minimum number of taxa.

The Middle/Late sites were mostly open settlements. Five cave sites are known along the Adriatic coast (sites 180, 184, 190, 193, 194) and 19 tell sites have been sampled inland. Forty-six sites (29%) only contained plant records represented as impressions (charred remains from site 155 were found within the clay matrix). These and the Early Neolithic plant impressions are included in the descriptions of cereal finds below but, for reasons explained previously (Chapters 5.1.2 & 6.2.1), are not included in any of the analyses. The highest concentration of sampled tell sites lies in Serbia (41% (n=7) of Serbian sites) and Romania (75% (n=6) of Romanian sites). Table 8.6 shows that despite a larger number of sampled open sites, more taxa tend to be found on tell sites. The higher and broader range of mode values demonstrate that the higher average is not simply due to an unusually rich site. Along the coast, the statistical results for caves and open sites are comparable, even though cave sites only represent a sixth of the total coastal group. Although it was not possible to compare sample volumes or provenance (context) between the areas, the discrepancies evident in

Tables 8.5 and 8.6 may result from such variables.

	Inland route		**Coastal route**	
Site type	Open	Tell	Open	Cave
N° sites	51	19	33	5
N° taxa – mean	13	27	12.1	13.2
median	6	17	9	9
mode	1, 2	4, 8, 11, 17	4	/
range	1-72	1-88	3-34	8-30

Table 8.6: Summary statistics of Middle/Late Neolithic sites with charred plant remains from the research area. Excludes sites of unknown type and is based on the minimum number of taxa.

Single samples were taken from a known 22 sites, and not necessarily for the purpose of recovering plants remains. The three taxa retrieved from Divostin, for example, were found within a pollen core (Grüger & Beug 1988: 418). The volume of these samples is unknown, nor is it always known how many items were found. These sites have a low average of 2.4 taxa per site. Since it is impossible to know, or indeed measure, the biases incurred by taking a small number of samples (of unknown volume from an unknown site size), all sites with charred plant remains were included in the analyses below.

Comparisons between individual sites and groups of sites is further complicated by varying levels of identification and recording (Tables 8.2 & 8.4). Not all reports specify which parts of cereals were identified (whether grain or chaff), and plant remains seem to have been better preserved inland. This is most notable with the wild/weed taxa: 42% (n=31) of inland 'weed' seeds were only recorded to genus level, a figure that rises to 65% (n=34) for the coastal record. The absence of cereal chaff and arable weeds is problematic when the flot or sieving mesh size is unknown. Sites 12 in Serbia and 23&24/132 in Hungary, from which a relatively high number of samples were taken, contained cereal grains and wild plant seeds but no chaff. The mesh size used for flotation is unknown and the complete absence of cereal chaff, albeit surprising, is not discussed in the original reports (Gyulai 2010a; Jezik 1998). Most of the sites from Hungary and Italy have a sample grade of 1 (Chapter 5.1.4) because results are amalgamated and presented as a list of species per site. So as to overcome the problems exposed above and make archaeobotanical records comparable, the data were simplified to presence by site. The broad range in the volume of samples and minimum number of taxa per site remain a potential issue; one cannot assume that the absence of taxa from a site, particularly of the more common taxa (such as emmer and einkorn), is simply a result of the sampling strategy. However, the grouping of sites into larger assemblages should minimise the potential biases incurred by inadequate sampling.

8.2 The Crops

8.2.1 The Early Neolithic

Table 8.7 lists all possible crops found charred at Impressed Ware and SKC sites from Italy, the western Balkans, Hungary and Romania, and their percentage presence by site. Twenty possible crop species/varieties are listed. Oat (*Avena sativa*) and grass pea were only reported along the Adriatic, whilst another three crops are only recorded from inland sites: 'new' glume wheat, common vetch and opium poppy.

	Impress W (26 sites)	**SKC (26 sites)**	**SKC Con (14 sites)**	**SKC Pann (12 sites)**
Barley	92%	81%	79%	83%
grains	77%	77%	71%	83%
chaff	12%	12%	14%	8%
6-row hulled	4%	12%	7%	17%
2-row hulled	23%	4%	0%	8%
Hulled barley	65%	58%	57%	58%
Naked barley	19%	15%	7%	25%
Emmer	92%	69%	71%	67%
grains	85%	69%	71%	67%
chaff	31%	23%	7%	72%
Einkorn	69%	69%	64%	75%
grains	62%	62%	64%	58%
chaff	23%	31%	7%	58%
1-grained	0%	27%	29%	25%
2-grained	0%	4%	7%	0%
Free-threshing	50%	46%	50%	42%
grains	46%	42%	50%	33%
chaff	12%	8%	0%	17%
Hexaploid	19%	31%	43%	17%
Tetraploid	4%	12%	7%	17%
Spelt	23%	12%	7%	17%
grains	8%	12%	7%	17%
chaff	23%	0%	0%	0%
'New' glume wheat	0%	12%	7%	17%
grains	0%	4%	0%	8%
chaff	0%	4%	0%	8%
Oat ?	8%	0%	0%	0%
Millet	4%	27%	7%	50%
Lentil	38%	46%	43%	50%
Pea	12%	42%	43%	42%
Grass pea	4%	0%	0%	0%
Bitter vetch	4%	8%	14%	0%
Common vetch	0%	8%	7%	8%
Broad bean	8%	4%	0%	8%
Flax (all seeds)	4%	8%	7%	8%
Opium poppy (cf.)	0%	4%	0%	8%

Table 8.7: Percentage presence (ubiquity) of Early Neolithic sites with charred crops, within catchment areas and bioregions. Taxa binomials are listed in Table 6.4.

8.2.1.1 Common cereals

Barley was the most common cereal. 2-row hulled barley was identified at sevens sites (sites 8, 18, 47, 23, 43, 57 and 58). Only one coastal (site 43) and three inland (sites 1, 16 and 22) sites have records of 6-row hulled barley. Naked barley is recorded from far fewer sites. It was only found without the hulled varieties at sites 40 and 61. Inland emmer was more common in the Continental zone than in Pannonia, where einkorn was more frequent. Einkorn has only been specifically identified to the single-grained variety at seven sites, all inland (sites 7, 12, 13, 14, 17, 18 and 36). The 2-grained variety is only recorded as a single grain from Măgura-buduiasca in south-western Romania (site 36). Both hexaploid and tetraploid varieties of free-threshing wheat were identified from coastal and inland sites. Coastal sites contain one record of tetraploid wheat, whereas finds of hexaploid varieties are more frequent but restricted to southern Italy (sites 44, 49, 51, 52 and 61). Inland, tetraploid free-threshing wheat grains were recorded from one Continental site in Romania (site 33), and three Pannonian sites (sites 21, 23 and 33). Hexaploid varieties are also more common inland, having been found at five Continental sites (1, 2, 4, 5 and 8) and three Pannonian ones (18, 23 and 33).

8.2.1.2 Problematic cereals

Millet was found in all three bioregions but never as more than ten caryopses. Three grains were found at Starčevo-Grad, but the context they were retrieved from was cut by a Roman feature rich in millet grains (Filipović 2014: 198). Single grains were found at sites 17, 18, 35 and 44. Six seeds were identified at site 36, two seeds were found at site 22, and ten millet seeds make up “the majority of macro-remains” at site 21 in Hungary (Gyulai 2012: 226; Gyulai 2010b: Table 2). However, two of the seeds from site 36 have since been radiocarbon dated to 1434-1268 BC and 1438-1620 AD (Motuzaite-Matuzeviciute *et al*. 2013: Table 2). Spelt wheat is recorded at three sites in Pannonia, possibly all identified from grains (the plant part is not specified at Circea in Romania). Finds of spelt are more common along the coast, where it was identified at two sites in Dalmatia (40 and 42), and four sites in Italy (43, 54, 61 and 67). The identification of chaff rather than grain can only be confirmed for sites 40 and 61. The 'new' glume wheat was found at three inland sites: a possible grain was recovered from At, 33 glume bases were identified at Ecsegfalva, and 44 glume bases at Măgura-buduiasca. Domesticated oat was tentatively identified from caryopses at two sites in southern Italy (sites 58 (10 grains) and 61 (2 grains), identified to *Avena* cf. *sativa*; Sargent 1987: 762). Oat and spelt at site 61 were not found during more recent excavations (Caldara *et al*. 2001).

8.2.1.3 Pulses

Lentil and pea were the most common pulses. Lentil was recovered from 10 coastal sites (sites 39, 46, 48, 52-57, 60), six Continental sites (1, 5, 7, 12, 13, 15) and five Pannonian sites (18, 21-23, 35). Pea was only present at three sites along the coast, all in southern Italy (48, 54, 58), five sites on the continent (1, 4-6, 13, 36), and five sites in Pannonia (16, 21-23, 33). The large mass of pure (weed free) charred peas and lentils found at Drenovać in the Morava Valley of central Serbia represents the largest concentration of pulses found in the research area for the whole of the Neolithic (Perić & Obradović 2012: 17). Grass pea is recorded from one site: Pokrovnic in Dalmatia. Quantities are not given but “its presence in samples” (Reed & Colledge 2016: 3) suggests seeds were not unique. Bitter vetch was only found at three sites (sites 15 (unknown quantity), 36 (6 seeds) and 56 (1 seed)). However, the seeds from site 15 (Jaričište Mali Borak) are of dubious provenance as they came from a context that was re-used during a Vinča phase (Filipović pers. comm. 13/11/15). Two sites contained single finds of common vetch: level II of Anza in the FYROM, and the Körös/LBK transitional phase of Tiszaszőlős-Domaháza (site 24) where it is recorded as *V.* cf. *angustifolia* L. (Gyulai 2010a: Appendix table). The latter site also contained a small broad bean, recorded as *V. faba* var. *minor* (Gyulai 2010a: Appendix table). Broad beans were also found as single occurrences at sites 43 and 54 in southern Italy.

8.2.1.4 Flax and Opium poppy

The only evidence for the use of flax fibres comes from Győmaendröd (site 26) where an imprint was identified as “flaxen cloth” (Gyulai 2010a: 72). The finds noted in Table 8.7 are all of seeds, presumably identified to the cultivated variety on the basis of their size, though measurements are not given. The three sites with flax are: site 38 in Dalmatia ('low presence'); site 7 in eastern Croatia (1 seed), and site 15 in western Serbia (unknown quantity). A possible fragment of an opium poppy seed from Ibrány-Nagyerdő constitutes the only contentious evidence for this species.

8.2.1.5 The ubiquity of crops

Figures 8.4 and 8.5 illustrate the ubiquity values of the main crops presented in Table 8.7 (excluding 'problematic cereals'). The figures enable the relative presence of crops to be compared between catchment areas and bioregions.

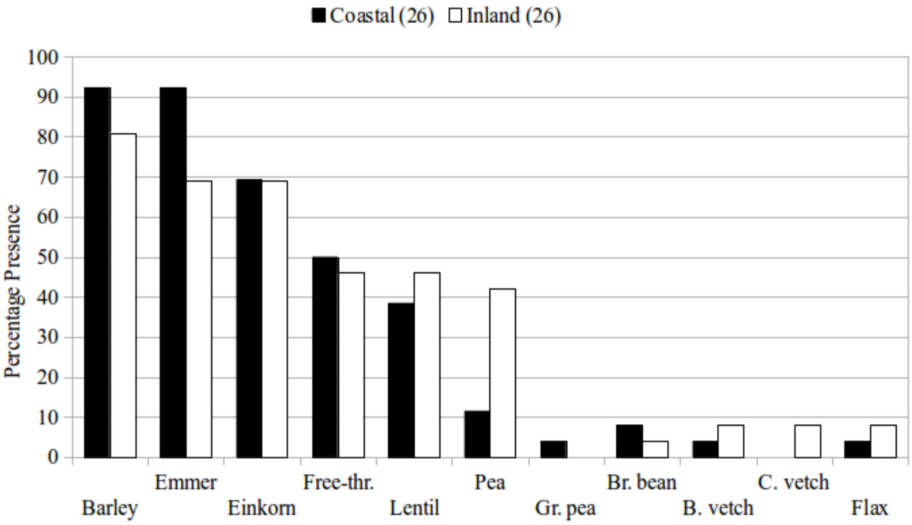


Figure 8.4: Percentage presence (ubiquity) of Early Neolithic sites on coastal and inland routes with evidence for cereal and pulse crops.

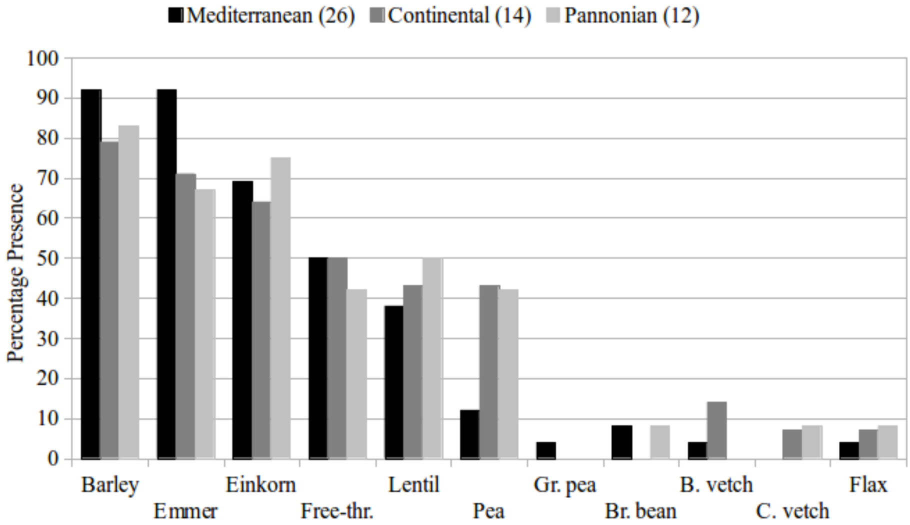


Figure 8.5: Percentage presence (ubiquity) of Early Neolithic sites with cereal and pulse crops found within the three bioregions.

The four main cereals were used across the research area but in different relative proportions. Along the coast barley and emmer were found in 92% (n=24) sites. Einkorn was present in 23% fewer sites (present in 18 sites), suggesting it may have been less commonly used. A similar relationship between the three cereals is seen in the Continental zone. In Pannonia, although barley has the highest ubiquity score, einkorn was more common than emmer. Free-threshing wheat, which, when counts are given, was always found in fewer numbers than emmer and einkorn, occurred in 13 sites along the coast, seven sites in the continent and five sites in Pannonia. Two Continental sites stand out: despite having been relatively well sampled Drenovać (site 13) contained no barley, and Ibrany-Nagyerdő (site 21) no glume wheats. The latter has records for hulled barley and a single tetraploid free-threshing wheat grain (which must remain dubious until chaff is confirmed; Gyulai 2010b: 221). Lentil was prevalent in Pannonia where it has been found more frequently than free-threshing wheat. Along the coast it was more common than pea, having been found in ten sites, compared to three. Proportions of lentil and pea only differed by one site in the Pannonian zone, and occurred at the same frequency in the Continental zone. Broad bean, bitter vetch and grass pea were only rarely found. The latter two were absent from Pannonia, which instead contained a similarly low proportion of common vetch. Flax also occurred in low proportions, having been found at only one site in all three bioregions.

In Greece (13 sites) and Bulgaria (18 sites) barley and einkorn were found at all sites (Figure 8.6). Both naked and hulled forms of barley were recorded, though the latter is much more common. Six-row hulled barley has been identified more frequently in Bulgaria than the 2-row variety, and the opposite is true for Greece. Conversely to the western Balkans, the presence of single-grained einkorn was confirmed at four sites in both Greece and Bulgaria. Emmer is only missing from Malăk Preslavec in Bulgaria and Toumba Balomenou in Greece, giving it a slightly lower ubiquity score to einkorn and barley. Free-threshing wheat was present in 56% (n=10) of Bulgarian sites, but only 31% (n=4) of Greek sites. Only hexaploid varieties have been identified. Lentil and pea were much more common than in the inland and coastal study areas, particularly in Greece where lentil was found at all sites. Grass pea and bitter vetch also have higher ubiquity scores, particularly in Bulgaria where the distinction between wild and domesticated grass pea is not always made. Flax is present in similar proportions to the other areas. The 'problematic' cereals are not common: domesticated oat has not been found; millet was only recorded from Argissa; 'new' glume wheat was identified at one site in Bulgaria and two in Greece, and spelt was only noted at Gălăbnik in Bulgaria. An additional crop, chickpea, is unique to Greece and Bulgaria. Wild einkorn grains (*Triticum boeticum*) are recorded from two sites in Bulgaria, and its modern distribution in south-eastern Bulgaria led Dennell to suggest that some domestication could have occurred locally (1978: 150). Similarly, wild barley, oat and lentil were found in Mesolithic levels at Franchthi, and although morphological evidence is missing, the domestication of some crops in Greece remains a possibility (Valamoti & Kotsakis 2007). In particular, Early Neolithic finds of grass pea are more common in Bulgaria and Greece than further east, and its modern distribution across the Mediterranean basin offers supportive evidence that the pulse may not have been part of the original Near Eastern crop package (Kislev 1989; Valamoti & Kotsakis 2007:82; Zohary *et al*. 2012: 97).

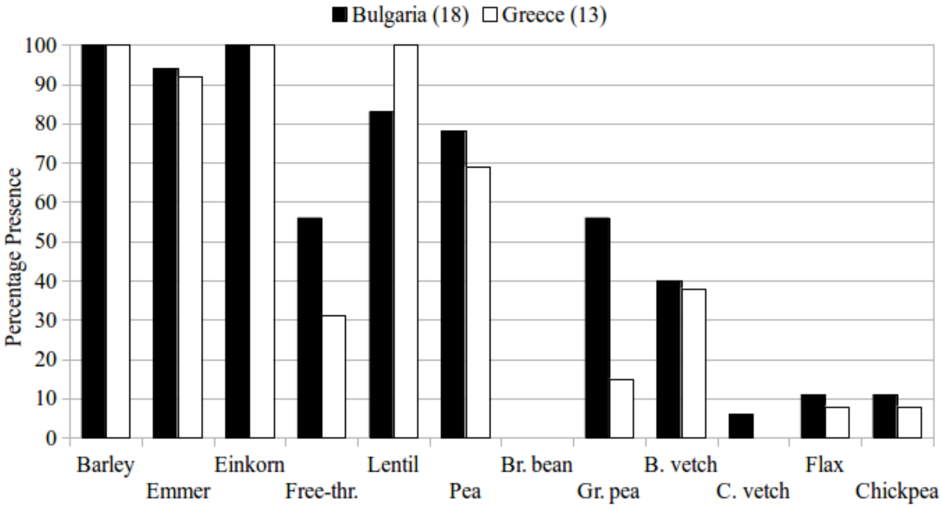


Figure 8.6: Percentage presence (ubiquity) of Early Neolithic sites with cereal and pulse crops in Greece and Bulgaria.

8.2.2 The Middle/Late Neolithic

Table 8.8 lists all the possible crops found charred within the coastal and inland catchments, and their percentage presence by site. These areas are subdivided into bioregions. Twenty-one possible crop species/varieties are listed. Oat (*Avena sativa*) was only recorded along the Adriatic, and tetraploid free-threshing wheat was only found on inland sites.

Percentage of Sites by Area	**Coastal (sites 38)**	**Inland (sites 73)**	**Dalmatia & S/C Italy (sites 23)**	**N. Italy (sites 15)**	**Continental & Alpine (sites 28)**	**Pannonian (sites 45)**
Barley	89%	71%	100%	73%	78%	69%
grains	84%	67%	91%	73%	70%	67%
chaff	26%	32%	39%	7%	30%	33%
6-row hulled	5%	19%	9%	0%	15%	22%
2-row hulled	18%	5%	30%	0%	0%	9%
Hulled barley	55%	49%	74%	27%	44%	53%
Naked barley	26%	13%	22%	0%	30%	24%
Emmer	84%	71%	87%	80%	78%	67%
grains	84%	68%	87%	80%	78%	62%
chaff	21%	41%	26%	13%	37%	44%
Einkorn	87%	68%	87%	87%	85%	58%
grains	82%	66%	87%	73%	81%	56%
chaff	16%	34%	13%	20%	44%	29%
1-grained	11%	30%	17%	0%	41%	24%
2-grained	5%	10%	9%	0%	11%	9%
Free-threshing	71%	45%	70%	73%	48%	42%
grains	71%	44%	70%	73%	48%	40%
chaff	8%	10%	9%	7%	11%	9%
Hexaploid	24%	23%	30%	13%	26%	20%
Tetraploid	0%	5%	0%	0%	4%	7%
Spelt	18%	16%	9%	33%	11%	16%
grains	18%	14%	9%	33%	7%	18%
chaff	5%	7%	4%	7%	7%	7%
'New' glume wheat	13%	16%	4%	27%	19%	16%
grains	0%	10%	0%	0%	15%	7%
chaff	13%	12%	4%	27%	11%	13%
Rye	3%	10%	4%	0%	7%	11%
Oat	8%	0%	13%	0%	0%	0%
Millet	21%	25%	26%	13%	26%	24%
Lentil	45%	51%	52%	33%	63%	44%
Pea	26%	38%	22%	33%	48%	33%
Grass pea	16%	18%	17%	7%	26%	13%
Bitter vetch	13%	17%	17%	7%	30%	11%
Common vetch	11%	3%	0%	27%	0%	4%
Broad bean	16%	5%	17%	13%	4%	7%
Flax (all seeds)	18%	23%	9%	33%	33%	18%
Opium poppy	5%	1%	0%	13%	0%	2%

Table 8.8: Percentage presence (ubiquity) of Middle/Late Neolithic sites with charred crops, within catchment areas and bioregions. Taxa binomials are listed in Table 6.4.

8.2.2.1 Common cereals and rye

Barley was found at all the sites in Dalmatia and southern and central Italy (hereafter s/c Italy), but was absent from four sites in northern Italy (sites 206, 210, 211, 213). Inland it was more common in the Continental than the Pannonian bioregion. Hulled barley was more common than naked varieties, which have not been recorded in northern Italy. Two-row hulled barley has been more frequently identified from coastal than inland sites, and the reverse is true for 6-row hulled barley. Emmer and einkorn were more common along the coast than inland, where they are most infrequent in the Pannonian region. Along the coast 2-grained einkorn was only identified at two sites: 181 and 183 in Dalmatia. It seems to have been more prevalent inland where it was identified at four sites in the Pannonian region (namely Slavonia, sites 83, 87, 90, 115), and three sites in the Continental zone (77, 78, 105). Free-threshing wheat was also more common along the coast, where hexaploid varieties were identified at nine Italian sites (sites 188, 192, 194, 196, 197, 204, 205, 206, 209), although identifications of rachis segments, rather than grains, can only be confirmed for site 205. Inland hexaploid rachis segments were recorded from four sites (sites 75, 97, 104, 106). Tetraploid rachis segments were only recovered from Okolište (site 75), though grains are recorded from three Hungarian sites (sites 133, 136, 138). Rye first appears in Middle/Late levels. It is represented by one grain from Turska Pećina in Dalmatia, ten grains from two Bosnian sites (sites 75 and 78) and 11 grains and one rachis internode from Uivar. Four Pannonian sites also contained rye grains (sites 83, 87, 135, 138), and an unusually high number were found at the latter site (n=74).

8.2.2.2 Problematic cereals

Millet was present in 23% of sites with charred remains (8 coastal and 18 inland sites). It only occurred as more than ten grains at five sites: three Hungarian sites contained a total of 137 seeds (sites 133, n=91; 135, n=20 and 138, n=26); Uivar had 17 grains, and Gomolova had 268 grains within 21 samples. Millet impressions were also noted from Hungarian sites 153 and 155. Spelt was less frequent than millet and was recorded from 12 inland and seven coastal sites. However, glume bases are only recorded from seven sites (sites 71, 76, 83, 87, 138, 184 and 219). Where counts of grain are given the highest number come from two Hungarian sites (sites 133, n=31 and 135, n=98). Although 'new' glume wheat may have been mistaken for spelt, five publications post-date the first description of the 'new' type (Jones *et al*. 2000a; Kohler-Schneider 2003), and it seems that spelt was a rare contaminant of wheat crops (Chapter 9.3). The 'new' type was identified at 12 inland and five coastal sites. Highest counts are registered from two Continental and two Pannonian sites: Uivar (site 174: 68,496 glume bases), Hermanov Vinograd (site 90: 76 glume base), Pločnik (site 97: 871 glume bases) and Belovode (site 104: 172 glume bases). Oat was only found at three sites, all in s/c Italy but was only identified from grains (sites 192 n=4, 196 n=1cf. and 204 n=14).

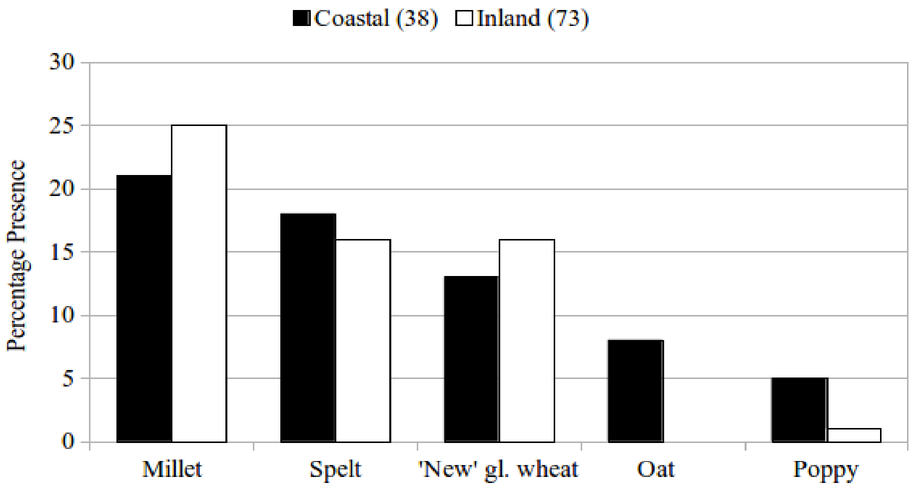


Figure 8.7: Percentage presence (ubiquity) of Middle/Late Neolithic sites with 'problematic' crops and opium poppy by catchment area.

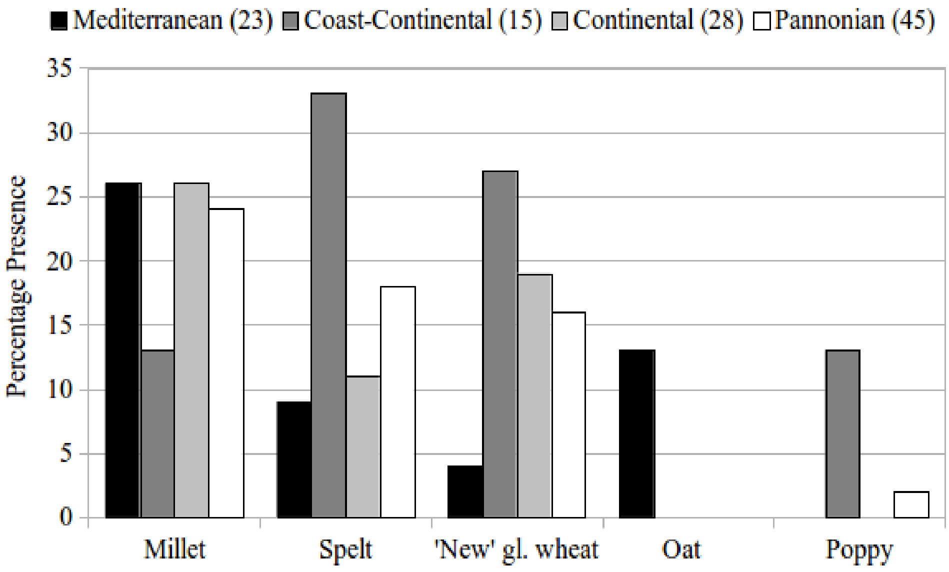


Figure 8.8: Percentage presence (ubiquity) by site of Middle/Late Neolithic 'problematic' crops and opium poppy by bioregion. See Figure 8.2 for the delimitation of bioregions.

8.2.2.3 Pulses

Lentils were found in about half of the coastal and inland sites. Unusually high quantities (>30 seeds) were counted from seven settlements in the Continental zone (sites 71, n=1709; 75, n=446; 97, n=77 and 104, n=81), and three in Pannonia (sites 107, n=95; 127, n=2179 and 174, n=86). Pea was found less often than lentils in all areas apart from northern Italy. However, in absolute counts, pea and lentils seem to have been found in similar quantities. Grass pea was found in similarly low proportions in both catchment areas. For site records in which counts are given grass pea only occurred as more than five seeds at two sites: Okolište contained 15 seeds and Battonya-Parázstanya (site 127) had an unusual quantity of '557+290cm^3'. Bitter vetch was found in all areas but was most common in the Continental zone, where the highest count came from Belovode (site 104, n=86). Apart from 12 specimens at Korića Han (site 78), and 11 at Capo Rondinella (site 188), all other sites had no more than 4 seeds. Common vetch was less regularly found than bitter vetch, except in northern Italy where it was recovered from four sites (sites 207, 218-220); counts are only available for Spilamberto (site 207, n=53). The two Pannonian sites (sites 90, 133) only contained single specimens. Broad bean was more common along the coast than inland. The highest count for Italy is 26 beans from Spilamberto; it has not been found in Dalmatia. Inland the highest count is three from Hermanov Vinograd (site 90).

8.2.2.4 Flax and opium poppy

Flax (seeds only) was slightly more common inland than along the coast, where it was mostly found in northern Italy (sites 206, 212, 214, 216, 219). Counts are only available from site 206 where 79 seeds were retrieved from two samples. Eight sites in Pannonia contained flax, with unusually high quantities of seeds (>100) from sites 174, 127 and 138. Flax seeds were found in nine Continental sites, where Jagnilo (site 71) contained the highest number of seeds (n=57). Seed measurements are only available for the three specimens found at Laminski Jaružani (site 80): 2.7-2.9mm long and 1.3-1.5mm thick. Opium poppy was found at two sites in northern Italy (site 207, n=1 and 216 ("scarce" Corti *et al*. 1998: 1386)), and at Hermanov Vinograd (3 seeds, two are mineralised).

8.2.2.5 The ubiquity of crops

Figures 8.9 to 8.13 illustrate the ubiquity values of the main crops presented in Table 8.8. The figures enable the relative presence of crops to be compared between catchment areas, bioregions and cultural groups.

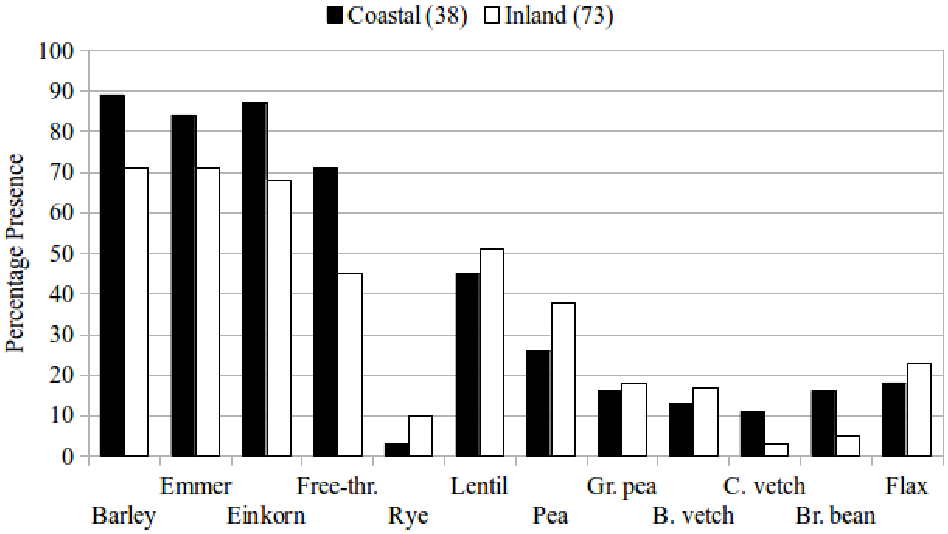


Figure 8.9: Percentage presence (ubiquity) of Middle/Late Neolithic sites with cereal and pulse crops found along the two routes of neolithisation.

Barley, emmer, einkorn and free-threshing wheat were more common on Adriatic sites, by at least 13%. The two most common pulses, lentil and pea, were more common inland. Grass pea was found in similar proportions in both areas, whereas common vetch and broad bean were almost absent from the inland zone. Bitter vetch and flax were slightly more common inland.

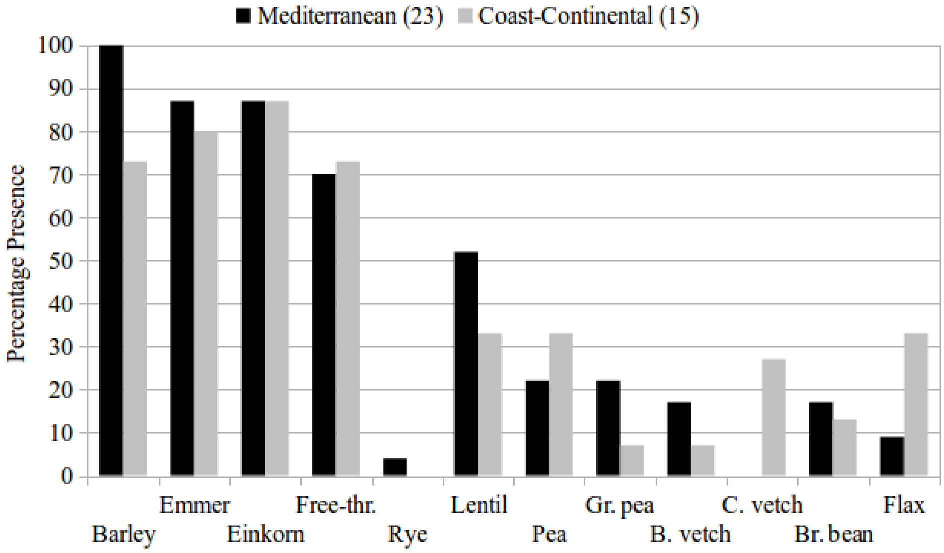


Figure 8.10: Percentage presence (ubiquity) of Middle/Late Neolithic sites with cereal and pulse crops found within the two bioregions of the Adriatic (Coast-Continental represents northern Italy).

Barley was found in all the sites of the Mediterranean bioregion but in only 73% (n=11) of sites in northern Italy. Emmer was slightly more common in the Mediterranean bioregion, and einkorn was the most common cereal in northern Italy (present in 13 sites in northern Italy, 20 in s/c Italy). Free-threshing wheat occurred in similar proportions, and was much more frequent than in both inland bioregions (Figure 8.11). All the pulses, apart from pea and common vetch, were more frequent in the Mediterranean bioregion. Flax was more common in northern Italy (5 compared to 2 sites).

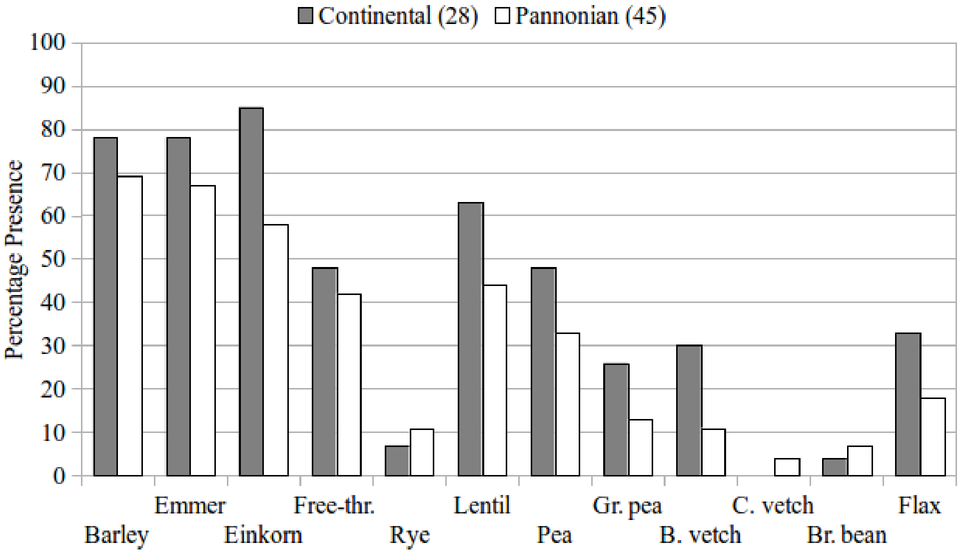


Figure 8.11: Percentage presence (ubiquity) of Middle/Late Neolithic sites with cereal and pulse crops found within the two inland bioregions.

Splitting the inland signature by bioregion illustrates how most of the crops were more frequent in the Continental area. Rye and broad bean were only slightly more common in Pannonia, where common vetch was recovered from two sites. Einkorn was the most frequent cereal within the continent whereas in Pannonia barley and emmer were more common than other crops. Lentil appears to have been more common than pea in both areas.

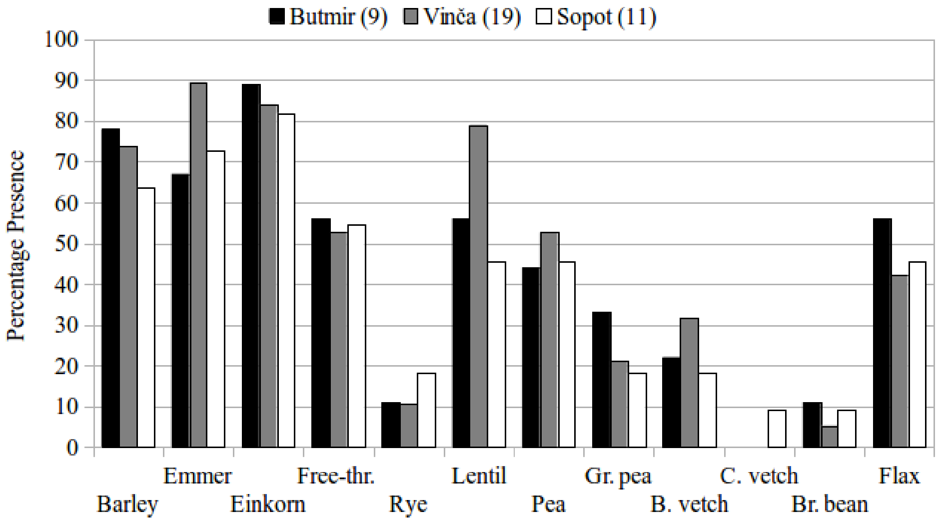


Figure 8.12: Percentage presence (ubiquity) of Middle/Late Neolithic sites with cereal and pulse crops found within the three inland cultural groups of the western Balkans (see Figure 8.3).

When inland sites of the western Balkans (excluding Hungary) are grouped according to their cultural attribution, it is evident that the only comparable frequencies are those for free-threshing wheat. The relative proportions of the three main cereals varies, with emmer predominating in the Vinča group and einkorn in the Sopot and Butmir groups. Lentil was very common in the Vinča group and has been found more frequently than barley. In the Sopot and Butmir groups lentil, pea and flax show similar frequencies. The Sopot group is the only one to contain all six pulses.

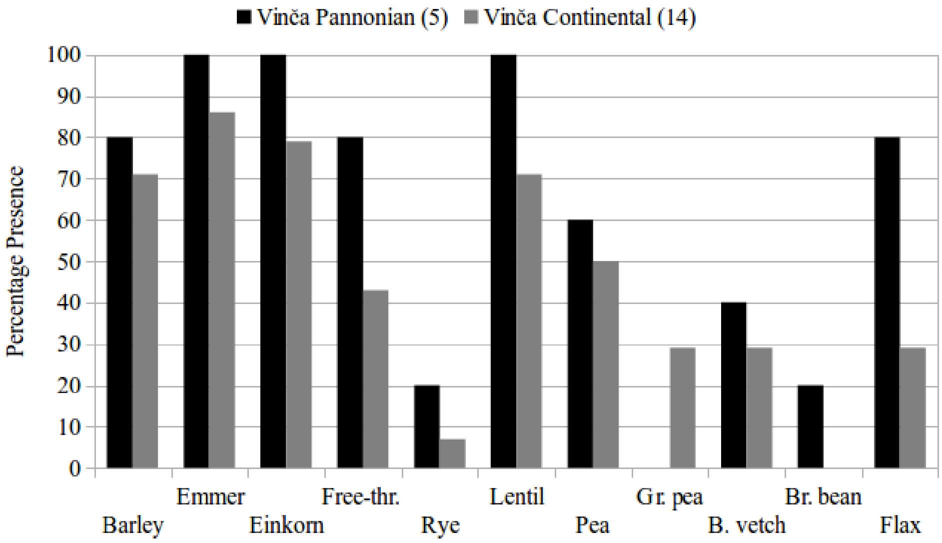


Figure 8.13: Percentage presence (ubiquity) of Middle/Late Neolithic sites with cereal and pulse crops found within the two bioregions of the Vinča distribution (see Figure 8.3).

The Vinča sites are located across two bioregions and it is clear that each area had a distinct distribution of crops. Emmer, einkorn and lentil occurred in all the Pannonian sites. In the Continental zone emmer and einkorn were more frequent than barley, which was as common as lentil. Lentil was the most common pulse. Free-threshing wheat appears to have been much more common in Pannonia, where it was as frequent as barley and is comparable to the Adriatic scores (Figure 8.10). Flax was also very common in Pannonia. Grass pea was only found within the Continental group, and broad bean within the Pannonian group.

8.2.3 Diversity between the Early and Middle/Late Neolithic

The ubiquity scores for the main crops from the coastal and inland areas are plotted by phase.

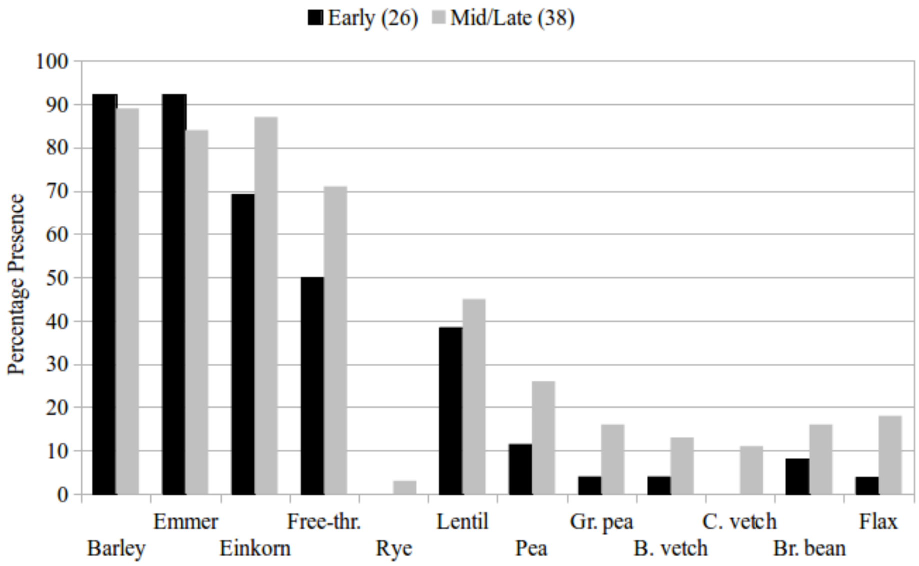


Figure 8.14: Percentage presence (ubiquity) of the Early and Middle/Late Neolithic sites with cereal and pulse crops found on coastal sites.

Barley was one of the most common cereals along the coast throughout the Neolithic. The frequency of emmer declined during the later phases whereas that of einkorn rose from 69% (18 sites) to 87% (33 sites). The frequency of free-threshing wheat also rose, and by the Middle/Late Neolithic the cereal was present in about two thirds of sites (n=11). The frequency of all the pulses increased during the later phase, when an additional pulse (common vetch) was introduced. The greatest increase in frequency is seen in the distribution of pea which was present in 15% more sites during the Middle/Late Neolithic (from 3 to 10 sites). Flax increased by 14% (from 1 to 7 sites).

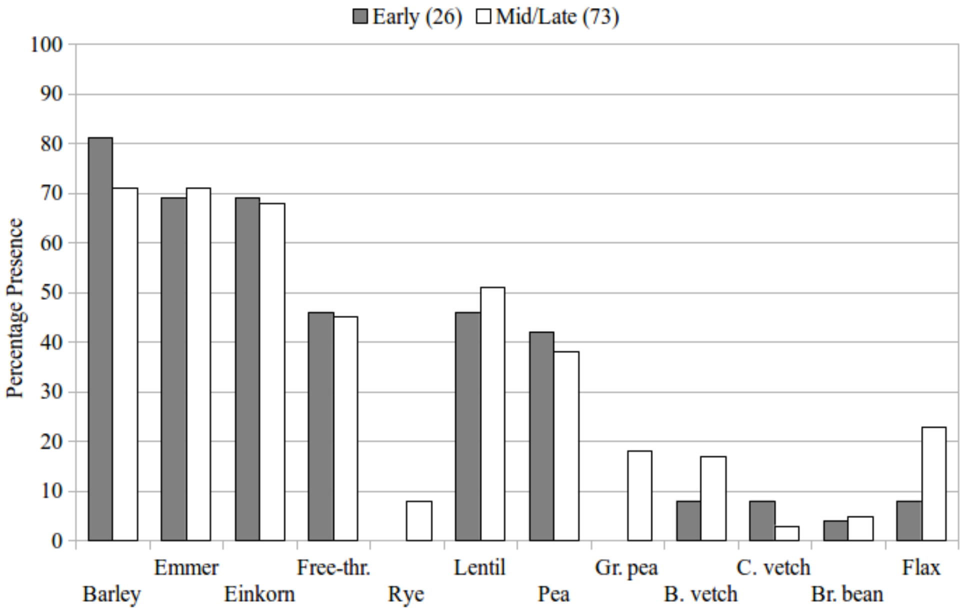


Figure 8.15: Percentage presence (ubiquity) of the Early and Middle/Late Neolithic sites with cereal and pulse crops found on inland sites.

Inland the ubiquity scores of the four main cereals were always lower than those from coastal sites. The presence of barley decreased whereas emmer, einkorn, free-threshing wheat, lentil and pea had very similar ubiquity scores during both phases of the Neolithic. Rye and grass pea appear for the first time in the later Neolithic. The frequency of bitter vetch increased, whereas that of common vetch decreased. Broad bean remained infrequent during the Neolithic, having been found at only one Early and four Middle/Late inland sites. Similarly to the coastal signal, the frequency of flax also increased substantially inland (by 15%, from 2 to 17 sites).

Violin plots of the Shannon diversity indices (H) for the crops and for the joint assemblages of crops and wild edible fruits and nuts are plotted (the range and frequencies of fruits and nuts is presented in section 8.3). Each circle represents an Adriatic site and each triangle an inland site. 'Problematic' cereals and taxa that occurred in less than 5% of sites from the whole Neolithic assemblage were not included in the calculations.

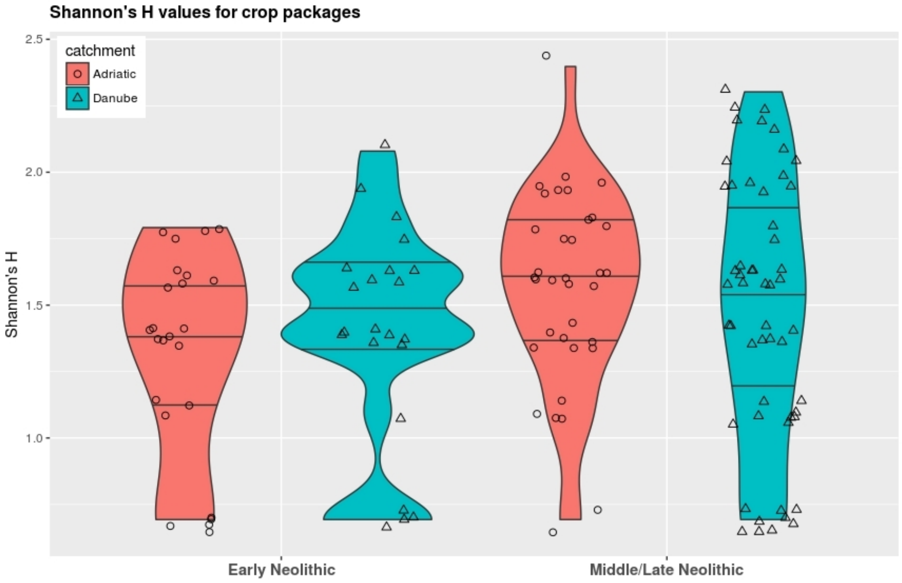


Figure 8.16: Shannon diversity indices for the coastal and inland crop packages during the Early and Middle/Late Neolithic.

Figure 8.17: Shannon diversity indices for the coastal and inland crops and edible wild fruits and nuts during the Early and Middle/Late Neolithic.

The difference in the diversity indices between Early and Middle/Late assemblages are statistically significant for Adriatic sites (Mann-Whitney U-test: *P*=0.004 in both figures), but not for inland sites as the *P*>0.05 (Mann-Whitney U-test: *P*=0.148 in Fig.8.16 and *P*=0.181 in Fig.8.17). In other words, only along the Adriatic did the Shannon values increase significantly, indicating a significant increase of richness in taxa (Chapter 6.3.3.1). This increase is mostly seen in the range of wild edible taxa used during the Middle/Late phase (section 8.3.3). Both catchment areas had greater diversity in the Middle/Late phase, even though the increase inland is not statistically significant. The distribution of diversity indices in the Danube catchment area are more evenly spread out across a greater range of values, suggesting that both poorest and richest sites (in the range of taxa) have been found inland.

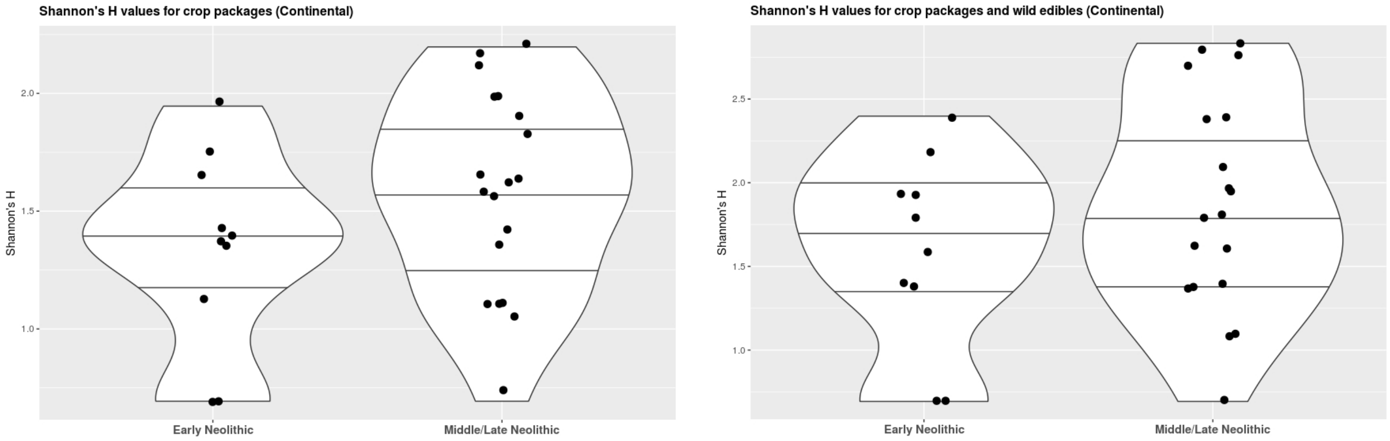


Figure 8.18: Shannon diversity indices for the Continental crops (left) and crops and edible wild fruits and nuts (right) during the Early and Middle/Late Neolithic.

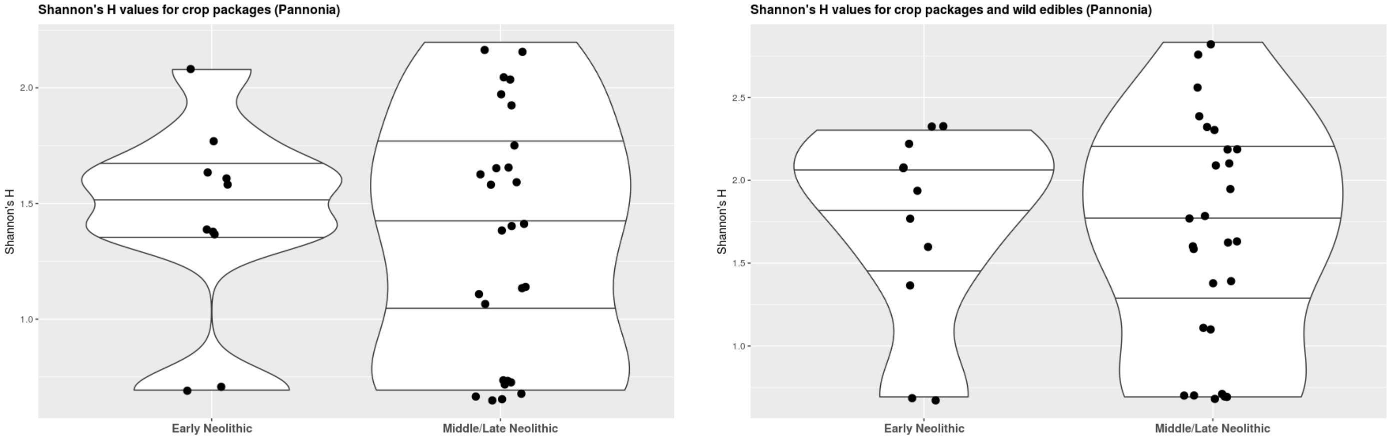


Figure 8.19: Shannon diversity indices for the Pannonian crops (left) and crops and edible wild fruits and nuts (right) during the Early and Middle/Late Neolithic.

When the inland catchment area is split into its bioregions the packages of crops and fruits and nuts continue to be statistically similar between the two phases of the Neolithic (Mann-Whitney U-test: *P*=0.083 for Fig.8.18 left, and *P*=0.019 for Fig.8.18 right (Continental), and *P*=0.083 for Fig.8.19

left and *P*=0.26 for Fig.8.19 right (Pannonia). The range and median are seen to increase in the Continental zone, whereas the latter decreases in Pannonia. The figures indicate that a similar range of taxa were used during both phases of the Neolithic.

8.2.4 Exploring the Data through Correspondence Analyses

Figure 8.20 was created from the same dataset of wild and domestic edible taxa used to calculate the Shannon diversity indices. It comprises of 22 taxa, 49 early sites and 111 middle/late sites (3 early sites were removed as outliers: Chapter 6.3.3.1). Axis 1 accounts for 14.2% of the variance, and the second axis for 9.15%. Taxa plot between about -1.2 to 2 along axis 1 and -4 to 2.8 along axis 2. Cereals, lentil and pea plot close to the centre and mostly have negative values along axis 1. Flax, grass pea and the vetches plot towards the extremes of the top and bottom right quadrants. Fruits and nuts all have positive values along axis 1 and mostly positive values along axis 2. The Early Neolithic sites plot between about -2 to 1 along axis 1, and -1.9 to 1.5 along axis 2. Middle/Late Neolithic sites plot across a broader range of values: between about -2.2 to 1.9 along axis 1 and -4.7 to 3.1 along axis 2.

All but one of the Early Neolithic sites from the Mediterranean bioregion have negative values along axis 1. Pannonian sites form another group. They are less tightly clustered then the coastal sites and have greater values along axis 1. The Continental group is distributed across both the Mediterranean and Pannonian groups. The single Alpine site is close to the centre, in the bottom, left quadrant. This distribution suggests that coastal sites have a similar range of taxa, whereas inland there is a greater diversity of represented taxa between sites. The sites seem to be distributed according to the variance in the proportion of crops to fruits/nuts. As such, it suggests that Mediterranean sites used fewer non-domesticates, whilst Pannonian sites relied more heavily on a wider range of fruits/nuts. A broader range of exploitation practices is seen across Continental sites. The extent to which exploitation practices were shaped by ecological and climatic conditions is unclear, but the distribution of Continental sites suggests personal choice was also important.

The Middle/Late CA plot shows less clustering. Mediterranean sites continue to plot closer to the cereals and pulses, whilst sites from northern Italy are mainly distributed in the top, right quadrant and closer to the fruits/nuts. No clustering is evident for the inland sites. As is also demonstrated by the violin plots (Figure 8.17), a greater diversity of exploitation practices compared to the Early Neolithic is evident between and within bioregions.

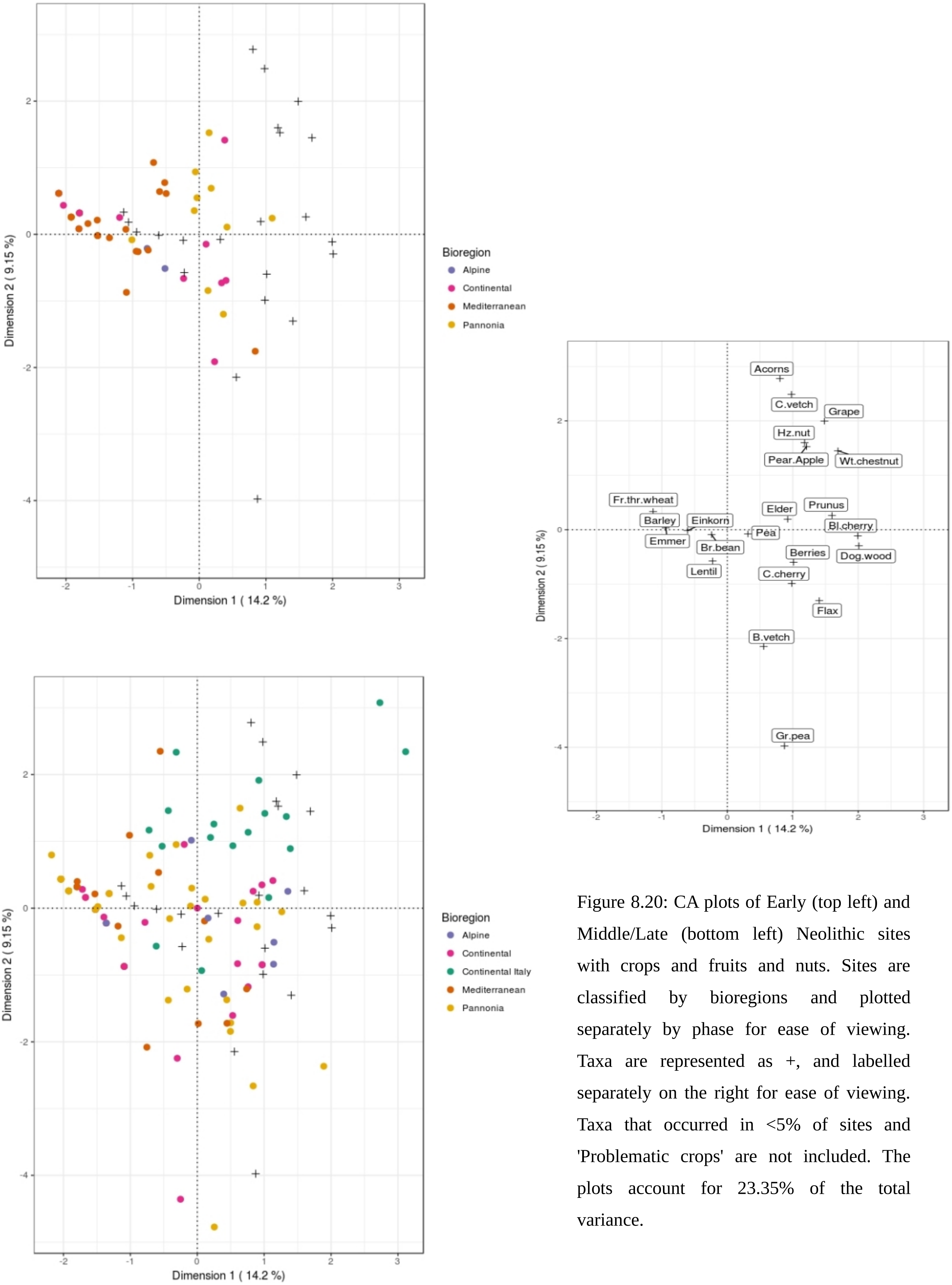
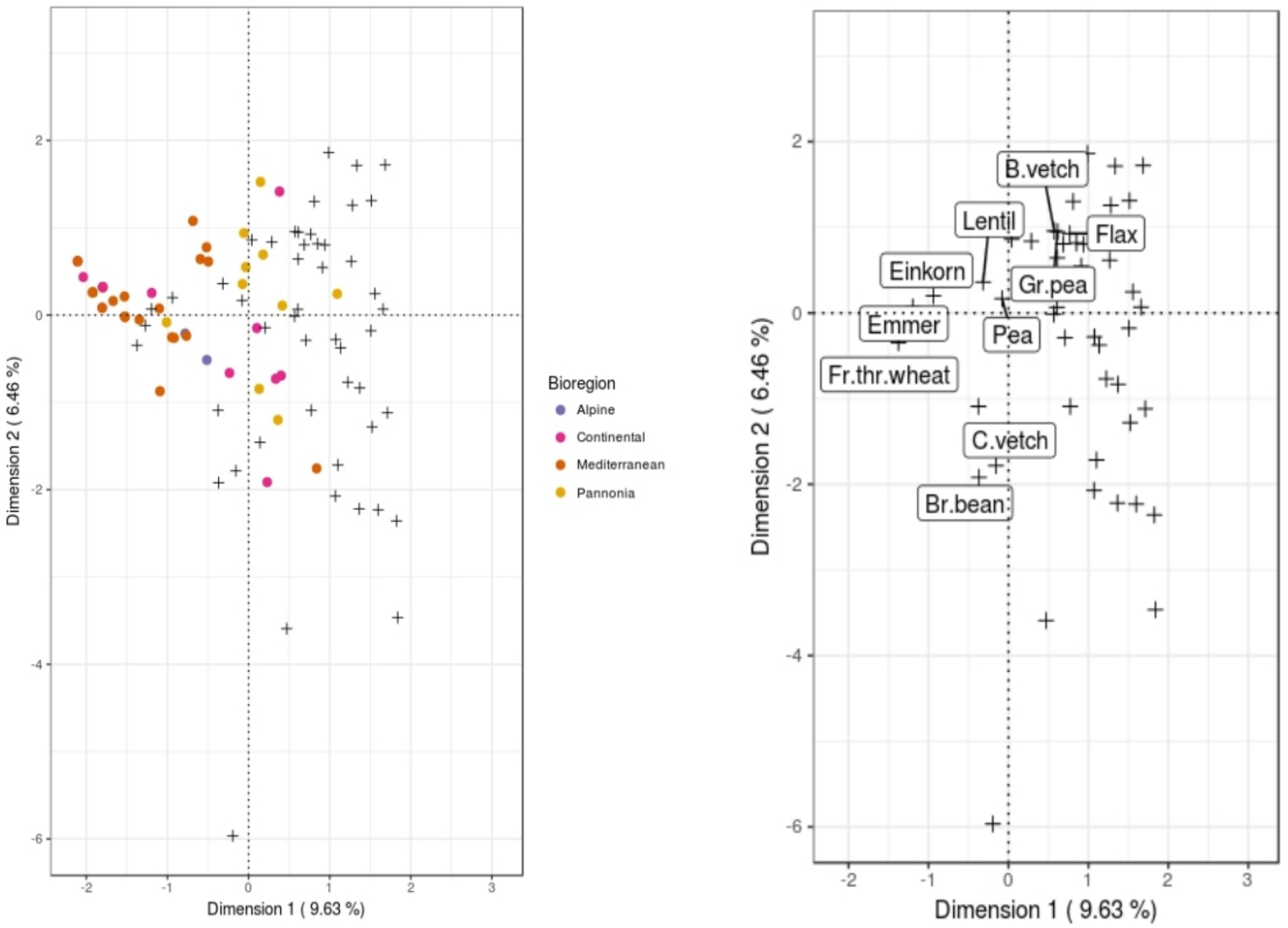


Figure 8.20: CA plots of Early (top left) and Middle/Late (bottom left) Neolithic sites with crops and fruits and nuts. Sites are classified by bioregions and plotted separately by phase for ease of viewing. Taxa are represented as +, and labelled separately on the right for ease of viewing. Taxa that occurred in <5% of sites and 'Problematic crops' are not included. The plots account for 23.35% of the total variance.



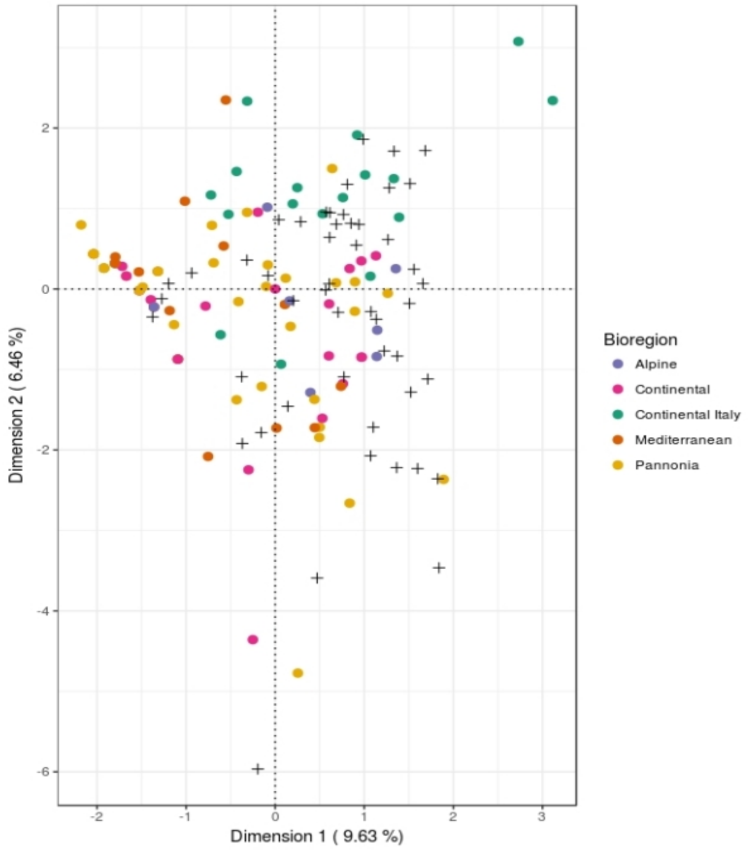


Figure 8.21: CA plots of Early (top left) and Middle/Late (bottom left) Neolithic sites with crops and 'weed' taxa. Sites are classified by bioregions and plotted separately by phase for ease of viewing. Taxa are represented as +, and labelled (only crops) separately on the right for ease of viewing. Taxa that occurred in <5% of sites are not included. The plots account for 16.09% of the total variance.

The dataset represented in Figure 8.21 comprises of 39 taxa, 49 early sites and 111 middle/late sites. Axis 1 accounts for 9.63%, and the second axis for 6.46%, of the variance. Taxa plot between about -1.4 to 1.8 along axis 1 and -6 to 1.8 along axis 2. Cereals, lentil and pea plot close to the centre and have negative values along axis 1. Only bitter vetch, flax and grass pea have positive values in both axis. All but two 'weed' taxa have positive values along axis 1 and plot across both positive and negative values along axis 2. The Early Neolithic sites plot between about -2.1 to 1.1 along axis 1, and -1.9 to 1.6 along axis 2. Middle/Late Neolithic sites plot across a broader range of values: between about -2.2 to 3.1 along axis 1 and -4.7 to 3.1 along axis 2.

All but one of the Early Neolithic sites from the Mediterranean bioregion have negative values along axis 1. Pannonian sites are mostly distributed in the top, right quadrant. Similarly to Figure 8.20, Continental sites are distributed across both the Mediterranean and Pannonian groups. Axis 1 seems to represent differences in the proportion of crops to weed taxa, whilst axis 2 may reflect differences in the composition of weed assemblages. The plot of Early Neolithic sites suggests that more common 'weeds' (those in >5% sites, n=39) are more frequent on inland than coastal sites. There is also greater variation in the proportions of crops and 'weeds' within the inland sites. A weaker relationship between sites of the same bioregion is evident during the Middle/Late Neolithic. Only northern Italian sites show a low level of clustering, towards the top, right quadrant. The plot illustrates that the more common 'weed' taxa do not clearly separate according to bioregion, suggesting that weed floras were not distinct but instead reflect similar ecological conditions, and therefore husbandry practices, across regions.

8.2.5 Crops and Climate

In order to explore whether the growth of crops may have been better suited to particular climatic zones and seasons within the year, information was obtained on the temperature requirements of modern crop varieties during key stages of their growth (Table 6.6). As is explained in Chapter 6.5, average winter and summer temperatures for each site at 8000BP (for the Early Neolithic) and 7000BP (for the Middle/Late Neolithic) were extracted from Mauri and colleagues' 2015 article (Tables 2.1 to 2.3, Appendix II). These were compared to the crops' required temperatures and results are summarised by research area in Tables 8.9 to 8.20. 'Problematic' crops and sites with impressions are not included. The wheat category includes emmer, einkorn and free-threshing, which are assumed to have had similar growing requirements to those listed for winter wheat in Table 6.6. Note that the minimum temperature tolerated during the early development of grass pea and broad bean (Tkill_grow) is not known. Sites listed in the first column of the tables with average winter (December, January and February) temperatures are those where crops could have germinated and began to grow. Those in the second column are sites where the average winter temperature was too low for germination, but where crops could have survived as seedlings. Crops at sites in the third column would have not been able to germinate or grow in the winter. Sites listed in the first column of the tables with average summer (June, July and August) temperatures are those where crops could have grown within their optimum temperature ranges. Sites in the second column would have experienced average summer temperatures above the optimum ranges for the growth and maturity of crops. Sites are placed under 'crop' or 'no crop' depending on whether that particular crop was found.

This approach aims to test the sixth hypotheses listed in Chapter 1: that farmers' adaptations to increasingly northerly latitudes can be explored through past climatic parameters and their suitability to particular crops. By exploring the climatic conditions under which crops were grown, and whether crops were adapted to a particular season, it is possible to suggest likely husbandry practices. For example, if a crop was present in an area where winters were too cold for its cultivation, one could suggest that spring-sowing was likely. On the other hand, if a crop was absent from an area where it could have grown, one can suggest that the crop was dropped for reasons other than an unsuitable climate. As is described in Chapter 6.5, this approach hinges on the uniformitarian assumption that Neolithic varieties had the same temperature thresholds as modern ones. It also assumes an exaggerated level of precision in the temperature reconstructions, and does not factor in the many other parameters that influence a plant's development (e.g. Grigg 1995). Nevertheless, it is felt that this approach uses available data to produce an additional tool with which to understand the changing Neolithic crop-package and husbandry practices.

8.2.5.1 The Early Neolithic

None of the sites had average winter temperatures below the Tkill_rest values of crops, i.e. all the crops within the three bioregions could have survived outside as dormant seeds during the winter. The average summer temperatures were never lower than the optimum growing range, and never higher than the crops' maximum tolerated temperatures (Tmax). Nevertheless, average summer temperatures at sites 43 and 44 in southern Italy were only one to two degrees lower than the maximum tolerated temperature for wheat, common vetch and bitter vetch.

Coastal (sites 39-44, 47-61, 63-67)	Average winter temperature (W_temp) > minimum germination and early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	39-44, 47-61, 63, 65, 67	64, 66				
Wheat	39-44, 47-61, 63-65, 67	66				
Lentil	39, 61	40–44, 48, 50-52, 59, 60, 63-67				
Pea	49, 55, 59	39-44, 47, 48, 50-54, 56-58, 60, 61, 63-67				
Grass pea	39	40–44, 48, 50-52, 59-61, 63-67				
Common vetch		all sites				
Bitter vetch	55	39-44, 47-55, 57-61, 63-67				
Broad bean	43, 54	39-42, 44, 47-53, 55-61, 63-67				
Flax	39	40–44, 48, 50-52, 59-61, 63-67				

Table 8.9: Average Early Neolithic winter temperatures for sites along the coast and the distribution of crops.

Coastal (sites 39-44, 47-61, 63-67)	Average summer temperature (S_temp.) is within the optimum growing temperature range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop
Barley			39-44, 47-61, 63, 65, 67	64, 66
Wheat	39, 54, 56, 57, 67		40-44, 47-53, 55, 58-61, 63-65	66
Lentil	39, 47, 49, 53-58, 61	40-44, 48, 50-52, 59, 60, 63-67		
Pea	55, 59	39-42, 52-54, 56-58, 60, 61, 63-65, 67	49	43, 44, 47, 48, 50, 51, 66
Grass pea	39	40–44, 48, 50-52, 59-61, 63-67		
Common vetch		39, 54, 56, 57, 67		40-44, 47-55, 58-61, 63-66
Bitter vetch			56	39-44, 47-55, 57-61, 63-67
Broad bean	43, 54	39-42, 44, 47-53, 55-61, 63-67		
Flax	39	40-42, 52-61, 63-65, 67		43, 44, 47-51, 66

Table 8.10: Average Early Neolithic summer temperatures for sites along the coast and the distribution of crops.

Along the coast average winter temperatures were not too low to inhibit the germination and development of seedlings of any of the crops listed. In fact, the minimum value of the optimum growing temperature range for pea and grass pea (10ºC) was reached during the winter at all but four of the Dalmatian and southern Italian sites (sites 39, 42, 56, 57). Many sites saw average summer temperatures above the range for optimum growth. These ranged from 20ºC to 27ºC which, as is mentioned above, do not exceed any of the crops' maximum tolerated temperatures. Fiorano (site 66) had no crops but little is known about its sampling strategy.

Continental (sites 1, 2, 4, 5, 8-15, 33, 36)	Average winter temperature (W_temp) > minimum germination and early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	2, 8, 9, 10		1, 4, 12, 14, 15, 33, 36	5, 11, 13		
Wheat			1-5, 8, 10-15, 33, 36	9		
Lentil			1, 5, 12, 13, 15, 36	2, 4, 8-11, 14, 33		
Pea		2	1, 4, 5, 13, 33, 36	8-12, 14, 15		
Grass pea		2		?other sites?		?other sites?
Common vetch		2, 8, 9, 10	1	4, 5, 11-15, 33, 36		
Bitter vetch			15	1, 2, 4, 5, 8-14, 33, 36		
Broad bean				?all sites?		?all sites?
Flax			15	1, 2, 4, 5, 8-14, 33, 36		

Table 8.11: Average Early Neolithic winter temperatures for sites in the Continental zone and the distribution of crops.

Continental (sites 1, 2, 4, 5, 8-15, 33, 36)	Average summer temperature (S_temp.) is within the optimum growing temperature range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop
Barley	4, 12, 14, 15	5, 11, 13	1, 2, 8, 9, 10, 33, 36	
Wheat	1, 4, 5, 8, 10-15	9	2, 33, 36	
Lentil	1, 5, 12, 13, 15, 36	2, 4, 8, 9, 10, 11, 14, 33		
Pea	1, 4, 5, 13, 33, 36	8-12, 14, 15		2
Grass pea		all sites		
Common vetch	1	4,5, 8-15		2, 33, 36
Bitter vetch	15	1, 4, 5, 11- 14		2, 8, 9, 10, 33, 36
Broad bean		all sites		
Flax	15	1, 4, 5, 8-14, 33, 36		2

Table 8.12: Average Early Neolithic summer temperatures for sites in the Continental zone and the distribution of crops.

The average Continental winter temperatures were generally too cold to support germination. Of the recovered crops only barley could have germinated during the winter. Crops sown and germinated before the onset of winter temperatures may have survived as seedlings until the spring. Average summer temperatures were within the optimal range for most crops at most sites. Sites 2, 33 and 36 had the highest average summer temperatures (between 23.1ºC-24.2ºC), falling 3ºC to 4ºC above the ideal range for barley and only just above, or at the limit of the ideal range for wheat, pea, bitter vetch, common vetch and flax. The sites where barley could have germinated and started growing in the winter (sites 2, 8, 9, 10) experienced average summer temperatures above the optimum range for that crop. Grass pea and broad bean were not grown despite suitable summer temperatures.

Pannonian (sites 6, 7, 16-24, 32, 35)	Average winter temperature (W_temp) > minimum germination and early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	6, 7, 16, 17, 35		18	19	21-24, 32	20
Wheat			6, 7, 16-19, 35	20	21-24, 32	20
Lentil			7, 18, 21-24, 35	6, 16, 17, 19, 20, 32		
Pea			6, 16, 33	7, 17-19, 35	21-24	20, 32
Grass pea				?all sites?		?all sites?
Common vetch			23&24	6, 7, 16-19, 35		20, 21, 22, 32
Bitter vetch		17, 35		6, 7, 16, 18, 19, 23-4		20, 21, 22, 32
Broad bean			?23&24?	?other sites?	?23&24?	?other sites?
Flax			7	6, 16-19, 23&24, 35		20, 21, 22, 32

Table 8.13: Average winter Early Neolithic temperatures for sites in the Pannonian zone and the distribution of crops.

Pannonian (sites 6,7, 16-24,32,35)	Average summer temperature (S_temp.) is within the optimum growing temp. range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop
Barley			6, 7, 16-18, 21-24, 32, 35	19, 20
Wheat	6, 7, 16-19, 21-24, 32, 35	20		
Lentil	7, 18, 21-24, 35	6, 16, 17, 19, 20, 32		
Pea	6, 16, 21-24	7, 17-20, 32, 35		
Grass pea		all sites		
Common vetch	23&24	6, 7, 16-24, 32, 35		
Bitter vetch		7, 16, 17, 19-24, 32, 35		6, 18
Broad bean	23&24	all other sites		
Flax	7	6, 16-24, 32, 35		

Table 8.14: Average summer temperatures for sites in the Pannonian zone and the distribution of crops.

The Pannonian Basin experienced the coldest winter average temperatures. Only barley could have germinated and grown during the winter, and perhaps bitter vetch though none have been recovered from the area. Compared to the other two research areas there is an increase in the number of sites where certain crops would not have survived if they had been sown and germinated before the onset of winter temperatures (sites in the third column of Table 8.13). All the sites had average summer temperatures above the optimal range for the growth of barley (Table 8.14). Note, however, that the average temperatures vary between 21ºC and 23ºC, and that modern barley varieties tolerate temperatures of up to 40ºC (Table 6.6). The summer average temperature for Circea (33) is 23.1ºC, only 0.1ºC higher than the optimum range for wheat. Lentil and pea were grown within their optimum temperatures. Common vetch and broad bean were found at one site in Hungary (site 23&24), presumably cultivated within suitable growing temperatures. As was noted for the Continental sites, grass pea has not been recovered despite ideal summer average temperatures.

8.2.5.2 The Middle/Late Neolithic

During the Middle/Late phase some winter average temperatures in the Continental zone dropped below the minimum viable temperature of some crops (Tkill_rest); sites with these temperatures are listed in the fourth column of the winter Table 8.17. Some summer average temperatures dropped below the optimal range for certain crops; sites with these temperatures are listed in the middle column of Tables 8.16, 8.18 and 8.20. The maximum tolerated temperature was only reached (not surpassed) for wheat and only at two sites, both in southern Italy.

Coastal (sites 180-200, 204-220)	Average winter temperature (W_temp) > minimum germination and early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	180-200, 204, 205, 207-209, 212, 217-220	206, 210, 211, 213	215, 216		214	
Wheat	180-200, 205		204, 206-209, 211, 212, 215-220	210, 213	214	
Lentil	180-184, 188, 190, 192, 193, 195, 197	185-187, 189, 191, 194, 196, 198-200, 205	204, 215, 212, 218-220	206-211, 213, 214, 216, 217		
Pea	183, 189, 192, 204, 205, 218-220	180-182, 184-188, 190, 191, 193-200, 206, 210, 212, 213, 217	215	207-209, 211, 216	214	
Grass pea	181, 182, 184, 193, 204, 219	all other sites				
Common vetch	218-220	180-200, 204-206, 208-213, 217	207	215, 216		214
Bitter vetch	183, 184, 188, 197	180-182, 185-187, 189-196, 198-200, 205	219	204, 206-213, 215-18, 220		214
Broad bean	218-220	180-200, 204-206, 208-213, 217	207	215, 216		214
Flax	181, 182	180, 183-200, 205	206, 212, 216, 219	204, 207-211, 213, 215, 217, 218, 220	214	

Table 8.15: Average Middle/Late Neolithic winter temperatures for sites along the coast and the distribution of crops.

Coastal (sites 180-200, 204-220)	Average summer temperature (S_temp.) is within the optimum growing temperature range		S_temp. < optimum growing temperature range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	207, 214				180-200, 204, 205, 208, 209, 212, 215-220	206, 210, 211, 213
Wheat	204, 206, 207, 214-216				180-200, 205, 208, 209, 211, 212, 217-220	210, 213
Lentil	180-184, 188, 190, 192, 193, 195, 197, 204, 212, 215, 218-220	185-187, 189, 191, 194, 196, 198-200, 205-211, 213, 214, 216, 217				
Pea	183, 204, 205, 214, 215, 218-220	181, 182, 206-209, 211, 216, 217			189, 192	180, 184-188, 190, 191, 193-200, 210, 212, 213
Grass pea	181, 182, 184, 193, 204, 219	all other sites				
Common vetch	207	204, 214-216			218-220	180-200, 205, 206, 208-213, 217
Bitter vetch		204, 207, 214-216			183, 184, 188, 197, 219	all other sites
Broad bean	192, 196, 195, 204, 207, 219	all other sites		214		
Flax	181, 182, 206, 216, 219	183, 204, 205, 207-209, 211, 215, 217, 218, 220	214		212	185, 187

Table 8.16: Average Middle/Late Neolithic summer temperatures for sites along the coast and the distribution of crops.

Coastal sites in Croatia and southern Italy had average winter temperatures that did not fall below the germination threshold of the crops listed. In fact, the minimum value of the optimum growing temperature range for pea and grass pea (10ºC) was reached at site 180 in Dalmatia and at all of the sites in southern Italy. Average winter temperatures in central and northern Italy were not high enough for germination but not too low to kill seedlings. Only at Vela in Trento (site 214) were temperatures too cold for the survival of seedlings. None of the average winter temperatures fell below the Tkill_rest values, i.e. germinules could have potentially survived dormant in the soil. The summer average temperatures rose above the optimum range for barley and wheat at all but a few sites in northern Italy. They never rose above the optimum range for lentil and grass pea. Temperatures within the optimum range for pea were seen at three sites in Dalmatia and at sites in northern Italy. Only sites in northern Italy had average summer temperatures cool enough to be within the optimum range for common and bitter vetch. Broad bean could have grown within its preferred temperature range at all sites but one: Vela in Trento in northern Italy where the average temperature was too cold. It was also too cold for flax. Three sites had summer average temperatures above the optimum range for flax, including Maserà in northern Italy (site 212).

Conti-nental (sites 71-82, 95-105, 175-179)	Average winter temp. (W_temp) > minimum germination & early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.		W_temp. < minimum tolerated temp. during rest prior to germination	
	Crop	No crop	Crop	No crop	Crop	No crop	Crop	No crop
Barley	96		72-79, 82, 98, 101, 102, 104, 105	80, 81, 99, 100, 103	71, 97, 175-178	95, 179		
Wheat			72-80, 82, 96, 98-105	81	71, 97, 175-179	95		
Lentil			all other sites	74, 76, 79-82, 95, 100, 101, 103, 179				
Pea			72, 73, 75, 82, 96, 98, 104, 105	74, 76-81, 99-103	71, 176, 178	175, 177, 179	95, 97	
Grass pea			?71, 74, 96, 97, 100, 104?	?other sites?	?71, 74, 96, 97, 100, 104?	?other sites?	?71, 74, 96, 97, 100, 104?	?other sites?
Common vetch				all other sites		71, 95, 97, 175-179		
Bitter vetch			96, 98, 104	72-82, 99-103, 105	71, 97, 177, 178	95, 175, 176, 179		
Broad bean				?all sites?		?all sites?		
Flax			73, 75, 76, 80, 98, 104	72, 74, 77-79, 81, 82, 96, 99-103, 105	71, 97	95, 175-179		

Table 8.17: Average Middle/Late Neolithic winter temperatures in the Continental zone and the distribution of crops.

Only barley could have germinated during the winter in the Continental zone. The crops could have survived the winter as seedlings at most of the sites. Eight sites had particularly low average temperatures which would not have enabled the survival of seedlings: Jagnilo in BiH (71), Valač (95) and Pločnik (97) in Serbia and five sites in Romania (sites 175-179). The Continental zone of the Middle/Late phase is the only area to contain sites where winter temperatures fell below the minimum viable temperature for any crop. Sites 95 and 97 also had particularly low summer average temperatures which fell below the optimum growing range of all the crops other than for the peas and vetches. Crops at other Continental sites would have mostly grown within their optimum ranges. The optimum temperature growing range for barley was the only one to have been surpassed at a majority of sites.

Continental (sites 71-82, 95-105, 175-179)	Average summer temperature (S_temp.) is within the optimum growing temperature range		S_temp. < optimum growing temperature range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	71-77, 101, 102, 175		97	95	78, 79, 82, 96, 98, 104, 105, 176-178	80, 81, 99, 100, 103, 179
Wheat	all other sites	81	97	95	177, 179	
Lentil	all other sites	74, 76, 79-82, 100, 101, 103, 179	97	95		
Pea	71-73, 75, 82, 95-98, 104, 105, 176, 178	all other sites				
Grass pea	71, 74, 96, 97, 100, 104	all other sites				
Common vetch		all other sites				177, 179
Bitter vetch	71, 96-98, 104	all other sites			177	179
Broad bean		all other sites		71, 95, 97		
Flax	71, 73, 76, 80, 82, 98, 104	72, 74, 75, 77-79, 81, 96, 99-103, 105, 175-179	97	95		

Table 8.18: Average Middle/Late Neolithic summer temperatures in the Continental zone and the distribution of crops.

Pannonian (sites 83-91, 106-140, 174)	Average winter temperature (W_temp) > minimum germination and early growth temp.		Min. germination temp. > W_temp > min. early growth temp.		W_temp. < minimum germination and early growth temp.	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley	86, 87, 106, 107, 108	85, 109	83, 84, 90, 110, 113, 116, 117, 120, 125, 126, 127, 174	88, 89, 91, 111, 112, 114, 118, 119, 121, 128	115, 122-124, 129, 131-138, 140	130, 139
Wheat			83-88, 90, 91, 106-110, 113, 116-118, 120, 125, 127, 128, 174	89, 111, 112, 114, 119, 121, 126,	115, 129, 131-138, 140	122-124, 130, 139
Lentil			83, 84, 87, 88, 90, 106-109, 112, 120, 125, 127, 129, 132, 133, 135, 138, 174	all other sites		
Pea			83, 84, 87, 90, 106, 107, 127, 174	85, 86, 88, 89, 91, 108, 109, 110-114, 116-121, 125, 126, 128	115, 130, 131, 133, 135, 138	122-124, 129, 132, 134, 136, 137, 139, 140
Grass pea			?87, 91, 117, 127, 128?	?other sites?	?87, 91, 117, 127, 128?	?other sites?
Common vetch			90	83-89, 91, 106-131, 174	133	132, 134-140
Bitter vetch			84, 90, 106, 130, 174	83, 85-89, 91, 107-129, 131		132-140
Broad bean			?90, 117, 174?	?other sites?	?90, 117, 174?	?other sites?
Flax			84, 87, 106-108, 127, 174	83, 85, 86, 88-91, 109-126, 128-131	138	132-137, 139, 140

Table 8.19: Average Middle/Late Neolithic winter temperatures in the Pannonian zone and the distribution of crops.

Barley is the only crop that could have germinated during the winter in the Pannonian zone. The crops could have survived as seedlings at *c*.64% of sites. If lentil was able to germinate before the onset of the coldest months, it could have survived at all the sites. None of the average temperatures fell below the minimum viable temperature for any of the crops. Unlike in the Continental zone, none of the summer average temperatures fell below the optimum growing ranges (Table 8.20). The latter were surpassed at about a third of sites for wheat, most sites for the vetches and all sites for barley.

Pannonian (sites 83-91, 106-140, 174)	Average summer temperature (S_temp.) is within the optimum growing temperature range		S_temp. < optimum growing temperature range		S_temp. > optimum growing temperature range	
	Crop	No crop	Crop	No crop	Crop	No crop
Barley					all other sites	85, 88, 89, 91, 109, 111, 112, 114, 118, 119, 121, 128, 130, 139
Wheat	83, 84, 88, 91, 106, 110, 113, 115, 116, 120, 132-138, 140	89, 111, 112, 114, 119, 122-124, 139			85-87, 90, 107-109, 117, 118, 125, 127-129, 131, 174	121, 126, 130,
Lentil	83, 84, 87, 88, 90, 106-109, 112, 120, 125, 127, 129, 132, 133, 135, 138, 174	all other sites				
Pea	83, 84, 87, 90, 106, 107, 115, 127, 135, 130, 131, 133, 138, 174	all other sites				
Grass pea	87, 91, 117, 127, 128	all other sites				
Common vetch		83, 84, 88, 89, 115, 123, 124, 134			90, 133	all other sites
Bitter vetch	84	83, 88, 89, 115, 123, 124, 134			90, 106, 130, 174	all other sites
Broad bean	90, 117, 174	all other sites				
Flax	84, 87, 106-108, 127, 138, 174	all other sites				

Table 8.20: Average Middle/Late Neolithic summer temperatures in the Pannonian zone and the distribution of crops.

In summary, average summer and winter temperatures during the Early Neolithic suggest that along the coast autumn-sown crops would have faired better. Inland crops could have been sown during the autumn if they were able to vernalize during the colder winter months. Only at sites 20-24 and 32 would crops not have been able to grow at all during the winter months. Average temperatures were lower at around 7000BP and growing crops over the winter appears to have become more difficult, particularly in the north of the Po Plain and in the Continental zone. At the height of summer many sites experienced average temperatures above the optimum range for barley, wheat, pea and vetches, although these never reached critical values.

These results lead to two main expectations:

1. that autumn-sowing was possible and preferential along the coast during the whole of the Neolithic;
2. that the majority of Continental and Pannonian sites would have struggled to grow crops over the winter if these could not vernalize, particularly during the Middle/Late phase. Responses may have been to abandon more sensitive crops, adopt spring-sowing for the more sensitive crops and/or diversify food resources (increased consumption of animal products and/or wild plants);

Compared to Greece and Bulgaria, grass pea and bitter vetch were far less common in the research area, and would apparently have been harder to cultivate inland, but not along the coast, suggesting that their absence was not (only) due to climatic conditions. Their frequencies increase during the colder Middle/Late phase (section 8.2.2.5), which may indicate that inland pulses were sown in the spring. Comparisons with results from the ecological study of weeds are introduced in the final summary of this chapter.

8.3 Edible Fruits and Nuts

The ubiquity of all seeds, nut-shells and fruit stones of edible fruits and nuts is presented in this section (note that the y-axes vary). Latin binomials of the taxa and groups of taxa (e.g. berries) can be found in Table 6.4.

8.3.1 The Early Neolithic

A total of 25 edible taxa were recorded. These were grouped into 14 nuts and fruits or types of fruits.

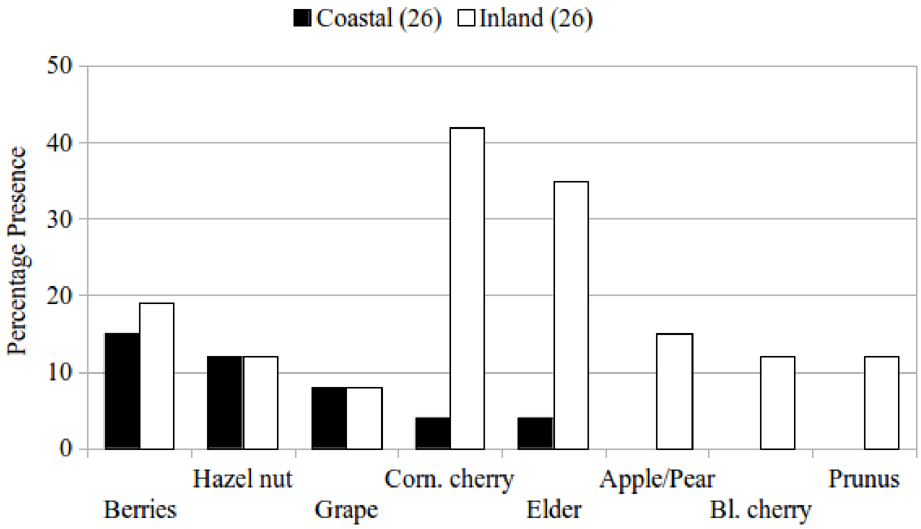


Figure 8.22: Percentage presence (ubiquity) of Early Neolithic sites with wild edible fruits and nuts from within the two catchment areas. Only taxa that occurred in >5% of sites are shown. Berries include *Rubus* sp. and *F. vesca*.

The graph suggests that a greater range of wild plants were eaten inland than along the coast, and that most taxa were more frequently found inland. Cornelian cherry and elder were present in 42% (n=11) to 35% (n=9) of inland sites respectively, whereas they were only recovered from one site along the coast. Whilst these species may not have grown as prolifically along the coast, there are no common coastal species frequently recovered from Adriatic sites. Seeds of *Rubus* berries and wild strawberry were the most frequent representations of wild fruits on coastal sites.

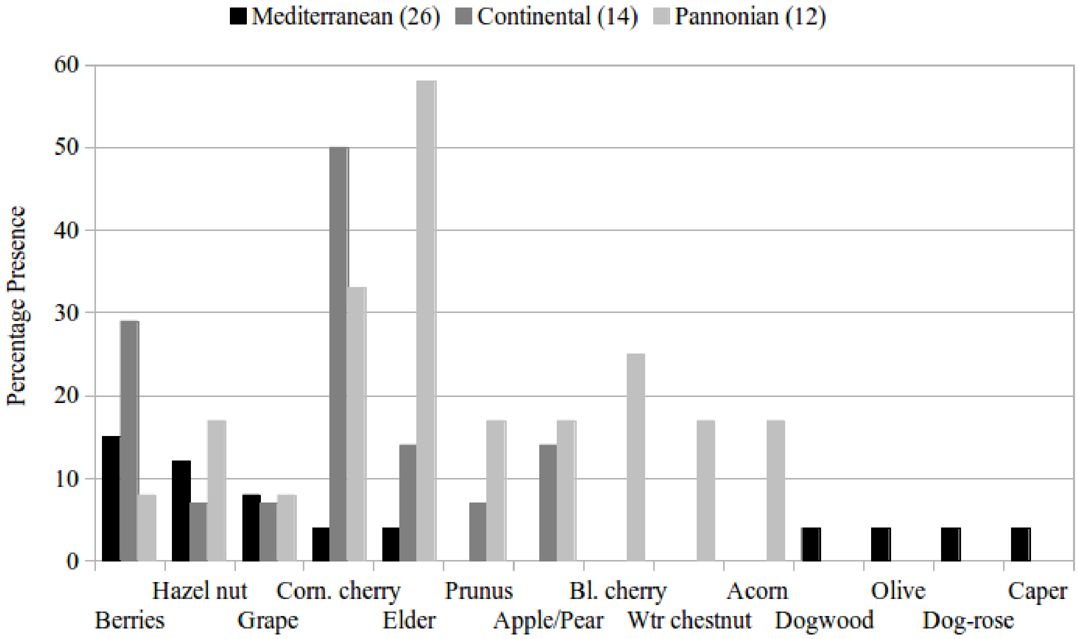


Figure 8.23: Percentage presence (ubiquity) of Early Neolithic sites with wild edible fruits and nuts from within the three bioregions.

Splitting the signal by bioregion reveals that the greatest diversity in wild edible taxa was in the Pannonian region. The three areas have five taxa in common, whilst the inland zones share an additional two: *Prunus* and apple/pear. Four taxa are unique to the coast but were only found at single sites and mostly in unknown quantities. Cornelian cherry was the most commonly gathered wild plant in the Continental zone, followed by berries, elder and apple/pear. The most ubiquitous taxa in Pannonia were cornelian cherry and elder, which has been found more frequently than all the pulses and free-threshing wheat. The 76 acorns found at Foeni-Salaş in Romania (site 35), and the "finger-thick layer of hazelnut shells" (Gyulai 2007: 131) from Méhtelek–Nádas in Hungary (site 20) represent the largest known concentrations of gathered edible plants in the research area. Table 8.21 summarises the results and shows that Pannonia had the greatest range and representation of taxa. Five of the ten Pannonian taxa were found in 17% (n=2) of sites, whereas single occurrences were more common in the other two zones. The smallest range of taxa was found in the Continental zone, where cornelian cherry has the same ubiquity score as free-threshing wheat.

Total taxa = 14	**Coast (26)**	**Con (14)**	**Pann (12)**
Total taxa	9	7	10
Found only once	67%	43%	20%
Taxa in ≥50% sites	0	1: *C.mas*	1: *Sambucus* spp.
mode of % by site	4%	7%	17%

Table 8.21: Summary of the finds of wild edible fruits and nuts in the Coastal, Continental and Pannonian bioregions.

Figure 8.24 illustrates the ubiquity scores for all the known edible fruits and nuts from Greece and Bulgaria. Caper is absent but an additional four plant types are recorded: almond, *Pistacia*, fig and pomegranate. Bulgaria had 14 taxa, 29% (n=4) of which were only found once. Greece had 12 taxa and 25% (n=3) were only found once. Much like the comparison between the inland and coastal zones of the western Balkans, Bulgaria had a greater range and an overall higher frequency of wild plant foods than Greece. The three taxa restricted to the Adriatic (excluding caper) are found in either Bulgaria or Greece: dogwood and dog-rose were present in Bulgaria whereas olive has only been found in Greece. The five taxa unique to the inland study area are mostly restricted to Bulgaria; only *Prunus* and acorn are recorded from both countries. Cornelian cherry has the highest ubiquity score in both Bulgaria and the inland zone of the western Balkans. In Greece the most frequent taxa were acorn, *Pistacia* and fig, none of which have been found on Adriatic sites.

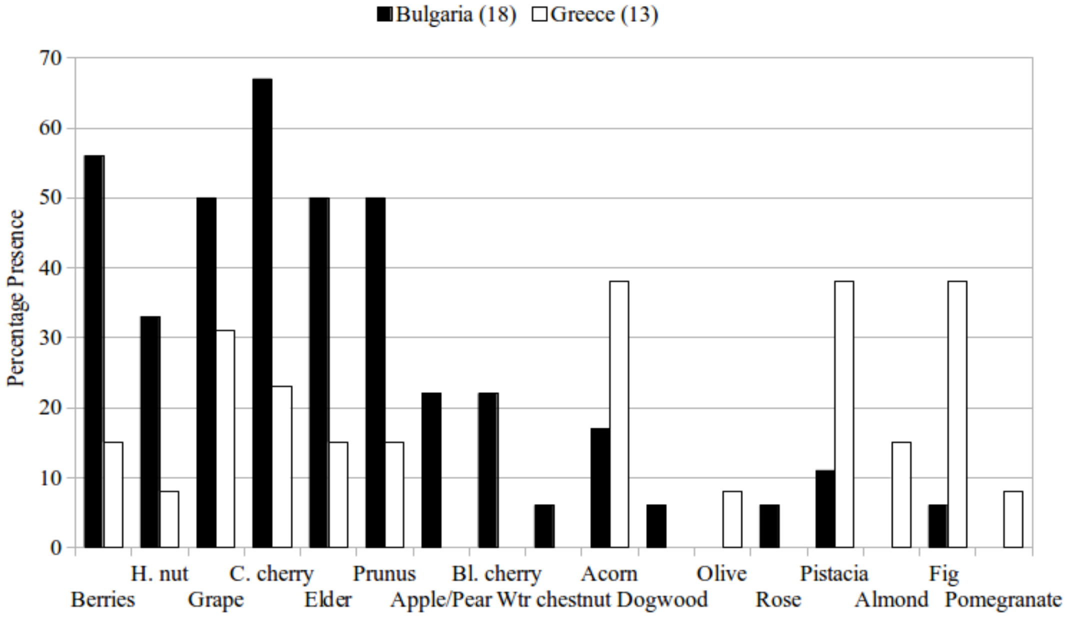


Figure 8.24: Percentage presence (ubiquity) of Early Neolithic sites with edible fruits and nuts from Greece and Bulgaria.

8.3.2 The Middle/Late Neolithic

A total of 32 edible taxa were recorded, seven more than in the Early Neolithic. These were grouped into 20 nuts and fruits or types of fruits.

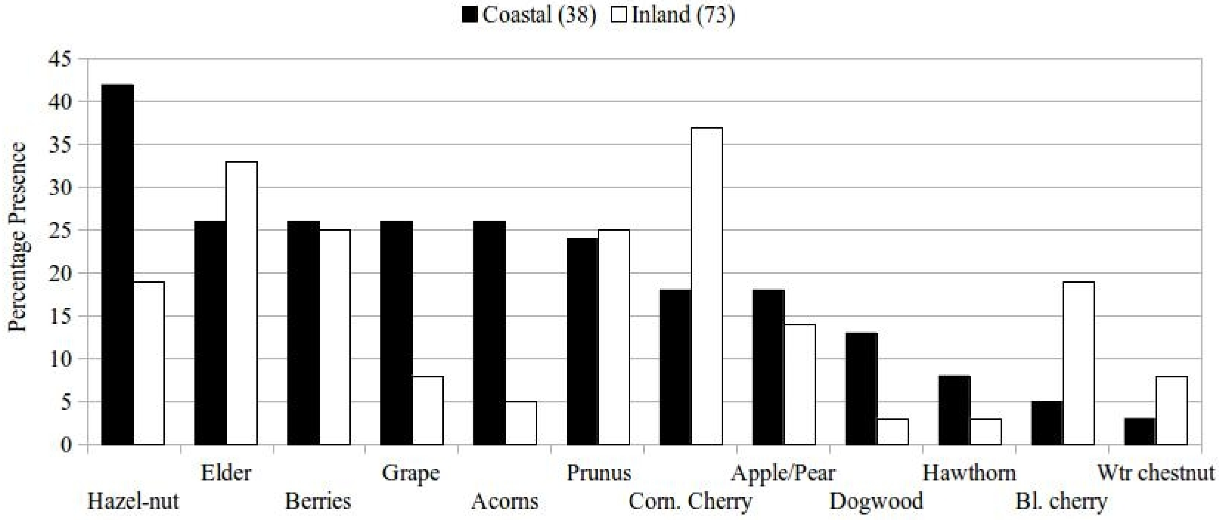


Figure 8.25: Percentage presence (ubiquity) of Middle/Late Neolithic sites with wild edible fruits and nuts from within the two catchment areas. Only taxa that occurred in >5% of sites are shown.

The more frequent taxa were used in both catchment areas. Contrary to the Early Neolithic, frequency scores for most of the taxa are now higher in coastal zones than inland. Only elder, cornelian cherry, bladder cherry and water-chestnut were more frequent inland. Berries and *Prunus* occurred at similar frequencies in both areas.

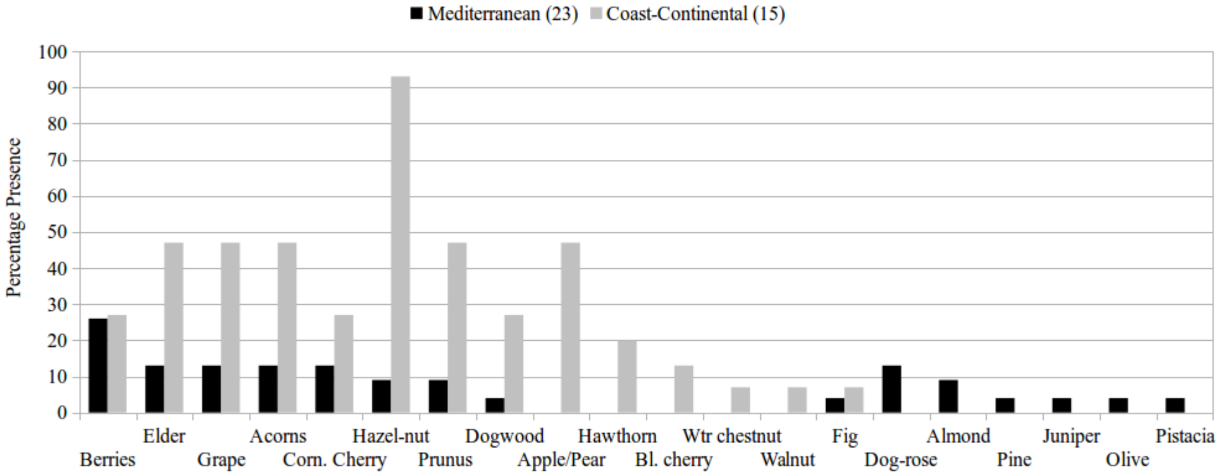


Figure 8.26: Percentage presence (ubiquity) of Middle/Late Neolithic sites with wild edible fruits and nuts from within the two bioregions of the Adriatic (Coast-Continental represents northern Italy).

When the Adriatic record is divided into bioregions it becomes clear that only nine taxa were found in both areas, and that, apart from berries, frequencies only rose above 15% in northern Italy. Fourteen taxa are recorded for northern Italy, and 15 taxa were found in southern Italy and Dalmatia. However, five of the latter were only found at single sites (fig, pine, juniper, olive and *Pistacia*). Three taxa in northern Italy were present at single sites (water-chestnut, walnut and fig).

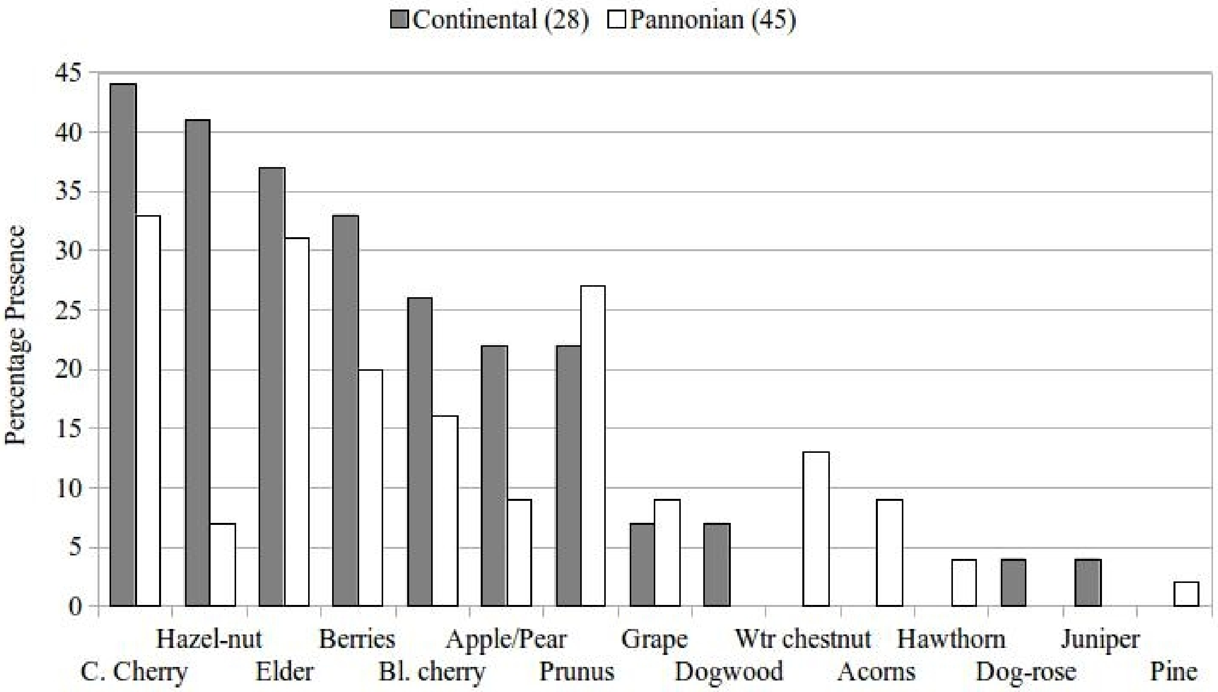


Figure 8.27: Percentage presence (ubiquity) of Middle/Late Neolithic sites with wild edible fruits and nuts from within the two inland bioregions.

When the inland zone is divided into its two main bioregions it becomes clear that the number of taxa is very similar between the two areas: 11 in the continent and 12 in Pannonia. However, 75% (n=6) of the taxa found in both areas were more frequent on Continental sites. The biggest difference is in the ubiquity of hazelnut, which was found in 11 Continental but only three pannonian sites. Only *Prunus* and grape were more common in Pannonia.

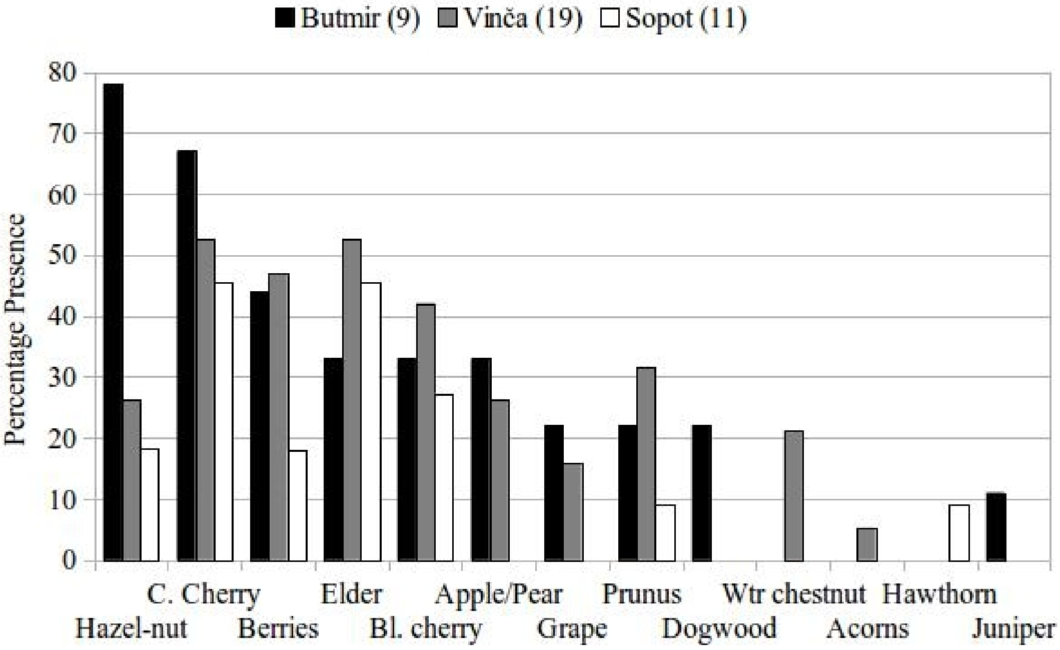


Figure 8.28: Percentage presence (ubiquity) of Middle/Late Neolithic sites with wild edible fruits and nuts from within the three inland cultural groups of the western Balkans.

Six taxa were common to the three inland cultural groups of the western Balkans. Hazelnut and cornelian cherry were most frequently used by the Butmir groups, whilst the Vinča and Sopot groups present higher frequencies of elder and cornelian cherry. The Sopot group used the narrowest range of fruits and nuts (n=7), whilst the Butmir and Vinča groups both used 10 taxa.

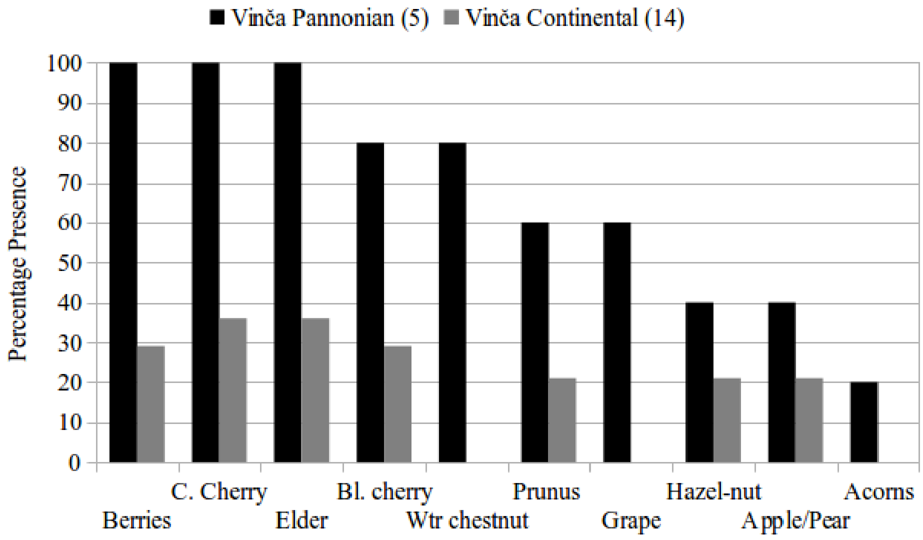


Figure 8.29: Percentage presence (ubiquity) of Middle/Late Neolithic sites with wild edible fruits and nuts from within the two bioregions of the Vinča distribution.

Differences can be seen in the presence and relative frequencies of fruits and nuts between Vinča sites of different ecological zones. Seven taxa were found from Continental sites whereas the Pannonian ones contained ten. Cornelian cherry and elder were the most common taxa in the continent. In Pannonia those two taxa were as common as berries.

8.3.3 Diversity between the Early and Middle/Late Neolithic

The ubiquity scores of the edible fruits and nuts from coastal and inland sites are plotted by Neolithic phase in Figures 8.28 and 8.29.

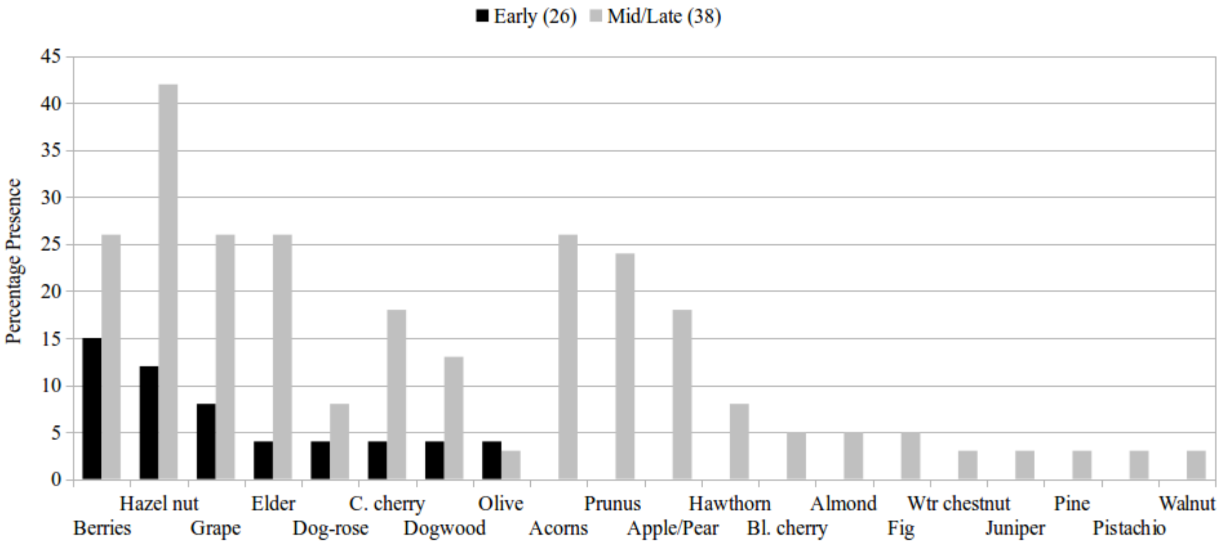


Figure 8.30: Percentage presence (ubiquity) of the Early and Middle/Late Neolithic sites with wild edible fruits and nuts from coastal sites.

The range and frequency of gathered fruits and nuts vastly increased from the Early to the Middle/Late Neolithic. The Middle/Late signature is mostly representative of northern Italy where a wider range of fruits and nuts were commonly used. In southern Italy and Dalmatia the range increased by seven taxa and those that were already used during the Early phase also increased in frequency. The exception to this trend is hazelnut which was found on 12% (n=3) of Early sites 9% (n=2) of later sites. Berries remained the most common type of fruit throughout both phases in southern Italy and Dalmatia.

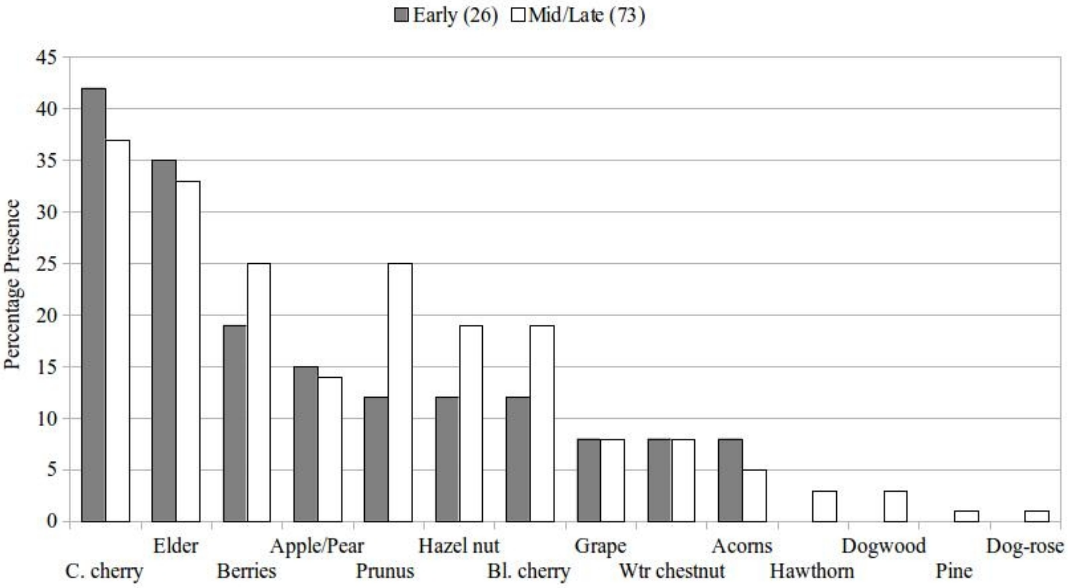


Figure 8.31: Percentage presence (ubiquity) of the Early and Middle/Late Neolithic sites with wild edible fruits and nuts from inland sites.

The range of gathered fruits and nuts also increased inland, though not as dramatically as along the coast. Four additional taxa were found during the Middle/Late phase but none were very common, occurring at only one or two sites. Of the ten taxa found within both phases, only four increased in frequency, and three became less common as the Neolithic developed. *Prunus*, hazelnut and bladder cherry appear to have became more important than apple/pear during the Middle/Late phase.

8.4 Potential Arable Weeds

In order to describe past husbandry regimes ecological and biological attributes were obtained for all the possible weed species (hereafter weeds). The following are excluded from the assemblages as they are unlikely to have grown in arable fields: the aquatic *Utricularia vulgaris* (seed from site 1), *Abies alba* (needles from sites 71 and 75), *Alnus glutinosa* (seeds from site 75) and *Phragmites* spp. (culms from sites 97, 104, 106, 133). The full lists of weed taxa by phase are presented in Tables 8.22 and 8.28, along with their percentage presence by site. Differences in the datasets available from each area are described (Tables 8.23 & 8.27) so as to illustrate some of the difficulties encountered during the analyses and interpretation of the data. Ecological and biological attributes were sought for taxa identified to species, and it is these that are used to describe past husbandry regimes.

8.4.1 The Early Neolithic

One-hundred and three possible weed taxa were recorded from the Early Neolithic sites (Table 8.22). Forty-seven were identified to species and four to one of two species: *Bromus sterilis/tectorum*, *Carex vulpina/muricata*, *Scirpus maritimus/lacustris* and *Setaria viridis/verticillata.* Sixty-three percent of sites with charred plant macro-remains contained records of weed seeds. Table 8.23 summarises the distribution of weed seeds across the research area, and illustrates not only how rare finds of wild/weed taxa are from Early Neolithic sites, but also how seldom they are identified to species.

Table 8.22: Early Neolithic 'weed' taxa	**Life span**	**Ubiquity scores of taxa by site**				
		All (33 sites)	**Coast** (15 sites)	**Inland** (18 sites)	**Con.** (8 sites)	**Pann.** (10 sites)
Agrostemma spp.		3%	7%			
Agrostemma githago	an/bi	3%		**6%**		**10%**
Ajuga spp.		3%	7%			
Astragalus spp.	per	3%		6%		10%
Avena fatua	an	3%		**6%**		**10%**
Avena / Hordeum	an	3%	7%			
Avena spp.	an	18%	20%	17%	25%	10%
Brassica / Sinapis spp.		6%		11%	13%	10%
Bromus arvensis	an	6%		**11%**		**20%**
Bromus hordeaceus	an	6%		**11%**	13%	10%
Bromus secalinus	an	6%		**11%**		**20%**

Table 8.22 continued		**Ubiquity scores of taxa by site**				
	Life span	**All** (33 sites)	**Coast** (15 sites)	**Inland** (18 sites)	**Con.** (8 sites)	**Pann.** (10 sites)
Bromus sterilis / tectorum	an	3%		**6%**		**10%**
Buglossoides arvensis	an	6%	7%	6%	13%	
Calamintha nepeta	per	3%		**6%**		**10%**
Carex elata	per	3%		**6%**		**10%**
Carex vulpina / muricata	per	3%		**6%**		**10%**
Caryophyllaceae indeterminate		6%	7%	6%		10%
Chenopodium album	an	36%	33%	39%	50%	30%
Chenopodium hybridum	an	6%		**11%**		**20%**
Chenopodiaceae indeterminate	an	9%	7%	11%	13%	10%
Chenopodium spp.	an	21%	13%	28%	38%	20%
Compositeae indeterminate		3%		6%		10%
Cruciferae indeterminate		3%		6%		10%
Cyperaceae indeterminate		15%	13%	17%	13%	20%
Cyperus spp.	per	3%	7%			
Dianthus spp.	per	3%	7%			
Digitaria spp.	an	3%		6%		10%
Echinochloa crus-galli	an	6%		**11%**	13%	10%
Eleocharis palustris	per	3%		**6%**		**10%**
Euphorbia cyparissias	per	3%		**6%**		**10%**
Euphorbia helioscopia	an	9%	**20%**			
Euphorbia palustris	per	3%	**7%**			
Euphorbia spp.		6%	13%			
Fumaria spp.	an	9%	20%			
Galeopsis ladanum	an	3%		**6%**		**10%**
Galium aparine	an	12%	7%	17%		30%
Galium spp.		18%	7%	28%	25%	30%
Galium spurium	an	9%		**17%**		**30%**
Heliotropium europaeum	an	3%	**7%**			
Heliotropium spp.		3%	7%			
Hyoscyamus niger	an/bi	6%	7%	6%	13%	
Hypericum spp.	per	3%	7%			
Lathyrus spp.		3%	7%			
Fabaceae indeterminate		21%	47%			
Large Fabaceae		12%	7%	17%	13%	20%
Small Fabaceae		21%	20%	22%	13%	30%
Liliaceae indeterminate		3%	7%			
Lolium cf. *rigidum*	an/bi	3%	**7%**			
Lolium spp.		15%	13%	17%	25%	10%
Lolium temulentum	an	3%		**6%**		**10%**
Malva sylvestris	bi/per	3%	**7%**			
Medicago spp.		12%	20%	6%		10%
Melilotus spp.		3%	7%			
Moraceae indeterminate		3%	7%			
Myosotis arvensis	an	3%		**6%**		**10%**
Odontites / Euphrasia spp.		3%		6%		10%
Ornithogalum pyramidale	per	3%		**6%**		**10%**
Panicum spp.		3%	7%			
Papaver spp.		9%	7%	11%	13%	10%
Plantago spp.		3%	7%			

Table 8.22 continued	**Life span**	**Ubiquity scores of taxa by site**				
		All (33 sites)	**Coast** (15 sites)	**Inland** (18 sites)	**Con.** (8 sites)	**Pann.** (10 sites)
Poaceae indeterminate		36%	20%	50%	25%	70%
Polygonum aviculare	an	6%	7%	6%	13%	
Polygonum convolvulus	an	21%		**39%**	50%	30%
Polygonaceae / Cyperaceae		3%	7%			
Polygonum dumetorum	an	3%		**6%**		**10%**
Polygonum lapathifolium	an	3%		**6%**		**10%**
Polygonum persicaria	an	3%		**6%**		**10%**
Polygonum / Rumex spp.		3%		6%		10%
Polygonum spp.		39%	40%	39%	50%	30%
Portulaca oleracea	an	3%	**7%**			
Prunella vulgaris	per	3%		**6%**		**10%**
Ranunculus repens	per	3%		**6%**		**10%**
Reseda spp.		3%	7%			
Rubiaceae indeterminate		3%		6%		10%
Rumex sp.	per	6%		11%	13%	10%
Sanguisorba officinalis	per	3%		**6%**		**10%**
Saponaria officinalis	per	3%		**6%**		**10%**
Scirpus maritimus / lacustris	per	3%		**6%**		**10%**
Indeterminate seed		33%	20%	44%	38%	50%
Setaria spp.		6%		11%	13%	10%
Setaria viridis / verticillata	an	9%		**17%**	13%	20%
cf. *Sherardia arvensis*	an	3%		**6%**		**10%**
Silene alba	an/per	3%	**7%**			
Silene spp.		15%	7%	22%	25%	20%
Solanaceae indeterminate		9%		17%	25%	10%
Solanum nigrum	an	15%		**28%**	25%	30%
Sonchus asper	an	3%		**6%**		**10%**
Stachys annua	an/per	3%		**6%**		**10%**
Stellaria media	an	3%	**7%**			
Stellaria spp.		3%		6%		10%
Teucrium chamaedrys	per	3%		**6%**		**10%**
Teucrium spp.		6%	7%	6%	13%	
Thalictrum minus	per	3%		**6%**		**10%**
Trifolium arvense	an/bi	3%		**6%**		**10%**
Trifolium spp.		3%		6%		10%
Urtica spp.		3%	7%			
Valerianella spp.	an	3%	7%			
Veronica hederifolia	an	6%	7%	6%		10%
Vicia hirsuta	an	3%		**6%**		**10%**
Vicia spp.		21%	47%			
Viola spp.		3%	7%			
Total taxa		**103**	**53**	**73**	**28**	**69**
Minimum Taxa			**36**	**54**	**19**	**53**

Table 8.22: Early Neolithic 'weed' taxa and their ubiquity scores within the analysed area. Shaded taxa highlight genus common to all areas. Bold numbers highlight species unique to an area.

	Imp. W	**SKC**	**SKC Con.**	**SKC Pann.**
Sites with charred plant remains	26	26	14	12
Sites with weed seeds	15	18	8	10
% of total sites	58%	69%	57%	83%
Total recorded weed taxa	53	73	28	69
% of taxa found in >1 site	30%	40%	43%	28%
Minimum number of taxa	36	54	19	53
№ taxa identified to species	14	43	9	40
% taxa identified to species	26%	59%	32%	58%
Highest occurring frequency*	33%	39%	50%	30%
№ species at that frequency	1	2	2	5
№ species unique to area	8	36	0	32

Table 8.23: Distribution, identification and seed sizes of the 'weed' taxa across the research areas; * of taxa identified to species.

The Adriatic assemblage had one of the lowest percentages of sites with weed taxa, of which only 26% (n=14) were identified to species. Some species identified from the inland region may have been present along the coast where they have not been identified beyond genus level. For example, *Agrostemma githago, Bromus arvensis, B. hordeaceus* and *B. secalinus* were found inland whereas the coast only has records of *Agrostemma* sp. and *Bromus* sp. This discrepancy is also evident between the Continental and Pannonian regions: only 32% (n=9) of Continental taxa were identified to species compared to 58% (n=40) of taxa from Pannonia. Nine genera were common to all areas (shaded in grey in Table 8.23). The only species found across all three bioregions was *Chenopodium album*. The majority of species were quite rare; about two thirds of taxa from all three bioregions were recorded from single sites. Nine Continental species were also found in Pannonia, and four were found along the coast. Fifty-seven percent (n=8) of coastal species were unique to Adriatic sites. Only three were also found in Pannonia: *C. album, G. aparine* and *Veronica hederifolia*. The Pannonian assemblage has the highest number of species unique to an area (n=32); only eight were also found on the continent and/or the coast. Those shared with Continental sites are *B. hordeaceus, C. album, Echinochloa crus-galli, P. convolvulus, S. nigrum* and *S. viridis/verticillata*.

Tables 8.24 to 8.26 record, by research area, the possible origin, Neolithic distribution and biological and ecological characteristics of the taxa identified to species. The key is presented with Table 8.24 but applies to all three tables.

Coastal weed species Total = 14	% by site (15 sites)	Origin	Habitat	LBK presence		Western Med. presence	Presence in B or G	Additional references
				Phase	Status			
Buglossoides arvensis	7	Eurasia	a				B&G	1, 3, 4
Chenopodium album	33	Eurasia	a, d	LBK I		P	B	1, 2, 3
Euphorbia helioscopia	20	N. Europe	a, d			P		2, 3, 4
Euphorbia palustris	7	Europe	wt					5
Galium aparine	7	Eurasia	all but wt	LBK I	ant	P	B&G	1, 2, 3, 12
Heliotropium europaeum	7	Med	a, d			P	B	3, 6
Hyoscyamus niger	7	Eurasia	d	LBK II-V	ant		B	1, 3
Lolium cf. *rigidum*	7	Med	a, g					7
Malva sylvestris	7	Eurasia	a, d	LBK II-V				1, 2, 3, 8
Polygonum aviculare	7	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3
Portulaca oleracea	7	Asia Minor	a, d				B&G	3, 9
Silene alba	7	Eurasia	a, d, p				B	1, 2, 3
Stellaria media	7	N. Eurasia	a, g, d	LBK I	ant	P		1, 2, 3
Veronica hederifolia	7	Med?	a, d, wd	LBK			B	1, 2, 3

Table 8.24: Characteristics obtained for species identified in the Coastal area. Habitat defines present-day areas where species are usually found: a= arable, d= disturbed, g= grassland, p= pasture, wd= woodland, wt= wetland (floodplain, marches, semi-aquatic). LBK presence and status is taken from Bogaard 2004: Table 4.4; 2011: appendix Table 2, and Kreuz & Schäfer 2011: Table 1. LBK phase refers to the first occurrence of a species. Ant= anthropochore, apo= apophyte, from Kreuz & Schäfer 2011: Table 1. Presence during the Early Neolithic of the western Mediterranean (c.5400-4500 cal. BC.) is taken from Antolín & Jacomet 2015: Table 4, and Antolín *et al*. 2015: Table 6. All remains were found in Spain. No records were found for weed seeds in France. Presence at Early Neolithic sites in Bulgaria (c.6100-5400 cal. BC.) and Greece (c.6200-5800 cal. BC) were taken from references in Table 2.6, Appendix II. Bojňanský & Fargašová 2007 and http://www.tela-botanica.org were consulted for all species. Additional references: 1- Stevens 1996: Tables 4.3-4.34; 2- Grime *et al*. 1989; 3- Hanf 1983; 4-Wilson & King 2003; 5- Wärner *et al*. 2011; 6- Royo-Esnal *et al*. 2010; 7- Hunt *et al*. 2009; 8- Murrumbidgee 2008; 9- Van Assche & Vandelook 2006; 10- Cudney *et al*. 2007; 11- http://www.cabi.org/isc/datasheet/8058; 12- http://www.cabi.org/isc/datasheet/20367; 13- Brennan 2009: 15-17.

All but one of the 14 species from the Mediterranean bioregion grow well in arable and disturbed land. *Euphorbia palustris* prefers wetter, heavier soils of river banks (Wärner *et al*. 2011). Seven of the species were found on LBK sites, and four of these are noted as anthropochores. Four species are known from the first phase of the LBK and two from the later phases. Six species were found in Neolithic settlements in Spain, and nine from settlements in Bulgaria. However, of those nine two have possible Mediterranean origins, four are very common and the rest were also found in Greece.

Table 8.24 Continued		Preferred soil attributes									
	Plant height	Ph	Texture	Fertility	Moisture	Life cycle	Seed bank	Repro-duction	Germ. Season	Sets seed	Flowering
B. arvensis	med	n, al	m	-f	dry, moist	an	3?, 4	seed	a/s	Jun-Aug	4
C. album	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2
E. helioscopia	low	n	l, m	f	moist, damp	an	?3	seed	a	Aug-Oct	3
E. palustris	high	al	h	f	moist, damp	per		seed	a/s	Aug-Oct	1
G. aparine	high, T	n		f	damp	an	2	seed	a+s	Jun-Sept	3
H. europaeum	low	al	m	/	dry	an	?3, 4	seed	s		2
H. niger	high	wa	l	f	moist	an/bi	?3				4
L. cf. rigidum	med	n, al	m, h	f	moist	an/bi	3	seed	a/s	Jun-Oct	4
M. sylvestris	high	n	l, m	f	dry	bi/per	?3	seed	a+s		4
P. aviculare	high	n	l	f	damp	an	4	seed	s	Jul-Nov	3
P. oleracea	low	n, al	l	f	dry	an	4	s/v	s		2
S. alba	med	n, al	l	f	moist, damp	an/per	?3, 4	seed	s/a		1
S. media	low	n	m	f	moist, damp	an	4	seed	a+s	Jun-Sept	3
V. hederifolia	med	al	m, h	f	dry, moist	an	?4	seed	a/s	Jun-Aug	1

Table 8.24 continued. Plant height is the maximum height reached in suitable growing conditions: low=<30cm, medium=30-60cm, high>60cm, T= twining. pH: al= alkaline, n= neutral, wa= weakly acid. Fertility: f= requires fertile soils, -f= thrives in poorer soils, if= indicator of nutrient-poor soils, /= grows in intermediate fertility. Life cycle: an= annual, bi= biennial, per= perennial. Seed bank (Grime *et al*. 1989): 1= transient seed bank, seeds will germinate before the next generation of seeds are produced; 2= seeds can overwinter and germinate in the spring; 3= mostly transient but some will survive in the seed bank; 4= persistent, seeds will remain in the soil for several seasons, even years, before germinating. Reproduction = by seed or vegetatively (v), s/v = mostly by seed, v/s = mostly vegetatively, v+s= both vegetatively and by seed. Germination season: a= autumn, s= spring, a/s= mostly autumn, s/a= mostly spring, a+s= either autumn or spring. Flowering onset and duration (Bogaard *et al*. 2001: Table 3, Chapter 6.3): 1= short flowering, early to intermediate onset; 2= late flowering, short to intermediate duration; 3= long flowering, early to intermediate onset; 4= medium flowering duration, intermediate onset. When information differed between sources the greatest value or range was used. Blank cells represent absent, unknown and/or indeterminate characteristics.

Forty-two percent (n=6) of the coastal species can grow to at least 60cm under favourable conditions. Twenty-nine percent (n=4) do not grow above 30cm. Apart from *Hyoscyamus niger*, the species prefer a neutral to slightly alkaline pH and mostly prefer moist conditions in medium to light soils. Three species are associated with dry soils, and an additional two will also tolerate dry conditions. Only one species, (*B.arvensis*) is more commonly found on soils of low nutrient status, and only one (*Heliotropium europaeum*) is indifferent to fertility levels. Sixty-four percent (n=9) of the species are annuals, although an additional 21% (n=3) may also reproduce as annuals. The two perennials or biennials tend to reproduce by seed like the annuals. Only *E.helioscopia* is known to only germinate in the autumn. Another three species will germinate preferentially in the autumn, and three can germinate in either season, depending on temperature and available water. Twenty-nine percent (n=4) of species are known to only germinate in the spring. The species set seed between June and October. Flowering onset and duration is described below.

Continental weed species. Total = 9	% by site (8 sites)	Origin	Habitat	LBK presence		Western Med. presence	Presence in B or G	Additional references
				Phase	Status			
Bromus hordeaceus	13	Eurasia	a, g, d, p	LBK				1, 2
Buglossoides arvensis	13	Eurasia	a				B&G	1, 3, 4
Chenopodium album	50	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3
Echinochloa crus-galli	13		a, d	LBK I	ant		B	
Hyoscyamus niger	13	Eurasia	d	LBK II-V	ant		B	1, 3
Polygonum aviculare	13	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3
Polygonum convolvulus	50	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3, 4
Setaria viridis/verticillata	13	Eurasia	a, d	LBK I	ant		B	
Solanum nigrum	13	Europe	d	LBK I	ant	P	B	1, 3

Table 8.25: Characteristics obtained for species identified in the Continental bioregion.

The nine species from the Continental bioregion all grow well in arable and disturbed land. All but one are recorded from LBK sites, predominantly dating to the first phase. Seven are noted as anthropochores and there are no apophytes. Four were found in Spain and eight in Bulgaria. Only *Buglossoides arvensis* was also common to Greece.

Table 8.25 Continued	Plant height	Preferred soil attributes				Life cycle	Seed bank	Repro-duction	Germ. Season	Sets seed	Flowering
		Ph	Texture	Fertility	Moisture						
B. hordeaceus	high	n, al	l, m	/	moist	an	3	seed	a	Jun-Aug	1
B. arvensis	med	n, al	m	-f	dry, moist	an	3?, 4	seed	a/s	Jun-Aug	1
C. album	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2
E. crus-galli	high	al	m, h	f	moist, damp	an	1	seed	a/s	Aug-Oct	3
H. niger	high	wa	l	f	moist	an/bi	?3				4
P. aviculare	high	n	l	f	damp	an	4	seed	s	Jul-Nov	3
P. convolvulus	high, T	n	m	/	moist, damp	an	?4	seed	s	Jul-Nov	2
S. viridis/vertici	high	n	m	f	moist	an	2?	seed	s		2
S. nigrum	med	n	l	f	moist	an	?3,?4	seed	s		2

Seventy-eight percent (n=7) of the species can grow to at least 60cm. There were no 'low' species, and one has a twining growth habit. As is seen along the coast, weakly acid soils are indicated by *H. niger*, although all the other species mainly prefer neutral soils. Soils of medium texture (e.g. loams) are best represented, though three species prefer light soils. All species grow well in moist conditions. Apart from *H. niger* which can grow as both an annual and biennial, all species are annuals and reproduce by seed. Only *B. hordeaceus* is known to germinate only in the autumn, whereas 56% (n=5) of species are spring germinators. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

Pannonian weed species. Total = 40	% by site (10 sites)	Origin	Habitat	LBK presence		Western Med. presence	Presence in B or G	Additional references
				Phase	Status			
Agrostemma githago	10	SE Europe	a	LBK			G	1, 3, 4
Avena fatua	10	SE Europe	a	LBK				10
Bromus arvensis	20	Eurasia	a, g, d	LBKII-V	ant		B	4
Bromus hordeaceus	10	Eurasia	a, g, d, p	LBK				1, 2
Bromus secalinus	20	S-C Europe	a	LBK I	ant		G	1, 4
Bromus sterilis/tectorum	10	Eurasia	all but wt	LBKII-V	ant		B	2
Calamintha nepeta	10	S-C Europe	p, g					
Carex elata	10	Europe	wt					
Carex vulpina/muricata	10	Eurasia		LBKII-V*	apo			
Chenopodium album	30	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3
Chenopodium hybridum	20	Eurasia	a, d	LBK I	ant	P	B	3
Echinochloa crus-galli	10		a, d	LBK I	ant		B	11
Eleocharis palustris	10	Eurasia	wt	LBK I				1, 2
Euphorbia cyparissias	10	Europe	a,d					2, 3
Galeopsis ladanum	10	Eurasia	a, d					3
Galium aparine	30	Eurasia	all but wt	LBK I	ant	P	B&G	1, 2, 3, 12
Galium spurium	30	Eurasia	a	LBK I	ant	P	B&G	1, 3, 12
Lolium temulentum	10	Med	a, d				G	4
Myosotis arvensis	10	Eurasia	a	LBK				1, 2, 3
Ornithogalum pyramidale	10	Med	a, d					
Poa annua	10	Eurasia	a, d, g, p	LBK I	ant		B	1, 2, 4
Polygonum convolvulus	30	Eurasia	a, d	LBK I	ant	P	B	1, 2, 3, 4
Polygonum dumetorum	10	Eurasia	wd	LBK I	apo			13
Polygonum lapathifolium	10		a, d, p	LBK I				2, 3
Polygonum persicaria	10	S-C Europe	a	LBK II-V	ant		B	1, 2, 3
Prunella vulgaris	10	Eurasia	d, g, p					1, 2, 3
Ranunculus repens	10	Eurasia	all but wt					1, 2, 3
Sanguisorba officinalis	10	Europe	g					
Saponaria officinalis	10	N. Europe	a, d, wd	LBK				2, 3
Scirpus maritimus/lacustri	10	Eurasia	wt			P		
Setaria viridis/verticillata	20	Eurasia	a, d	LBK I	ant		B	
Sherardia arvensis	10	Europe	a	LBK II-V	ant		B	2, 3, 4
Solanum nigrum	30	Europe	d	LBK I	ant	P	B	1, 3
Sonchus asper	10	Eurasia	a, d					2, 3
Stachys annua	10	Med?	a, d					3
Teucrium chamaedrys	10	Eurasia	a, g, d				B	
Thalictrum minus	10	Eurasia	g, wd					
Trifolium arvense	10	N. Europe	a, g, p, d	LBK I	ant			1, 2, 3
Veronica hederifolia	10	Med?	a, d, wd	LBK			B	1, 2, 3
Vicia hirsuta	10	Eurasia	d, g, p	LBK			B	1, 2, 3

Table 8.26: characteristics obtained for species identified in the Pannonian bioregion.

All but six of the 40 species from the Pannonian bioregion grow well in arable and disturbed land. *Calamintha nepeta*, *Polygonum dumetorum* and *Thalictrum minus* prefer grassland or woodland habitats, and *Carex elata*, *Eleocharis palustris* and *Scirpus maritimus/lacustris* grow on damp to wet soils of seasonally or regularly flooded areas. Sixty-five percent (n=26) of species are known from LBK sites (35%, n=14 in the LBK I), and only two are registered as apophytes (a woodland and a wetland species). Eighteen percent (n=7) were found in Neolithic Spain, though the majority are very common weeds. Apart from the common *Galium* species, 14 have been found in Bulgaria and only three in Greece.

Table 8.26 Continued		Preferred soil attributes									
	Plant height	Ph	Texture	Fertility	Moisture	Life cycle	Seed bank	Repro-duction	Germ. Season	Sets seed	Flowering
A. githago	high	n	m	f	damp	an/bi	1	seed	a/s	Aug-Oct	2
A. fatua	high	n	all	f	moist, damp	an	3	seed	s		2
B. arvensis	high	n	m	f	not wet	an	1	seed	a/s	Jul-Sept	1
B. hordeaceus	high	n, al	l, m	/	moist	an	3	seed	a	Jul-Sept	1
B. secalinus	high	al	m	/	moist	an	1	seed	a	Jul-Sept	1
B. sterilis/tectorum	high	n, al	m	/	moist	an	3	seed	a/s	Jul-Sept	1
C. nepeta	med	n	m	/	moist	per		s/v		Aug-Oct	2
C. elata	high	al	m, h	/	damp, wet	per		v		Jun-Aug	1
C. vulpina/muricata	high				not dry	per		v		Jun-Aug	
C. album	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2
C. hybridum	high	al	m, h	f	moist, damp	an		seed	s	Aug-Oct	2
E. crus-galli	high	al	m, h	f	moist, damp	an	1	seed	a/s	Aug-Oct	3
E. palustris	high	n	m	if	wet	per	3?, 4	v/s		Jun-Aug	1
E. cyparissias	med	n, al	m	-f	dry	per		v			4
G. ladanum	med	al	l	f	dry	an	?4	seed			2
G. aparine	high, T	n	m	f	moist, damp	an	2	seed	a+s	Jun-Aug	3
G. spurium	med, T	n, al	m	f	dry, moist	an		seed	a+s	Jun-Aug	3
L. temulentum	high	n	m	/	moist	an		seed	a/s	Aug-Oct	1
M. arvensis	low	n, al	l, m	/	dry, moist	an	4	seed	a/s	From May	3
O. pyramidale	low	al	m	f	moist	per					1
P. annua	low	n	m	f	damp	an/per	?4	s/v			1
P. convolvulus	high, T	n	m	/	moist, damp	an	?4	seed	s	Jul-Nov	2
P. dumetorum	high, T	n	m	/	moist, damp	an		seed	s		2
P. lapathifolium	high	n, wa	m, h	f	damp	an	4	seed	s		2
P. persicaria	high	wa	l	f	damp	an	4	seed	s		2
P. vulgaris	med	n, al	h	f	moist	per	?3	v/s	s	Aug-Oct	4
R. repens	med	al	h	f	damp	per	?4	v/s		Jun-Aug	4
S. officinalis	high	al	m, h	/	moist, damp	per					2
S. officinalis	high	al	l	f	dry, moist	per		v			2
S. maritimus/lacustris	high	n	h	/	wet	per		v			1
S. viridis/verticillata	high	n	m	f	moist	an	2?	seed	s		2
S. arvensis	med	n, al	m	/	moist	an	2?	seed	a		4
S. nigrum	med	n	l	f	moist	an	?3,?4	seed	s		2
S. asper	high	al	h	f	moist	an	?3	seed	a+s		3
S. annua	low	al	m	/	dry, moist	an/per		seed	s		2
T. chamaedrys	low	al	l	-f	dry, moist	per					4
T. minus	high	al	m	-f	moist	per		v			2
T. arvense	low	n, wa	l, m	-f	dry	an/bi	3	seed	a		4
V. hederifolia	med	al	m, h	f	dry, moist	an	?4	seed	a/s	Jun-Aug	1
V. hirsuta	med, T	n, wa	l, m			an	?4	seed	a/s	Jun-Sept	3

Only 15% (n=6) of the species found in Pannonia do not grow above 30cm, whilst 60% (n=24) will reach at least 60cm under favourable conditions. Five species have twining habits. Only one plant

(*Polygonum persicaria*) is associated with weakly acid soils. Neutral and lightly alkaline soils are represented by the same number of species. Soils of medium texture are mostly represented, although four species prefer heavier soils and five lighter soils. Eighty-five percent (n=34) of species grow well in moist soils, and only three species prefer dry soils. Fifty-eight percent (n=23) of species are annuals, although another 10% (n=4) can also reproduce as annuals. Perennials are represented by *c*.35% (n=14) of species. These mostly reproduce vegetatively. Only 8% (n=3) of species will germinate in the autumn, although an additional 20% (n=8) are more likely to germinate in the autumn than the spring. Those that germinate specifically in the spring make up 28% (n=11) of the assemblage. Apart from *Myosotis arvensis* which flowers and fruits throughout the summer, the species set seed between June and October. Soil fertility and flowering onset and duration are described below.

The relative proportions of life cycles, categories of flowering onset and duration and levels of soil fertility between the three bioregions are compared in Figures 8.30 to 8.32. Unlike the descriptions, the proportions illustrated are based on the minimum number of taxa per group, and not just the taxa identified to species (Chapter 6.3.3 and Table 8.23).

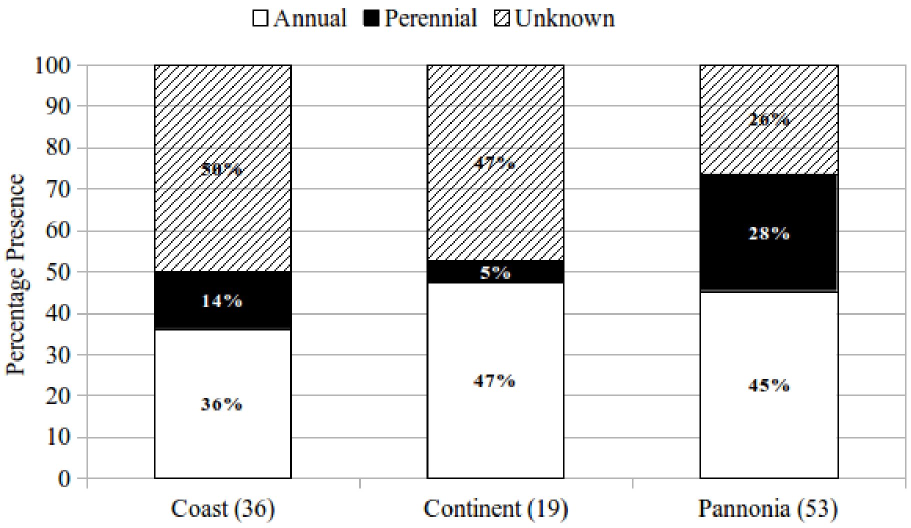


Figure 8.32: Relative proportions of annuals and perennials in the three bioregions. The percentages represent the minimum number of taxa within a bioregion.

The Continental zone had the highest proportion of annuals (47%, n=9) and the lowest proportion of perennials (5%, n=1). Perennials represented 28% (n=15) of taxa from Pannonia, and annuals 45% (n=24). The lowest proportion of annuals was found in the coastal area (36%, n=13), but life cycles are unknown for half of the assemblage.

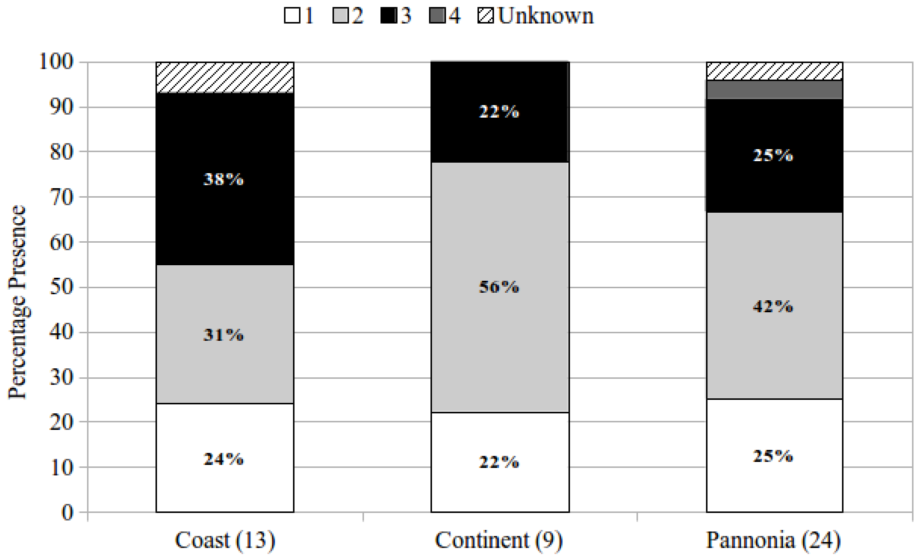


Figure 8.33: Relative proportions of flowering onset and duration categories of annuals in the three bioregions, i.e. the percentage of annuals of a particular flowering category within each region. 1 = short flowering, early to intermediate onset; 2 = late flowering, short to intermediate duration; 3 = long flowering, early to intermediate onset; 4 = medium flowering duration, intermediate onset (Bogaard *et al*. 2001: Table 3).

The figure shows that species in category 1, usually associated with autumn sowing (Chapter 5.4.8), occurred in a quarter or less of all three groups. Plants in category 2, usually associated with spring sowing, represent a third of the coastal assemblage (31%, n=3) and between 56% (n=5) and 42% (n=10) of the Continental and Pannonian groups respectively. Species with long flowering periods are most common in the coastal group where they make up 38% (n=5) of the assemblage. These tend to be at a competitive advantage in spring-sown crops but are also found in autumn-sown crops (Bogaard *et al*. 2001: 1175, 1179). Only one of the four species in that category (*E. helioscopia*) is known to only germinate in the autumn. A single species falls within category 4: *Sherardia arvensis* in Pannonia, which germinates in the autumn.

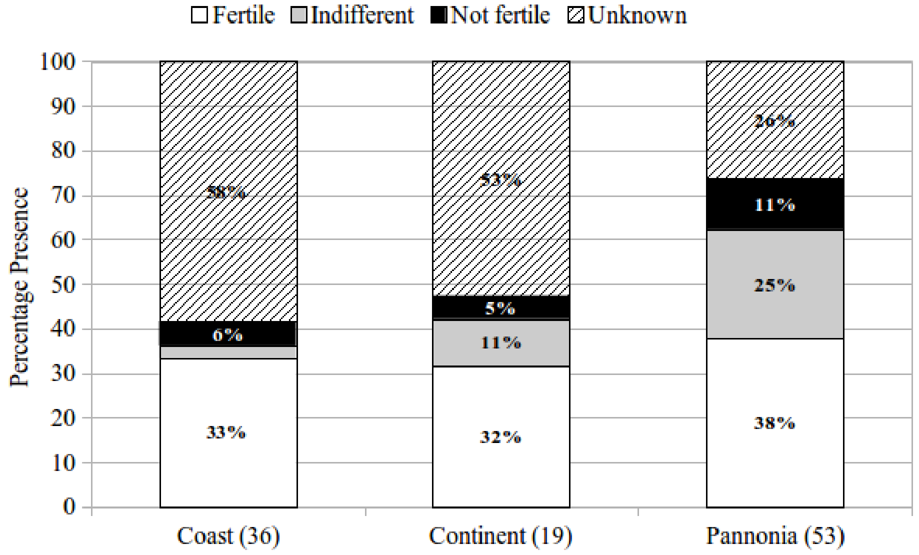


Figure 8.34: Relative proportions of soil fertility levels in the three bioregions. The percentages represent the minimum number of taxa within a bioregion.

Although species requiring nitrogen-rich soils represent up to half or more of the taxa identified to species, the 'unknown' make up a significant portion of the assemblages when taxa not identified to species are included, particularly along the coast. Thirty-three percent (n=12) of species from the coast and 32% (n=6) from the continent are indicative of fertile soils. This figure increases to 38% (n=20) in Pannonia. Plants unaffected by levels of fertility are best represented in Pannonia and would have been at a competitive advantage on lesser fertile soils. Taxa with a preference for poor soils were infrequent. *Eleocharis palustris*, an indicator of infertile soils (Grime *et al*. 1988: 232) is only present in Pannonia.

8.4.2 The Middle/Late Neolithic

Two-hundred and fifty-two possible weed taxa were recorded from Middle/Late Neolithic sites in the research area (Table 8.27). One-hundred and forty-two were identified to species and 11 to one of two or three species. Seventy-seven percent (n=85) of sites with charred plant macro-remains contained records of weed seeds. Table 8.28 summarises the distribution of weed seeds across the research area, and illustrates how variable the number of sites with weed taxa and the number of taxa identified to species are between areas.

	Adriatic Bioregions		**Inland Bioregions**		**Inland – Cultures**			
	Med. (Croatia, S&C Italy)	**Coast-Con.** (N. Italy)	**Con.** (incl. Alpine)	**Pann.**	**Butmir** (Alpine)	**Sopot** (Con. & Pann.)	**Vinča** (Con. & Pann.)	**Hungary** (Pann.)
Sites with charred plant remains	23	15	27	45	9	11	19	31
Sites with weed seeds	20	7	22	36	9	10	14	23
% of total sites	87%	47%	81%	80%	100%	91%	74%	74%
Total recorded weed taxa	56	49	127	183	83	74	128	112
% of taxa found in >1 site	48%	18%	46%	52%	45%	30%	40%	44%
Minimum represented taxa	40	37	94	145	64	56	93	95
№ taxa identified to species	13	29	57	124	45	29	64	91
% taxa identified to species	23%	59%	45%	68%	54%	39%	50%	81%
Highest occurring frequency*	20%	29%	41%	33%	56%	50%	64%	48%
№ species at that frequency	1	3	1	1	1	1	1	1
№ species unique to area	4	8	13	73	7	9	15	44

Table 8.27: Distribution, identification and seed sizes of the weed taxa across the research area; * of taxa identified to species.

Table 8.28: Middle/Late Neolithic 'weed' taxa and their ubiquity scores within the analysed areas. Species unique to an area are presented in bold; shaded genus/species are common to all four bioregions; shaded ubiquity scores are taxa common to the coastal bioregions or the three inland cultural groups.

Table 8.28: Middle/Late Neolithic 'weed' taxa		**Ubiquity scores of taxa by site within defined areas**												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Aethusa cynapium	an	1%		**2%**				**3%**						**4%**
Agrimonia spp.	per	1%		2%				3%			7%		20%	
Agrostemma githago	an/bi	9%	4%	12%		14%		19%		10%	14%		40%	17%
Agrostis spp.		2%		3%				6%		10%	7%		20%	
Ajuga chamaepitys	an	4%	4%	**3%**		14%	5%	3%	11%		7%		20%	
Ajuga reptans	per	2%		**3%**				**6%**		**20%**				
Ajuga spp.	per	1%	4%		5%									
Alchemilla spp.	per	1%		2%			5%		11%					
Alchemilla vulgaris	per	1%		**2%**				**3%**						**4%**
Althaea officinalis	per	1%		**2%**			**5%**		**11%**					
Amaranthus lividus	an	1%		**2%**				**3%**						**4%**
Amaranthus spp.	an	4%		5%			5%	6%	11%		7%		20%	4%
Anagallis arvensis	an	1%		**2%**				**3%**						**4%**
Anagallis spp.	an/bi	1%		2%			5%		11%					
Anemone nemorosa	per	1%		**2%**				**3%**						**4%**
Androsace spp.		1%		2%			5%				7%	11%		
Anchusa spp.	bi/per	1%		2%				3%		10%				
Anthemis arvensis	an	1%		**2%**				**3%**			**7%**		**20%**	
Anthemis cotula	an	1%		**2%**			**5%**		**11%**					
Anthemis spp.		1%		2%			5%		11%					
Aphanes / Alchemilla spp.		2%		3%				6%		10%				4%
Apium graveolens	bi	1%		**2%**				**3%**		**10%**				
Artemisia spp.		1%		2%				3%		10%				
Asperula spp.		1%		2%			5%				7%	11%		
Astragalus cicer	per	1%	**4%**		**5%**									
Astragalus glycyphyllos	per	1%		**2%**				**3%**						**4%**
Atriplex spp.	an	2%		3%				6%		10%	7%		20%	
Atropa bella-donna	per	2%		**3%**			5%	3%	11%		7%		20%	
Atriplex patula/hastata	an	6%	4%	7%		14%	9%	6%	22%					9%
Avena fatua	an	9%		**14%**				**22%**						**35%**
Avena spp.	an	28%	41%	22%	55%		27%	19%	22%	30%	50%	44%	60%	4%
Brassica rapa	an/bi	1%		**2%**				**3%**						**4%**
Brassica nigra	an	1%		**2%**				**3%**			**7%**		**20%**	
Brassica / Sinapis spp.		5%	4%	5%	5%		5%	6%		20%	7%		20%	
Brassica spp.		1%		2%			5%		11%					
Bromus inermis / ramosus	per	1%		**2%**				**3%**						**4%**
Bromus arvensis	an	13%		**19%**			27%	14%	44%		29%	22%	40%	13%
Bromus hordeaceus	an	1%	**4%**			**14%**								

Table 8.28: continued

		Ubiquity scores of taxa by site within defined areas												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Bromus spp.		22%	11%	28%	10%	14%	36%	22%	33%	30%	57%	44%	80%	9%
Bromus secalinus / mollis	an	13%		**19%**			27%	14%	44%		21%	22%	20%	17%
Buglossoides arvensis	an	7%	4%	9%	5%		14%	6%	11%		29%	22%	40%	
Buglossoides spp.		1%	4%		5%									
Camelina sativa	an	1%		**2%**				**3%**						**4%**
Camelina spp.	an	1%		2%				3%			7%		20%	
Campanulaceae indeterminate		1%		2%			5%				7%	11%		
Capsella bursa-pastoris	an	1%		**2%**			**5%**				**7%**	**11%**		
Carex distans	per	1%		**2%**				**3%**			**7%**		**20%**	
Carex flacca	per	1%		**2%**				**3%**			**7%**		**20%**	
Carex hirta	per	1%		**2%**				**3%**						**4%**
Carex nigra	per	1%		**2%**				**3%**		**10%**				
Carex spp.	per	9%	7%	10%	5%	14%	5%	14%		10%	29%	11%	60%	4%
Carex sylvatica	per	1%		**2%**				**3%**		**10%**				
Carex vulpina / muricata	per	6%		**9%**			5%	11%	11%	10%	7%		20%	9%
Caryophyllaceae indeterminate		11%	11%	10%	10%	14%	23%	3%	22%	10%	21%	33%		
Centaurea spp.		1%		2%			5%				7%	11%		
Cerastium spp.		4%	4%	3%	5%		5%	3%		10%	7%	11%		
Chenopodium album	an	32%	19%	38%	20%	14%	41%	36%	44%	50%	50%	44%	60%	26%
Chenopodium botrys	an	1%	**4%**			**14%**								
Chenopodiaceae/Caryophyllaceae		2%		3%			9%				14%	22%		
Chenopodium ficifolium	an	2%		**3%**			5%	3%	11%		7%		20%	
Chenopodium hybridum	an	12%		**17%**			14%	19%	33%		21%		60%	17%
Chenopodiaceae indeterminate		14%	15%	14%	15%	14%	23%	8%	22%	30%	14%	22%		
Chenopodium polyspermum	an	4%		**5%**			5%	6%	11%		14%		40%	
Chenopodium spp.	an	24%	19%	26%	15%	29%	32%	22%	33%	20%	57%	44%	80%	9%
Cichorium intybus	per	2%		**3%**				**6%**						**9%**
Compositeae indeterminate		8%	4%	10%	5%		9%	11%	11%	30%	14%	11%	20%	
Conium maculatum	an/bi	1%		**2%**				**3%**			**7%**		**20%**	
Convolvulus arvensis	per	5%	4%	5%		14%		8%			7%		20%	9%
Coronilla varia	per	4%	7%	2%	5%	14%		3%						4%
Cruciferae indeterminate		6%		9%			9%	8%	11%	10%	21%	11%	40%	
Cuscuta europaea	an	2%		**3%**				**6%**						**9%**
Cynodon spp.	per	1%		2%			5%				7%	11%		
Cyperaceae indeterminate		8%	15%	5%	20%		9%	3%	11%	10%				4%
Cyperus spp.	per	2%	4%	2%	5%		5%		11%					
Digitaria ischaemum	an	2%		**3%**				**6%**						**9%**
Digitaria sanguinalis	an	2%		**3%**				**6%**						**9%**
Digitaria spp.	an	1%		2%			5%		11%					

Table 8.28: continued

		Ubiquity scores of taxa by site within defined areas												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Echinochloa crus-galli	an	18%		**26%**			32%	22%	44%	20%	36%	33%	40%	17%
Eleocharis palustris	per	4%		**5%**				**8%**						**13%**
Euphorbia cyparissias	per	1%		**2%**				**3%**						**4%**
Euphorbia helioscopia	an	4%	7%	2%	10%			3%			7%		20%	
Euphorbia peplus	an	1%		**2%**				**3%**		**10%**				
Euphorbia spp.		1%		2%			5%		11%					
Festuca / Lolium spp.		1%		2%				3%		10%				
Festuca pratensis	per	4%	4%	3%		14%		6%						9%
Festuca spp.	per	1%	4%			14%								
Fragaria / Potentilla spp.	per	1%		2%				3%		10%				
Fumaria schleicheri	an	1%		**2%**				**3%**			**7%**		**20%**	
Galium aparine / tricornutum	an	1%		**2%**				**3%**			**7%**		**20%**	
Galeopsis spp.	per	1%	4%		5%									
Galeopsis / Stachys spp.		1%		2%				3%		10%				
Galium aparine	an	13%		**19%**			27%	14%	33%	20%	43%	33%	60%	
Gallium mollugo	per	5%		**7%**				**11%**			7%		20%	13%
Galium spp.		14%	19%	12%	20%	14%	18%	8%			36%	33%	40%	4%
Galium spurium	an	13%		**19%**			14%	22%	22%		21%	11%	40%	26%
Gallium verum	per	2%		**3%**			5%	3%			7%	11%		4%
Geranium spp.		1%		2%			5%		11%					
Glaucium corniculatum	an	1%		**2%**				**3%**						**4%**
Glyceria maxima	per	1%		**2%**				**3%**						**4%**
Poaceae indeterminate		35%	26%	40%	20%	43%	45%	36%	44%	50%	57%	44%	80%	26%
Heliotropium europaeum	an	1%		**2%**				**3%**						**4%**
Hordeum bulbosum/ spontaneum		2%		**3%**			**9%**				**14%**	**22%**		
Hordeum murinum	an	1%		**2%**				**3%**						**4%**
Hordeum spp. grain		1%		2%			5%							
Hyoscyamus niger	an/bi	11%	4%	14%	5%		23%	8%	44%	10%	7%	11%		9%
Hyoscyamus spp.		2%	4%	2%	5%		5%		11%					
Hypericum spp.	per	4%	7%	2%	10%		5%				7%	11%		
Juncus spp.		1%		2%				**3%**		**10%**				
Lamiaceae indeterminate		8%	4%	10%		14%	18%	6%	22%	10%	21%	22%	20%	
Lamium amplexicaule	an	1%		**2%**				**3%**			**7%**		**20%**	
Lamium spp.		1%	4%		5%									
Lapsana communis	an	6%		**9%**			18%	3%	33%		14%	11%	20%	
Lathyrus nissolia	an	2%		**3%**			**9%**		**22%**					
Lathyrus spp.		6%	19%		25%									

Table 8.28: continued		**Ubiquity scores of taxa by site within defined areas**												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Fabaceae indeterminate		18%	33%	10%	25%	57%	14%	8%	11%	10%	21%	11%	40%	4%
Large Fabaceae		24%	15%	28%	20%		50%	14%	56%	60%	29%	44%		
Small Fabaceae		11%	19%	7%	20%	14%	9%	6%	11%	10%				4%
Leopoldia comosa	per	1%		**2%**				**3%**						**4%**
Liliaceae indeterminate		4%	7%	2%	10%		5%		11%					
Linum catharticum	an	1%		**2%**				**3%**			**7%**		**20%**	
Linum spp.		4%	4%	3%	5%		5%	3%			7%	11%		4%
Lolium/Hordeum spp.		1%		2%			5%				7%	11%		
Lolium multiflorum	an	1%	**4%**			**14%**								
Lolium perenne	per	1%		**2%**			**5%**				**7%**	**11%**		
Lolium remotum	an	1%		**2%**				**3%**						**4%**
Lolium spp.		12%	11%	12%	15%		23%	6%	22%	10%	21%	22%	20%	
Lolium temulentum	an	5%	4%	5%	5%		9%	3%	22%	10%				
Lotus corniculatus	per	1%		**2%**				**3%**						**4%**
Lychnis flos-cuculi	per	2%		**3%**				**6%**		10%				4%
Malva pusilla	an/per	1%		**2%**				**3%**						4%
Malva spp.		2%		3%				6%			7%		20%	4%
Malva sylvestris	bi/per	2%		**3%**				**6%**			7%		20%	4%
Medicago lupulina	an/per	6%	4%	7%		14%		11%			7%		20%	13%
Medicago minima	an	2%		**3%**				**6%**						**9%**
Medicago sativa	per	2%	**7%**		5%	14%								
Medicago spp.		8%	11%	7%	10%	14%	5%	8%		10%	14%	11%	20%	4%
Melampyrum arvense	an	1%		**2%**				**3%**						**4%**
Melilotus albus	an/bi	2%		**3%**				**6%**			7%		20%	4%
Melissa officinalis	per	1%	**4%**			**14%**								
Mentha spp.	per	2%		3%			5%	3%		10%	7%		20%	
Molinia caerulea	per	1%		**2%**				**3%**						**4%**
Montia fontana	an/per	1%		**2%**				**3%**		**10%**				
Myosotis arvensis	an	1%		**2%**			**5%**		**11%**					
Nigella arvensis	an	1%	**4%**			**14%**								
Oxalis corniculata	an/per	1%		**2%**				**3%**						**4%**
Panicoideae indeterminate		1%		2%			5%							
Panicum spp.		1%	4%			14%								
Papaver spp.		2%		3%				6%		10%	7%		20%	
Papaver dubium / somniferum	an	1%		**2%**				**3%**		**10%**				
Phalaris spp.		2%		3%				6%		10%	7%		20%	
Phleum pratense	per	1%		**2%**				**3%**						**4%**
Phleum spp.		6%	4%	7%	5%		9%	6%		20%	14%	22%		

Table 8.28: continued		**Ubiquity scores of taxa by site within defined areas**												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Physalis / Solanum spp.		1%		2%				3%		10%				
Picris hieracioides	bi/per	1%	**4%**			**14%**								
Pimpinella major / saxifraga	per	1%		**2%**				**3%**						**4%**
Plantago lanceolata	per	11%		**16%**			9%	19%	22%	10%	14%		40%	17%
Poa annua		1%		**2%**				**3%**						**4%**
Poa pratensis	per	4%		**5%**				**8%**						**13%**
Poa spp.		5%		7%			5%	8%		10%	7%	11%		9%
Polygonum arenastrum	an	1%		**2%**			**5%**				**7%**	**11%**		
Polygonum aviculare	an	15%	4%	21%		14%	27%	17%	33%	10%	36%	33%	40%	13%
Polygonum convolvulus	an	38%	7%	52%		29%	50%	53%	56%	40%	64%	56%	80%	48%
Polygonum dumetorum	an	1%		**2%**				**3%**						**4%**
Polygonaceae indeterminate		13%	7%	16%	10%		27%	8%	22%	10%	29%	33%	20%	9%
Polygonum lapathifolium	an	5%		**7%**			5%	8%	11%	10%	7%		20%	4%
Polygomun minus	an	5%		**7%**				**11%**			7%		20%	13%
Polygonum mite	an	1%		**2%**				**3%**						**4%**
Polygonum persicaria	an	8%	4%	10%		14%	27%		44%	10%	7%	11%		
Polygonum / Rumex spp.		5%	7%	3%	10%			6%		10%	7%		20%	
Polygonum spp.		27%	22%	29%	25%	14%	32%	28%	11%	30%	57%	56%	60%	17%
Potamogeton spp.	per	1%	4%			14%								
Potentilla argentea	per	1%	**4%**		**5%**									
Potentilla reptans	per	2%		**3%**				**6%**			7%		20%	4%
Potentilla spp.	per	7%	7%	7%	10%			11%		30%	7%		20%	
Primulaceae indeterminate		1%	4%			14%								
Prunella vulgaris	per	2%		**3%**				**6%**			7%		20%	4%
Puccinellia spp.		1%		2%				3%			7%		20%	
Ranunculus acris/repens/bulbosus	per	7%		**10%**			5%	14%	11%	10%	7%		20%	13%
Ranunculus arvensis	an	1%		**2%**			**5%**		**11%**					
Ranunculus spp.		2%	4%	2%	5%		5%				7%	11%		
Raphanus raphanistrum	an	1%		**2%**			**5%**				**7%**	**11%**		
Rumex acetosella	per	6%	4%	7%		14%	5%	8%	11%	10%				9%
Rumex acetosa	per	5%	4%	5%		14%	5%	6%			14%	11%	20%	4%
Rumex crispus	per	5%	4%	5%		14%	9%	3%	22%					4%
Rumex obtusifolius	per	4%		**5%**				**8%**			7%		20%	9%
Rumex sanguineus	per	2%		**3%**				**6%**			7%		20%	4%
Rumex spp.	per	9%	7%	10%	10%		18%	6%	22%	20%	14%	11%	20%	
Sanguisorba officinalis	per	4%		**5%**				**8%**						**13%**
Saponaria officinalis	per	4%		**5%**				**8%**						**13%**
Schoenoplectus mucronatus	per	1%		**2%**				**3%**						**4%**

Table 8.28: continued

		Ubiquity scores of taxa by site within defined areas												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Schoenoplectus spp.		1%		2%			5%				7%	11%		
Scirpus maritimus / lacustris	per	6%		**9%**			5%	11%			14%	11%	20%	13%
Scirpus / Schoenoplectus spp.		1%		2%			5%				7%	11%		
Scirpus spp.	per	1%		2%			5%							
Scleranthus annuus	an	4%		**5%**			5%	6%	11%					9%
Scleranthus spp.		1%		2%				3%			7%		20%	
Scrophularia spp.	per	1%		2%			5%				7%	11%		
Indeterminate seed		44%	26%	52%	25%	29%	32%	64%	22%	80%	43%	33%	60%	57%
Setaria glauca / pumila	an	2%		**3%**			5%	3%	11%					4%
Setaria italica	an	6%	7%	5%		29%	5%	6%		10%	7%		20%	4%
Setaria / Panicum	an	4%	7%	2%		29%	5%			10%				
Setaria spp.	an	5%	7%	3%		29%	5%	3%			14%	11%	20%	
Setaria viridis / verticillata	an	21%	11%	26%	5%	29%	27%	25%	11%	10%	50%	44%	60%	22%
Sherardia arvensis	an	4%		**5%**				**8%**		10%				9%
Silene alba		1%		**2%**				**3%**						**4%**
Silene spp.		7%	4%	9%	5%		14%	6%	22%		21%	11%	40%	
Sisymbrium spp.		1%		2%			5%				7%	11%		
Solanum dulcamara	per	5%	4%	5%		14%	9%	3%	11%		7%	11%		4%
Solanaceae indeterminate		7%		10%			14%	8%			43%	33%	60%	
Solanum nigrum	an	15%	4%	21%		14%	32%	14%	33%		36%	33%	40%	13%
Solanum spp.		4%	4%	3%	5%		9%				14%	22%		
Sonchus arvensis	per	1%		**2%**			**5%**		**11%**					
Sparganium erectum	per	1%		**2%**				**3%**						**4%**
Spartium junceum	per	1%	**4%**		**5%**									
Sparganium spp.	per	1%		2%				3%			7%		20%	
Stachys annua	an/per	5%		**7%**			5%	8%			14%	11%	20%	9%
Stellaria media	an	6%		**9%**			9%	8%	22%					13%
Stellaria palustris	per	2%		**3%**			**9%**		**22%**					
Taraxacum officinale	per	1%	**4%**			**14%**								
Teucrium/Ajuga spp.		1%		2%				3%			7%		20%	
Teucrium chamaedrys	per	4%		**5%**			5%	6%	11%		14%		40%	
Teucrium spp.		13%	15%	12%	20%		23%	6%	22%		21%	22%	20%	4%
Thalictrum flavum	per	2%		**3%**				**6%**						**9%**
Thalictrum spp.	per	1%		2%			5%			10%				
Thymelaea passerina	an	2%		**3%**			5%	3%	11%		7%		20%	
Trifolium arvense	an/bi	6%		**9%**			9%	8%			14%	22%		13%
Trifolium campestre	an/bi	2%	4%	2%		14%		3%			7%		20%	
Trifolium/Medicago		4%		5%			5%	6%		20%	7%		20%	

Table 8.28: continued		**Ubiquity scores of taxa by site within defined areas**												
	Life span	**All** (85 sites)	**Coast** (27 sites)	**Inland** (58 sites)	**Med.** (20 sites)	**Coast-Con.** (7)	**Con.** (22 sites)	**Pann.** (36 sites)	**Butmir** (9 sites)	**Sopot** (10 sites)	**Vinča** (14 sites)	**Vinča** (Con. 9)	**Vinča** (Pan. 5)	**Hungary** (23 sites)
Trifolium pratense	per	1%		**2%**				**3%**						**4%**
Trifolium repens	per	5%		**7%**			9%	6%			21%	22%	20%	4%
Trifolium spp.		11%	4%	14%	5%		14%	14%	11%	20%	29%	22%	40%	4%
Trigonella spp.	an	2%	4%	2%	5%			3%			7%		20%	
Umbelliferae indeterminate		5%	4%	5%	5%		9%	3%	11%	10%	7%		20%	
Urtica dioica	per	4%		**5%**			5%	6%	11%	20%				
Urtica urens	an	4%	4%	3%	5%			6%		10%				4%
Vaccaria pyramidata	an	4%		**5%**			**14%**		22%		7%	11%		
Vaccaria spp.	an	1%		2%			5%		11%					
Valerianella dentata	an	1%	**4%**			**14%**								
Valerianella locusta	an	1%		**2%**				**3%**		**10%**				
Verbena officinalis	bi/per	6%	4%	7%		14%	14%	3%	11%	20%	7%	11%		
Verbascum spp.		4%	7%	2%	10%		5%		11%					
Veronica hederifolia	bi/per	4%		**5%**			9%	3%	22%		7%		20%	
Veronica spp.		2%		3%			5%	3%	11%		7%		20%	
Vicia cracca	per	1%		**2%**				**3%**						**4%**
Vicia grandiflora	an	1%	**4%**		**5%**									
Vicia/Lathyrus spp.		2%		3%			9%				7%	11%		
Vicia spp.		20%	22%	19%	25%	14%	23%	17%	33%	10%	29%	11%	60%	9%
Vicia tetrasperma	an	1%		**2%**				**3%**						**4%**
Viola arvensis	an	2%		**3%**				**6%**						**9%**
Viola spp.		1%		2%			5%		11%					
Viola tricolor	an/per	1%		**2%**				**3%**			**7%**		**20%**	
Xanthium strumarium	an	2%		**3%**			5%	3%	11%					4%
Total taxa		**252**	**88**	**230**	**56**	**49**	**127**	**183**	**83**	**74**	**128**	**72**	**94**	**112**
Total species		**153**	**38**	**140**	**13**	**29**	**57**	**124**	**45**	**29**	**64**	**28**	**52**	**91**
Total species unique to area			**13**	**114**	**4**	**8**	**13**	**73**	**7**	**9**	**15**	**5**	**10**	**44**

Of the bioregions, the Coast-Continental group had the lowest percentages of sites with weed seeds, of which 59% (n=29) were identified to species. The Mediterranean zone had a similar proportion of sites with weed seeds as the inland bioregions but a much lower number of weed taxa, of which only 23% (n=13) of were identified to species. Inland, identification to species was most common on Hungarian specimens and least common on taxa from eastern Croatian sites (Sopot sites). Some species identified from the inland region may have been present along the coast where they have not been identified beyond genus level. For example, six species of *Carex* and three of *Bromus* have been identified inland whereas the coast only has records of *Carex* sp. and one species of *Bromus*. This discrepancy is also evident between the three inland cultural groups: *c*.50% of Butmir (n=45) and Vinča (n=64) taxa were identified to species compared to 39% (n=29) of Sopot taxa. Seven genus and only two species (*C. album* and *S. viridis/verticillata)* were common to all areas (shaded grey in Table 8.27). Additionally, *Coronilla varia* and *Medicago sativa* were found in both Coastal bioregions. The three inland cultural groups had another nine species in common. There were more species that were unique to certain areas, particularly to Hungary (Table 8.28). The Pannonian bioregion had the highest frequency of taxa present at more than one site (52%, n=95), and the Coast-Continental bioregion had the lowest (18%, n=9). *Chenopodium album* was the most common taxa in the Mediterranean and Sopot groups. *P. convolvulus* was the most common taxa in the Butmir, Vinča, and Hungarian sites. In northern Italy *S. italica, S. viridis/verticillata* and *P. convolvulus* were the most common taxa. In summary, Pannonia was the bioregion with the highest number of sites with charred weed taxa, and contained the highest number of taxa identified to species (44%, n=81 of which are unique to Hungary). Less than half of the taxa within each analysed group was present in more than one site, and only two species were common to all groups. Overall *C. album* and *P. convolvulus* were the most common taxa.

Tables 8.29 to 8.35 record, by research area, the biological and ecological characteristics of the taxa identified to species. See Table 8.24 for the key and references 1-13.

Mediterranean weed species. Total = 13	% by site (20 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flowering
						pH	texture	fertility	moisture					
Astragalus cicer	5%	3	wd, g	per	high	al	m	-f	dry, moist		v/s		Aug-Oct	1
Buglossoides arvensis	5%	1, 3, 4	a	an	med	n, al	m	-f	dry, moist	3?, 4	s	a/s	Jun-Aug	1
Chenopodium album	20%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Coronilla varia	5%	3	a,d,g, wd	per	high	al	m, l	/	dry		v/?s			4
Euphorbia helioscopia	10%	2, 3, 4	a, d	an	low	n	l,m	f	moist, damp	?3	s	a	Aug-Oct	3
Hyoscyamus niger	5%	2, 3, 4	d	an/bi	high	al	l	f	moist	?3	s			4
Lolium temulentum	5%	1	a, d	an	high	n	m	/	moist		s	a/s	Aug-Oct	1
Medicago sativa	5%	3	a, d, g	per	high	n, al	m	f	dry		v/s			4
Potentilla argentea	5%	1	g, p	per	med	a	l	-f	dry		v/?s			4
Setaria viridis/verticillata	5%		a, d	an	high	n	m	f	moist	2?	s	s		2
Spartium junceum	5%		d, g	per	high	n	l, m	-f	dry		s	s/a	Autumn	4
Urtica urens	5%	2, 3	a, d	an	med	n	m	f	moist	4	s	s/a	July +	3
Vicia grandiflora	5%	3	a, d	an	high, T		m		dry, moist		s	a		1

Table 8.29: Characteristics obtained for species identified in the Mediterranean bioregion.

Two of the 13 species identified in the Mediterranean bioregion are today more associated with grasslands or woodlands than arable or disturbed land. Fifty-four percent (n=7) are annuals though an additional species can also reproduce as an annual. Thirty-eight percent (n=5) are perennials that reproduce mainly vegetatively. Only one species does not grow above 30cm, whilst 69% (n=9) can reach 60cm or higher. One twining species was identified. The species prefer neutral to slightly alkaline soils of medium texture. Acid soils are indicated by one species (*Potentilla argentea*). Lighter, sandier soils are indicated by two species. Whilst the majority of species grow in moist conditions, 31% (n=4) are adapted to dry soils. Two species are known to germinate only in the autumn and two only in the spring. The species set seed between June and October. Soil fertility and flowering onset and duration are described below.

Coast-Continental weed species. Total = 29	% by site (7 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flower-ing
						pH	texture	fertility	moisture					
Agrostemma githago	14%	1, 3, 4	a	an/bi	high	n	m	f	damp	1	s	a/s	Aug-Oct	2
Ajuga chamaepitys	14%	3	a	an	low	al	m	/	dry, moist		s			4
Atriplex patula/hastata	14%	2, 3	a, d, g, p	an	high	al	m	f	moist, damp		s	s	Autumn	2
Bromus hordeaceus	14%	1, 2	a, g, d, p	an	high	n, al	l, m	/	moist	3	s	a	Jun-Aug	1
Chenopodium album	14%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Chenopodium botrys	14%	3	a, d	an	high	n, al	m	f	moist	?4	s	s	Autumn	2
Convolvulus arvensis	14%	2, 3	a, d	per	high, T	n	m, l	f	dry	4	v/s	s	Aug-Oct	4
Coronilla varia	14%	3	a,d,g, wd	per	high	al	m, l	/	dry		v/?s			4
Festuca pratensis	14%	1, 2	p, g	per	high	wa	m, h	/	damp	1	v/s	a	Jul-Sept	1
Lolium multiflorum	14%	2	a, d, p	an	med	n, al	m, h	f	moist	1	s	a	Jun-Aug	1
Medicago lupulina	14%	1, 2, 3	a, g	an/per	med	al	h	-f	dry, moist	4	s	s	Jun-Sept	4
Medicago sativa	14%	3	a, d, g	per	high	n, al	m	f	dry		v/s			4
Melissa officinalis	14%		wd	per	high	n, al	m	/	moist		v/s			4
Nigella arvensis	14%	3	a, d, g, p	an	med	al	m	/	dry, moist	2 to 4	s	s		2
Picris hieracioides	14%	3	a, d	bi/per	high	al	m	f	dry		v/?s			2
Polygonum aviculare	14%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	29%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum persicaria	14%	1, 2, 3	a	an	high	wa	l	f	damp	4	s	s		2
Rumex acetosella	14%	1, 2, 3	a, d, g, p	per	med	a	l	-f	dry, moist	4	v/s		Jun-Sept	3
Rumex acetosa	14%	1, 2, 3	a, d, g, p	per	high	wa	m	f	moist	1	s/v	a	Jun-Sept	1
Rumex crispus	14%	1, 2, 3	a, d	per	high	n	h	f	damp	4	s/v	a+s	from Aug.	3
Setaria italica	29%		a, g, p	an	high	n	m	/	dry, moist	2 to 4	s	s		2
Setaria viridis/verticillata	29%		a, d	an	high	n	m	f	moist	2?	s	s		2
Solanum dulcamara	14%	2, 3	d, wd	per	high	n	h	f	moist, damp	?2	s/v	s	Aug-Oct	4
Solanum nigrum	14%	1, 3	d	an	med	n	l	f	moist	?3,?4	s	s		2
Taraxacum officinale	14%	2, 3	a, d	per	med		m	f	moist	1	s	a+s		3 or 4
Trifolium campestre	14%	1, 2, 3	a, g, d	an/bi	low	n	l, m	/	dry	3	s	a		4
Valerianella dentata	14%	1, 2, 3	a, d	an	low	/		/	moist	2 to 4	s	s	Jun-Aug	1
Verbena officinalis	14%	1, 3	d, p	bi/per	high	al	m	f	dry		v/?s		Aug-Oct	2

Table 8.30: Characteristics obtained for species identified in northern Italy.

Two of the 29 species identified in the Coast-Continental bioregion of northern Italy are today more associated with pastures, grasslands or woodlands than arable or disturbed land. Forty-eight percent (n=14) are annuals though an additional three species can also reproduce as annuals. Forty-one percent (n=12) are perennials or biennials, and 25% (n=7) of those reproduce mainly by seed. Ten percent (n=3) of species do not grow above 30cm, whilst 69% (n=20) can reach at least 60cm. Two twining species were identified. On the whole, the species prefer neutral to slightly alkaline soils of medium texture. Acidic soils are indicated by four species, one of which (*Rumex acetosella*) is an indicator of nutrient-deficient sandy soils (Hanf 1983: 403). Four species prefer lighter soils and three heavier soils. Whilst the majority of species grow in moist conditions, 21% (n=6) are adapted to dry soils and 14% (n=4) prefer damp soils. Five species are known to only germinate in the autumn and fourteen only in the spring. The species set seed between June and October. Soil fertility and flowering onset and duration are described below.

Two of the 45 species identified from Butmir sites are today more associated with pastures, grasslands or wetlands than arable or disturbed land. Sixty-nine percent (n=31) are annuals though an additional species can also reproduce as an annual. Twenty-nine percent (n=13) are perennials or biennials, and 31% (n=14) of those reproduce mainly by seed. Seven percent (n=3) of species do not grow above 30cm, whilst 44% (n=20) can reach at least 60cm. Two twining species were identified. On the whole, the species prefer neutral to slightly alkaline soils of medium texture. Acidic soils are indicated by five species, including *Scleranthus annus* which is an indicator of acidic soils (Hanf 1983: 184). Seven species prefer lighter soils and seven heavier soils, including *Anthemis cotula* which is an indicator of heavy wet, clay loams (Hanf 1983: 235). Whilst the majority of species grow in moist conditions, 18% (n=8) prefer damp to wet soils and only 7% (n=3) are adapted to dry soils. Two species are known to germinate only in the autumn, although an additional six will also usually germinate in the autumn. Sixteen will germinate only in the spring and nine can germinate in either season. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

Table 8.31: Characteristics obtained for species identified from Butmir sites. Additional references: 14- http://www.cabi.org/isc/datasheet/56864

Butmir weed species. Total = 45	% by site (9 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flower-ing
						pH	texture	fertility	moisture					
Ajuga chamaepitys	11%	3	a	an	low	al	m	/	dry, moist		s			4
Althaea officinalis	11%		p, g	per	high	al	m, h	/	damp		v+s			4
Anthemis cotula	11%	1, 3	a, d	an	med	wa	h	/	damp, wet	?3/4	s	a+s	Aug-Oct	4
Atropa bella-donna	11%		a, wd, g	per	high	al	m	f	moist		s/v	s		1
Atriplex patula/hastata	22%	2, 3	a, d, g, p	an	high	al	m	f	moist, damp		s	s	Autumn	2
Bromus arvensis	44%	4	a, g, d	an	high	n	m	f	not wet	1	s	a/s	Jun-Aug	1
Bromus secalinus/mollis	44%	1, 2, 4	a, g, d, p	an	high	n, al	l, m	/	moist	3	s	a+s	Jun-Aug	1
Buglossoides arvensis	11%	1, 3, 4	a	an	med	n, al	m	-f	dry, moist	3?, 4	s	a/s	Jun-Aug	1
Carex vulpina/muricata	11%			per	high				not dry		v		Jun-Aug	
Chenopodium album	44%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Chenopodium ficifolium	11%	1, 3	a	an	high	n	h	f	moist, damp	?4	s	s	Autumn	2
Chenopodium hybridum	33%	3	a, d	an	high	al	m, h	f	moist, damp	?4	s	s	Aug-Oct	2
C. polyspermum	11%	3	a, d	an	med	n	h	f	moist	?4	s	s	Autumn	2
Echinochloa crus-galli	44%	12	a, d	an	high	al	m, h	f	moist, damp	4	s	a/s	Aug-Oct	3
Galium aparine	33%	1, 2, 3, 6	all but wt	an	high, T	n	m	f	moist, damp	4	s	a+s	Jun-Aug	3
Galium spurium	22%	1, 3, 6	a	an	med, T	n, al	m	f	moist		s	a+s	Jun-Aug	3
Hyoscyamus niger	44%	2, 3, 4	d	an/bi	high	al	l	f	moist	?3	s			4
Lapsana communis	33%	1, 2, 3	a, d	an	high	al	h	f	moist	3	s	a+s	Jun-Sept	2
Lathyrus nissolia	22%	1, 3	a,d,p, wd	an	med, T		h	/	dry	?1, ?3	s	a		1
Lolium temulentum	22%	1	a, d	an	high	n	m	/	moist		s	a/s	Aug-Oct	1
Myosotis arvensis	11%	1, 2, 3	a	an	low	n, al	l, m	/	dry, moist	4	s	a/s	May +	3
Plantago lanceolata	22%	1, 2, 3	a, d, g, p	per	high	al	m	/	dry, moist	3	v+s	a+s	Jun-Sept	3
Polygonum aviculare	33%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	56%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum lapathifolium	11%	2, 3	a, d, p	an	high	n, wa	m, h	f	damp	4	s	s		2
Polygonum persicaria	44%	1, 2, 3	a	an	high	wa	l	f	damp	4	s	s		2
R. acris/repens/bulbosus	11%	1, 2, 3	all but wt	per	med	n, al	m, h				v/s		Jun-Aug	4
Ranunculus arvensis	11%	2, 3	a, d	an	med	/	m	/	moist, damp		s	a		1
Rumex acetosella	11%	1, 2, 3	a, d, g, p	per	med	a	l	-f	dry, moist	4	v/s		Jun-Sept	3
Rumex crispus	22%	1, 2, 3	a, d	per	high	n	h	f	damp	4	s/v	a+s	from Aug.	3
Scleranthus annuus	11%	1, 2, 3	a	an	low	a	l	-f	dry	?4	s	a+s	Jun-Aug	3
Setaria glauca/pumila	11%		a, g, p	an	med	n	m	/	dry, moist	2 to 4	s	s		2
Setaria viridis/verticillata	11%		a, d	an	high	n	m	f	moist	2?	s	s		2
Solanum dulcamara	11%	2, 3	d, wd	per	high	n	h	f	moist, damp	?2	s/v	s	Aug-Oct	4
Solanum nigrum	33%	1, 3	d	an	med	n	l	f	moist	?3,?4	s	s		2
Sonchus arvensis	11%	2, 3	all but wt	per	high	n, al	m	/	moist		v/s			2
Stellaria media	22%	1, 2, 3	a, g, d	an	low	n	m	f	moist, damp	4	s	a+s	Jun-Sept	3
Stellaria palustris	22%		wt	per	high	wa	h	-f	damp, wet	2	v/s			1
Teucrium chamaedrys	11%		a, g, d	per	low	al	l	-f	dry, moist					4
Thymelaea passerina	11%	3	a, d, g, p	an	med	al	m	/	dry, moist		s			2
Urtica dioica	11%	1, 2, 3	a, d	per	high	wa	l, m	f	damp	4	v/s	s/a	Aug-Oct	4
Vaccaria pyramidata	22%	3	a, d	an	med	al	h	/	dry, moist		s	s		2
Verbena officinalis	11%	1, 3	d, p	bi/per	high	al	m	f	dry		v/?s		Aug-Oct	2
Veronica hederifolia	22%	1, 2, 3	a, d, wd	an	med	al	m, h	f	dry, moist	?4	s	a/s	Jun-Aug	1
Xanthium strumarium	11%	3, 14	a, d	an	high	/	/	f	moist to wet	3	s	s		2

Sopot weed species. Total = 29	% by site (10 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flowering
						pH	texture	fertility	moisture					
Agrostemma githago	10%	1, 3, 4	a	an/bi	high	n	m	f	damp	1	s	a/s	Aug-Oct	2
Ajuga reptans	20%	2, 3	p	per	low	n	m	f	moist	?3/4	v/s			4
Apium graveolens	10%		g, wt	bi	high	n	h	/	damp, wet		s	a		2
Carex nigra	10%	2	wt, p	per	high	/	h	-f	damp, wet	?3/4	v	s	Aug-Oct	1
Carex sylvatica	10%	2	wd, wt	per	high	n, al	h	/	damp	?3/4	v/s			1
Carex vulpina/muricata	10%			per	high				not dry		v		Jun-Aug	
Chenopodium album	50%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Echinochloa crus-galli	20%	12	a, d	an	high	al	m, h	f	moist, damp	4	s	a/s	Aug-Oct	3
Euphorbia peplus	10%	2, 3	a, d	an	low	n, al	m, l	f	dry, moist	?4	seed	s	Aug-Oct	3
Galium aparine	20%	1, 2, 3, 12	not wt	an	high, T	n	m	f	moist, damp	4	s	a+s	Jun-Aug	3
Hyoscyamus niger	10%	2, 3, 4	d	an/bi	high	al	l	f	moist	?3	s			4
Lolium temulentum	10%	1	a, d	an	high	n	m	/	moist		s	a/s	Aug-Oct	1
Lychnis flos-cuculi	10%	1	g	per	high	n	h	/	moist to wet	4	v/s			
Montia fontana	10%	1, 3	a, d	an/per	low	n, wa	m, h	/	damp, wet		s/v			1
P. somniferum/dubium	10%	1, 2, 3	a	an	med	n	m	/	moist	4	s	s/a	Jun-Sept	3
Plantago lanceolata	10%	1, 2, 3	a,d,g, p	per	high	al	m	/	dry, moist	3	v+s	a+s	Jun-Sept	3
Polygonum aviculare	10%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	40%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum lapathifolium	10%	2, 3	a, d, p	an	high	n, wa	m, h	f	damp	4	s	s		2
Polygonum persicaria	10%	1, 2, 3	a	an	high	wa	l	f	damp	4	s	s		2
R. acris/repens/bulbosus	10%	1, 2, 3	not wt	per	med	n, al	m, h				v/s		Jun-Aug	4
Rumex acetosella	10%	1, 2, 3	a,d,g, p	per	med	a	l	-f	dry, moist	4	v/s		Jun-Sept	3
Setaria italica	10%		a, g, p	an	high	n	m	/	dry, moist	2 to 4	s	s		2
Setaria viridis/verticillata	10%		a, d	an	high	n	m	f	moist	2?	s	s		2
Sherardia arvensis	10%	2, 3, 4	a	an	med	n, al	m	/	moist	2?	s	a		4
Urtica dioica	20%	1, 2, 3	a, d	per	high	wa	l, m	f	damp	4	v/s	s/a	Aug-Oct	4
Urtica urens	10%	2, 3	a, d	an	med	n	m	f	moist	4	s	s/a	from July	3
Valerianella locusta	10%	2, 3	a, d	an	low	/	m	/	moist	2 to 4	s	a		1
Verbena officinalis	20%	1, 3	d, p	bi/per	high	al	m	f	dry		v/?s		Aug-Oct	2

Table 8.32: Characteristics obtained for species identified from Sopot sites.

Vinča Continental weed species. Total = 28	% by site (9 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flower-ing
						pH	texture	fertility	moisture					
Bromus arvensis	22%	4	a, g, d	an	high	n	m	f	not wet	1	s	a/s	Jun-Aug	1
Bromus secalinus/mollis	22%	1, 2, 4	a,g,d, p	an	high	n, al	l, m	/	moist	3	s	a+s	Jun-Aug	1
Buglossoides arvensis	22%	1, 3, 4	a	an	med	n, al	m	-f	dry, moist	3?, 4	s	a/s	Jun-Aug	1
Capsella bursa-pastoris	11%	1, 2, 3	a	an	med	n	m	f	moist	4	s	s/a	Jun-Oct	3
Chenopodium album	44%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Echinochloa crus-galli	33%	12	a, d	an	high	al	m, h	f	moist, damp	4	s	a/s	Aug-Oct	3
Galium aparine	33%	1, 2, 3, 6	not wt	an	high, T	n	m	f	moist, damp	4	s	a+s	Jun-Aug	3
Galium spurium	11%	1, 3, 6	a	an	med, T	n, al	m	f	moist		s	a+s	Jun-Aug	3
Gallium verum	11%	2	p, g, d	per	high, T	n, al	m	-f	dry	?4	v/s		Sept-Nov	2
H. bulbosum/spontaneum	22%		a,d,g, p		high	n, al	m	/	dry, moist			a		1
Hyoscyamus niger	11%	2, 3, 4	d	an/bi	high	al	l	f	moist	?3	s			4
Lapsana communis	11%	1, 2, 3	a, d	an	high	al	h	f	moist	3	s	a+s	Jun-Sept	2
Lolium perenne	11%	1, 2		per	high	n, al	m, h	f	moist	1	s	a	Jun-Aug	1
Polygonum arenastrum	11%	2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum aviculare	33%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	56%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum persicaria	11%	1, 2, 3	a	an	high	wa	l	f	damp	4	s	s		2
Raphanus raphanistrum	11%	2, 3	a, d	an	high	a	m	f	moist	?4	s	s		4
Rumex acetosa	11%	1, 2, 3	a,d,g, p	per	high	wa	m	f	moist	1	s/v	a	Jun-Sept	1
Scirpus maritimus/lacustris	11%		wt	per	high	n	h	/	wet		v			1
Setaria viridis/verticillata	44%		a, d	an	high	n	m	f	moist	2?	s	s		2
Solanum dulcamara	11%	2, 3	d, wd	per	high	n	h	f	moist, damp	?2	s/v	s	Aug-Oct	4
Solanum nigrum	33%	1, 3	d	an	med	n	l	f	moist	?3,?4	s	s		2
Stachys annua	11%	3	a, d	an/per	low	al	m	/	dry, moist		s	s		2
Trifolium arvense	22%	1, 2, 3	a, g, d	an/bi	low	n/wa	l, m	/	dry	3	s	a		4
Trifolium repens	22%	1, 2, 3	a,d,g, p	per	low	/	h	f	moist, damp	4	v/s		Aug-Oct	3 or 4
Vaccaria pyramidata	11%	3	a, d	an	med	al	h	/	dry, moist		s	s		2
Verbena officinalis	11%	1, 3	d, p	bi/per	high	al	m	f	dry		v/?s		Aug-Oct	2

Table 8.33: Characteristics obtained for species identified from Vinča sites within the Continental bioregion.

Five of the 29 species identified from the Sopot sites (Table 8.32) are today more associated with pastures, grasslands, woodlands or wetlands than arable or disturbed land. Fifty-two percent (n=15) are annuals though an additional three species can also reproduce as annuals. Thirty-eight percent (n=11) are perennials or biennials that reproduce vegetatively. Fourteen percent (n=4) of species do not grow above 30cm, whilst 69% (n=20) can reach at least 60cm. Two twining species were identified. On the whole, the species prefer neutral to slightly alkaline soils of medium texture. Weakly-acidic soils are indicated by two species. Four species prefer lighter soils and four heavier soils. The majority of species grow in moist to damp conditions. Four species can grow in wet soils and only one is adapted to dry soils. Four species are known to germinate only in the autumn, and an additional six will usually germinate in the autumn. Nine will germinate only in the spring and two can germinate in either season. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

One (*Scirpus maritimus/lacustris*) of the 28 species identified from the Continental Vinča sites (Table 8.33) is today not considered an arable weed. Sixty-one percent (n=17) are annuals though an additional three species can reproduce as annuals. Twenty-five percent (n=7) are perennials or biennials, and 43% (n=3) of those reproduce mainly by seed. Eleven percent (n=3) of species do not grow above 30cm, whilst 71% (n=20) can reach at least 60cm. Four twining species were identified. On the whole, the species prefer neutral to slightly alkaline soils of medium texture. Weakly-acidic soils are indicated by two species. Five species prefer lighter soils and five heavier soils. Whilst the majority of species grow in moist conditions, 14% (n=4) prefer damp to wet soils and 11% (n=3) are adapted to dry soils. Four species are known to germinate only in the autumn, and an additional three will usually germinate in the autumn. Eleven will germinate only in the spring and four can germinate in either season. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

Four of the 52 species identified from the Pannonian Vinča sites are today more associated with pastures, grasslands, woodlands or wetlands than arable or disturbed land. Fifty-four percent (n=28) are annuals though an additional seven species can reproduce as annuals. Thirty-three percent (n=17) are perennials or biennials, and 29% (n=5) of those reproduce mainly by seed. Fifteen percent (n=8) of species do not grow above 30cm, whilst 60% (n=31) can reach at least 60cm. Six twining species were identified.

Vinča Pannonian weed species. Total = 52	% by site (5 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flower-ing
						pH	texture	fertility	moisture					
Agrostemma githago	40%	1, 3, 4	a	an/bi	high	n	m	f	damp	1	s	a/s	Aug-Oct	2
Ajuga chamaepitys	20%	3	a	an	low	al	m	/	dry, moist		s			4
Anthemis arvensis	20%	1, 3, 4	a, d	an	med	wa	l	/	moist	4	s	a/s		4
Atropa bella-donna	20%		a, wd, g	per	high	al	m	f	moist		s/v	s		1
Brassica nigra	20%	1, 3, 15	a, d	an	high	/	m, l	f	moist	4	s	a/s		4
Bromus arvensis	40%	4	a, g, d	an	high	n	m	f	not wet	1	s	a/s	Jun-Aug	1
Bromus secalinus/mollis	20%	1, 2, 4	a, g, d, p	an	high	n, al	l, m	/	moist	3	s	a+s	Jun-Aug	1
Buglossoides arvensis	40%	1, 3, 4	a	an	med	n, al	m	-f	dry, moist	3?, 4	s	a/s	Jun-Aug	1
Carex distans	20%		p, g	per	med	n	m	/	damp		v/s			1
Carex flacca	20%	2	p, g	per	med	n, al	h	-f	damp	4	v/s	s		1
Carex vulpina/muricata	20%			per	high				not dry		v		Jun-Aug	
Chenopodium album	60%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Chenopodium ficifolium	20%	1, 3	a	an	high	n	h	f	moist, damp	?4	s	s	Autumn	2
Chenopodium hybridum	60%	3	a, d	an	high	al	m, h	f	moist, damp	?4	s	s	Aug-Oct	2
Chenopodium polyspermum	40%	3	a, d	an	med	n	h	f	moist	?4	s	s	Autumn	2
Conium maculatum	20%	2, 3	d	an/bi	high	n	m	f	moist, damp	2, 3	s	a/s		1
Convolvulus arvensis	20%	2, 3	a, d	per	high, T	n	m, l	f	dry	4	v/s	s	Aug-Oct	4
Echinochloa crus-galli	40%	12	a, d	an	high	al	m, h	f	moist, damp	4	s	a/s	Aug-Oct	3
Euphorbia helioscopia	20%	2, 3, 4	a, d	an	low	n	l,m	f	moist, damp	?3	s	a	Aug-Oct	3
Fumaria schleicheri	20%	3	a, d	an	med	n, al	m	f	dry		s	s		2
Galium aparine/tricornutum	20%	3	a, d	an	high, T	n	m		moist	?4	s	a+s		
Galium aparine	60%	1, 2, 3, 6	not wet	an	high, T	n	m	f	moist, damp	4	s	a+s	Jun-Aug	3
Gallium mollugo	20%		not wet	per	high, T	n, al	m	f	moist		v/s			3
Galium spurium	40%	1, 3, 6	a	an	med, T	n, al	m	f	moist		s	a+s	Jun-Aug	3
Lamium amplexicaule	20%	1, 3, 16	a, d	an	low	n, al	m	f	moist		s	a+s		3
Lapsana communis	20%	1, 2, 3	a, d	an	high	al	h	f	moist	3	s	a+s	Jun-Sept	2
Linum catharticum	20%	2	d, p	an	high	n, al	m	-f	moist, damp	2 to 4	s	s	Jul-Oct	2
Malva sylvestris	20%	1, 2, 3, 8	a, d	bi/per	high	n	l, m	f	dry	?3	s	a+s		4
Medicago lupulina	20%	1, 2, 3	a, g	an/per	med	al	h	-f	dry, moist	4	s	s	Jun-Sept	4
Melilotus albus	20%	3, 17	a, d	an/bi	high	al	l, m	-f	dry, moist	4	s	a+s	Autumn	3
Plantago lanceolata	40%	1, 2, 3	a, d, g, p	per	high	al	m	/	dry, moist	3	v+s	a+s	Jun-Sept	3
Polygonum aviculare	40%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	80%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum lapathifolium	20%	2, 3	a, d, p	an	high	n, wa	m, h	f	damp	4	s	s		2
Polygomun minus	20%	3	/	an	low	a	h	f	damp, wet	4	s	s		2
Potentilla reptans	20%	1, 2, 3	a, d	per	high	n, al	h	/	damp, wet		v/?s			4
Prunella vulgaris	20%	1, 2, 3	a, d, g, p	per	med	n, al	h	/	moist	?3	v/?s		Aug-Oct	4
Ranunculus acris/repens/bulbos	20%	1, 2, 3	not wet	per	med	n, al	m, h				v/s		Jun-Aug	4
Rumex acetosa	20%	1, 2, 3	a, d, g, p	per	high	wa	m	f	moist	1	s/v	a	Jun-Sept	1
Rumex obtusifolius	20%	1, 2, 3	a, d	per	high	n	h	f	damp	4	s	a+s	from Aug.	3
Rumex sanguineus	20%	1, 2	g, wd	per	high	n, al	h	f	damp	4	s/v	s		3
Scirpus maritimus/lacustris	20%		wt	per	high	n	h	/	wet		v			1
Setaria italica	20%		a, g, p	an	high	n	m	/	dry, moist	2 to 4	s	s		2
Setaria viridis/verticillata	60%		a, d	an	high	n	m	f	moist	2?	s	s		2
Solanum nigrum	40%	1, 3	d	an	med	n	l	f	moist	?3,?4	s	s		2
Stachys annua	20%	3	a, d	an/per	low	al	m	/	dry, moist		s	s		2
Teucrium chamaedrys	40%		a, g, d	per	low	al	l	-f	dry, moist					4
Thymelaea passerina	20%	3	a, d, g, p	an	med	al	m	/	dry, moist		s			2
Trifolium campestre	20%	1, 2, 3	a, g, d	an/bi	low	n	l, m	/	dry	3	s	a		4
Trifolium repens	20%	1, 2, 3	a, d, g, p	per	low	/	h	f	moist, damp	4	v/s		Aug-Oct	3 or 4
Veronica hederifolia	20%	1, 2, 3	a, d, wd	an	med	al	m, h	f	dry, moist	?4	s	a/s	Jun-Aug	1
Viola tricolor	20%	1, 2, 3	a, d	an/per	high	wa	l, m	/	moist	?4	s	a+s		3

Table 8.34: Characteristics obtained for species identified from Vinča sites within the Pannonian bioregion. Additional references: 15- http://www.cabi.org/isc/datasheet/10097; 16- http://www.cabi.org/isc/datasheet/29728; 17- http://www.cabi.org/isc/datasheet/33693

On the whole, the species from Vinča sites in pannonia prefer neutral to slightly alkaline soils of medium texture. Weakly-acidic soils are indicated by three species. Four species prefer lighter soils and 11 heavier soils. Whilst the majority of species grow in moist conditions, 19% (n=10) prefer damp to wet soils and only 8% (n=4) are adapted to dry soils. Only three species are known to germinate specifically in the autumn, though an additional eight will usually germinate in the autumn. Nineteen will germinate only in the spring and eleven can germinate in either season. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

Hungarian weed species. Total = 91	% by site (23 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flower-ing
						pH	texture	fertility	moisture					
Aethusa cynapium	4%	1, 2, 3	a	an	high	n, al	m, h	f	moist	?3	s	s/a	Aug-Oct	2
Agrostemma githago	17%	1, 3, 4	a	an/bi	high	n	m	f	damp	1	s	a/s	Aug-Oct	2
Alchemilla vulgaris	4%	2	p, g, wd	per	med	n	m, h	f	moist		s/v	s	Autumn	4
Amaranthus lividus	4%	3	a, d	an	high	al	m	f	dry, moist	3 /4	s	s	Autumn	2
Anagallis arvensis	4%	2, 3	a, d	an	low	/	/	/	/	4	s	s/a	July-Oct	4
Anemone nemorosa	4%	1	wd, g	per	med	n, al		/	moist	2	v/s	s		
Astragalus glycyphyllos	4%		wd, g	per	high	al	m	-f	moist		v/s		Aug-Oct	4
Atriplex patula/hastata	9%	2, 3	a, d, g, p	an	high	al	m	f	moist, damp		s	s	Autumn	2
Avena fatua	35%	10	a	an	high	n	/	f	moist, damp	3	s	s	Jun-Sept	2
Brassica rapa	4%	1, 2, 3	a, d	an/bi	high	n, al	m	f	moist	4	s			4
Bromus inermis/ramosus	4%	2	wd, g	per	high	n, al	m	/	moist	2	s	s	Autumn	
Bromus arvensis	13%	4	a, g, d	an	high	n	m	f	not wet	1	s	a/s	Jun-Aug	1
Bromus secalinus/mollis	17%	1, 2, 4	a, g, d, p	an	high	n, al	l, m	/	moist	3	s	a+s	Jun-Aug	1
Camelina sativa	4%	3	a, d, g	an	high	al	m, l	/	dry, moist		s	s/a		
Carex hirta	4%		wt, p	per	high	n	h	/	damp, wet		v/s			1
Carex vulpina/muricata	9%			per	high				not dry		v		Jun-Aug	
Chenopodium album	26%	1, 2, 3	a, d	an	high	n	m, h	f	moist	4	s	s	Aug-Oct	2
Chenopodium hybridum	17%	3	a, d	an	high	al	m, h	f	moist, damp	?4	s	s	Aug-Oct	2
Cichorium intybus	9%	3	d	per	high	al	m	f	moist		s	s		2
Convolvulus arvensis	9%	2, 3	a, d	per	high, T	n	m, l	f	dry	4	v/s	s	Aug-Oct	4
Coronilla varia	4%	3	a,d,g, wd	per	high	al	m, l	/	dry		v/?s			4
Cuscuta europaea	9%	18	a, d, wd	an	high, T	n, al	/	/	moist		s/v	s		2
Digitaria ischaemum	9%		a, d	an	low	/	/	/	not wet		s	s		2
Digitaria sanguinalis	9%		a, d	an	med	/	/	/	not wet		s	s		2
Echinochloa crus-galli	17%	12	a, d	an	high	al	m, h	f	moist, damp	4	s	a/s	Aug-Oct	3
Eleocharis palustris	13%	1, 2	wt	per	high	n	m	if	wet	3?, 4	v/s		Jun-Aug	1
Euphorbia cyparissias	4%	2, 3	a, d	per	med	n, al	m	-f	dry		v			4
Festuca pratensis	9%	1, 2	p, g	per	high	wa	m, h	/	damp	1	v/s	a	Jul-Sept	1
Gallium mollugo	13%		all but wt	per	high, T	n, al	m	f	moist		v/s			3
Galium spurium	26%	1, 3, 6	a	an	med, T	n, al	m	f	moist		s	a+s	Jun-Aug	3
Gallium verum	4%	2	p, g, d	per	high, T	n, al	m	-f	dry	?4	v/s		Sept-Nov	2
Glaucium corniculatum	4%	3	a, d	an	med	al	l	/	dry		s			1
Glyceria maxima	4%	2	wt	per	high	n, al	m	-f	wet	3	v/s	s	Aug-Sept	2
Heliotropium europaeum	4%	3, 6	a, d	an	med	al	m	/	dry	?3, 4	s	s		2
Hordeum murinum	4%	19	a, d	an	high	al	m	f	dry	?3, ?4	s	s	Autumn	4
Hyoscyamus niger	9%	2, 3, 4	d	an/bi	high	al	l	f	moist	?3	s			4

Table 8.35: Characteristics obtained for species identified from sites in Hungary (of various cultural groups). Additional references: 18- http://www.cabi.org/isc/datasheet/17113; 19- Johnston *et al*. 2009; 20- Merou & Papanastasis 2009.

Table 8.35 continued						Preferred soil attributes								
	% by site (23 sites)	Add. Refs.	Habitat	Life cycle	Plant height	pH	texture	fertility	moisture	Seed bank	Reproduction	Germ. Season	Sets seed	Flowering
Lolium remotum	4%		a	an	high	n	m, h	/	moist	?1	s	a		1
Lotus corniculatus	4%	2		per	med	n, al	m	-f	dry, moist	?3	s	s		4
Lychnis flos-cuculi	4%	1	g	per	high	n	h	/	moist to wet	4	v/s			
Malva pusilla	4%	3	a, d	an/per	med	n	/	f	dry, moist		s	a+s		3
Malva sylvestris	4%	1, 2, 3, 8	a, d	bi/per	high	n	l, m	f	dry	?3	s	a+s		4
Medicago lupulina	13%	1, 2, 3	a, g	an/per	med	al	h	-f	dry, moist	4	s	s	Jun-Sept	4
Medicago minima	9%	3, 20	g	an	low	al	l	-f	dry	2 to 4	s	a/s	Autumn	1
Melampyrum arvense	4%	3	a	an	med	al	m	/	dry, moist		s	a/s		1
Melilotus albus	4%	3, 17	a, d	an/bi	high	al	l, m	-f	dry, moist	4	s	a+s	Autumn	3
Molinia caerulea	4%	2	g, p	per	high	/	m	-f	damp	2 to 4	v/s	s	Aug-Oct	2
Oxalis corniculata	4%	3		an/per	low	n	m	f	moist		v/s			3
Phleum pratense	4%	2	a, d, g, p	per	high	al			moist	1	s	a	Jun-Aug	1
Pimpinella major/saxifraga	4%	2	g, p	per	high	n, al	m		moist	2 to 4	s	s	Autumn	2
Plantago lanceolata	17%	1, 2, 3	a, d, g, p	per	high	al	m	/	dry, moist	3	v+s	a+s	Jun-Sept	3
Poa annua	4%	1, 2, 4	a, d, g, p		low	n	m	f	damp		s/v			1
Poa pratensis	13%	2	a, d, g, p	per	high	n	m	/	moist	?3	v/?s		Autumn	1
Polygonum aviculare	13%	1, 2, 3	a, d	an	high	n	l	f	damp	4	s	s	Jul-Nov	3
Polygonum convolvulus	48%	1, 2, 3, 4	a, d	an	high, T	n	m	/	moist, damp	?4	s	s	Jul-Nov	2
Polygonum dumetorum	4%	13	wd	an	high, T	n	m	/	moist, damp		s	s		2
Polygonum lapathifolium	4%	2, 3	a, d, p	an	high	n, wa	m, h	f	damp	4	s	s		2
Polygomun minus	13%	3	/	an	low	a	h	f	damp, wet	4	s	s		2
Polygonum mite	4%	3	/	an	med	n, al	m, h	f	damp, wet	4	s	s		2
Potentilla reptans	4%	1, 2, 3	a, d	per	high	n, al	h	/	damp, wet		v/?s			4
Prunella vulgaris	4%	1, 2, 3	a, d, g, p	per	med	n, al	h	/	moist	?3	v/?s		Aug-Oct	4
Ranunculus acris/repens/bulbosus	13%	1, 2, 3	all but wt	per	med	n, al	m, h				v/s		Jun-Aug	4
Rumex acetosella	9%	1, 2, 3	a, d, g, p	per	med	a	l	-f	dry, moist	4	v/s		Jun-Sept	3
Rumex acetosa	4%	1, 2, 3	a, d, g, p	per	high	wa	m	f	moist	1	s/v	a	Jun-Sept	1
Rumex crispus	4%	1, 2, 3	a, d	per	high	n	h	f	damp	4	s/v	a+s	from Aug.	3
Rumex obtusifolius	9%	1, 2, 3	a, d	per	high	n	h	f	damp	4	s	a+s	from Aug.	3
Rumex sanguineus	4%	1, 2	g, wd	per	high	n, al	h	f	damp	4	s/v	s		3

Table 8.35 continued

	% by site (23 sites)	Add. Refs.	Habitat	Life cycle	Plant height	Preferred soil attributes				Seed bank	Reproduction	Germ. Season	Sets seed	Flowering
						pH	texture	fertility	moisture					
Saponaria officinalis	13%	2, 3	a, d, wd	per	high	al	l	f	dry, moist		v			2
Schoenoplectus mucronatus	4%		g, wt	per	high	n, al	h	f	damp, wet		v/?s			2
Scirpus maritimus/lacustris	13%		wt	per	high	n	h	/	wet		v			1
Scleranthus annuus	9%	1, 2, 3	a	an	low	a	l	-f	dry	?4	s	a+s	Jun-Aug	3
Setaria glauca/pumila	4%		a, g, p	an	med	n	m	/	dry, moist	2 to 4	s	s		2
Setaria italica	4%		a, g, p	an	high	n	m	/	dry, moist	2 to 4	s	s		2
Setaria viridis/verticillata	22%		a, d	an	high	n	m	f	moist	2?	s	s		2
Sherardia arvensis	9%	2, 3, 4	a	an	med	n, al	m	/	moist	2?	s	a		4
Silene alba	4%	1, 2, 3	a, d, p		high	n, al	l	f	moist, damp	?3, 4	s	s/a		1
Solanum dulcamara	4%	2, 3	d, wd	per	high	n	h	f	moist, damp	?2	s/v	s	Aug-Oct	4
Solanum nigrum	13%	1, 3	d	an	med	n	l	f	moist	?3,?4	s	s		2
Sparganium erectum	4%	2	wt	per	high	n	m, h	f	wet		v/s			
Stachys annua	9%	3	a, d	an/per	low	al	m	/	dry, moist		s	s		2
Stellaria media	13%	1, 2, 3	a, g, d	an	low	n	m	f	moist, damp	4	s	a+s	Jun-Sept	3
Thalictrum flavum	9%		g, wt	per	high	al	m	/	damp, wet		v/s			1
Trifolium arvense	13%	1, 2, 3	a, g, d	an/bi	low	n, wa	l, m	/	dry	3	s	a		4
Trifolium pratense	4%	1, 2, 3	a, p	per	low				damp	3	s	a		4
Trifolium repens	4%	1, 2, 3	a, d, g, p	per	low	/	h	f	moist, damp	4	v/s		Aug-Oct	3 or 4
Urtica urens	4%	2, 3	a, d	an	med	n	m	f	moist	4	s	s/a	from July	3
Vicia cracca	4%	1, 2, 3	a, d, g	per	high, T	/	m	f	moist, damp	?1	v+s	a	Aug-Sept	1
Vicia tetrasperma	4%	1, 3	a, g	an	high, T	a	l	-f	moist		s	a		3
Viola arvensis	9%	1, 2, 3	a, d	an	high	n, al	/	/	dry, moist	?4	s	a+s		3
Xanthium strumarium	4%	3, 14	a, d	an	high	/	/	f	moist to wet	3	s	s		2

Sixteen of the 91 species identified from sites in Hungary are today more associated with pastures, grasslands, woodlands or wetlands than arable or disturbed land. Forty-two percent (n=38) are annuals though an additional nine species can reproduce as annuals. Forty-five percent (n=41) are perennials or biennials, and 27% (n=11) of those reproduce mainly by seed. Thirteen percent (n=12) of species do not grow above 30cm, whilst 66% (n=60) can reach at least 60cm. Nine twining species were identified. On the whole, the species prefer neutral to slightly alkaline soils of medium texture. Weakly-acidic soils are indicated by five species, including *S. annus* which is an indicator of acidic soils (Hanf 1983: 184). Ten species prefer lighter soils and 13 heavier soils. Whilst the majority of species grow in moist conditions, 21% (n=19) prefer damp to wet soils and 13% (n=12) are adapted to dry soils. Only nine species are known to germinate specifically in the autumn, and an additional four will usually germinate in the autumn. Thirty-four will germinate only in the spring and eleven can germinate in either season. The species set seed between June and November. Soil fertility and flowering onset and duration are described below.

The relative proportions of life cycles, categories of flowering onset and duration and levels of soil fertility between the seven groups are compared in Figures 8.33 to 8.38. Unlike the descriptions, the proportions are based on the minimum number of taxa per group, and not just the taxa identified to species (Chapter 6.3.3 and Table 8.28). The whole Vinča group is illustrated before it is split into its Continental and Pannonian constituents.

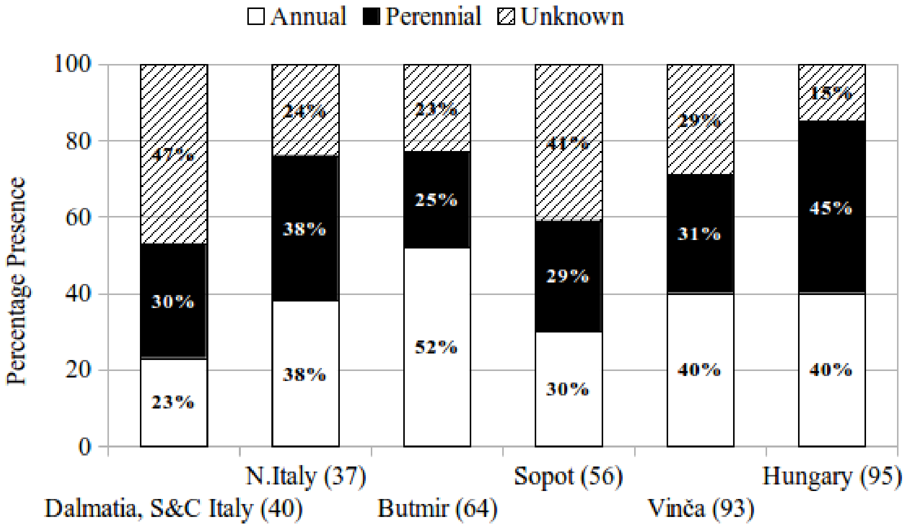


Figure 8.35: Relative proportions of annuals and perennials in the two coastal zones, the three inland cultural groups and Hungary. The percentages represent the minimum number of taxa within each group.

The northern Italian and Sopot groups had equal proportions of annuals and perennials (38%, n=14 and 30%, n=17 respectively). The Hungarian and Mediterranean groups contained slightly more perennials than annuals. The Butmir group was the only group to contain more than twice as many annuals than perennials (52%, n=33 compared to 25%, n=16). Within the Vinča group annuals were more predominant than perennials by *c*.15%, n=14.

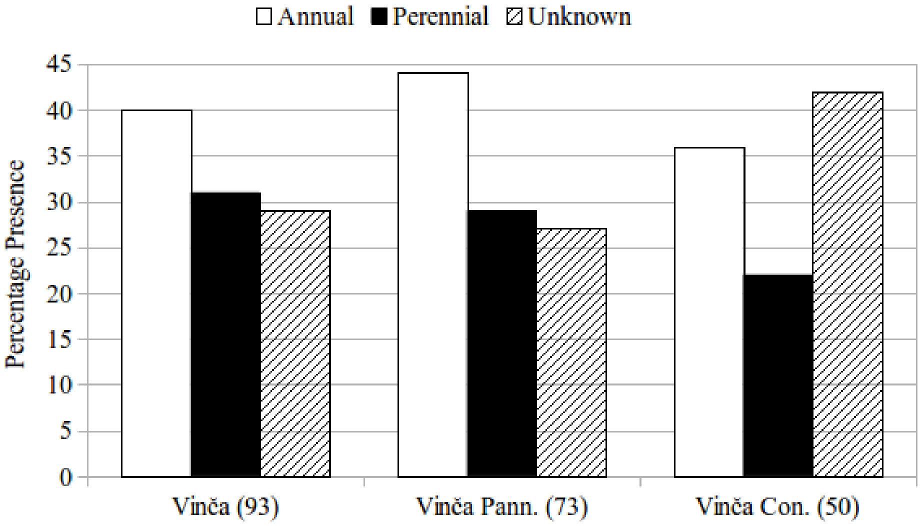


Figure 8.36: Relative proportions of annuals and perennials in the two bioregions of the Vinča cultural group. The percentages represent the minimum number of taxa within each group.

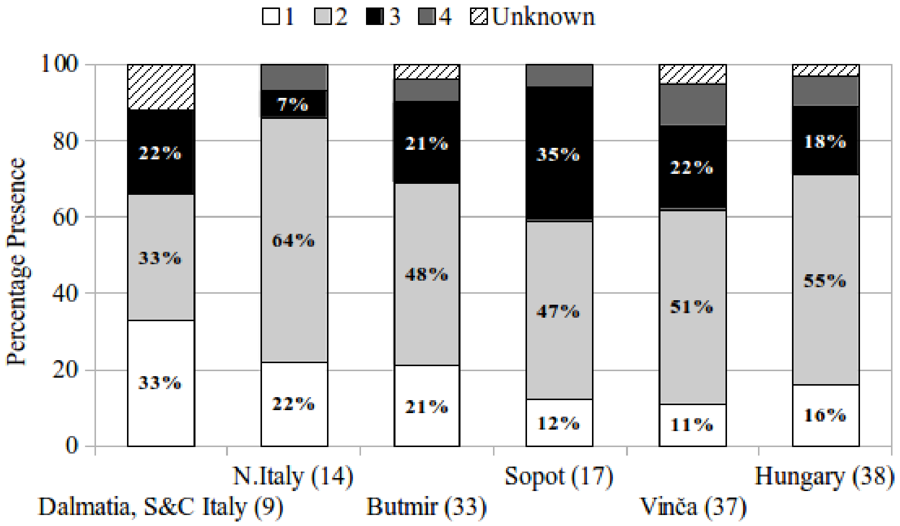


Figure 8.37: Relative proportions of flowering onset and duration categories of annuals in the two coastal zones, the three inland cultural groups and Hungary, i.e. the percentage of annuals of a particular flowering category within each region. 1 = short flowering, early to intermediate onset; 2 = late flowering, short to intermediate duration; 3 = long flowering, early to intermediate onset; 4=medium flowering duration, intermediate onset (Bogaard *et al*. 2001: Table 3).

The Mediterranean group was the only one to contain as many category 1 as category 2 plants. In the other groups, category 2 species were more frequent than those of category 1 by at least 27%. Category 4 plants were infrequent and those of category 3 were most common in the Sopot group.

They never occurred more frequently than those of category 2 but were only less frequent that those of category 1 in the coastal groups. Both the Vinča groups had large proportions of category 2 species. Category 3 species were more common in the Continental than Pannonian Vinča assemblages.

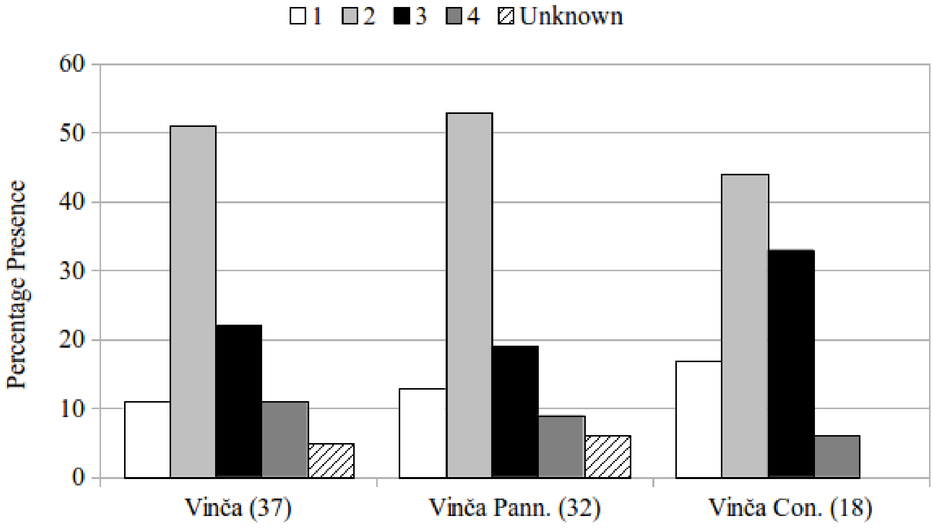


Figure 8.38: Relative proportions of flowering onset and duration categories of annuals in the two bioregions of the Vinča cultural group.

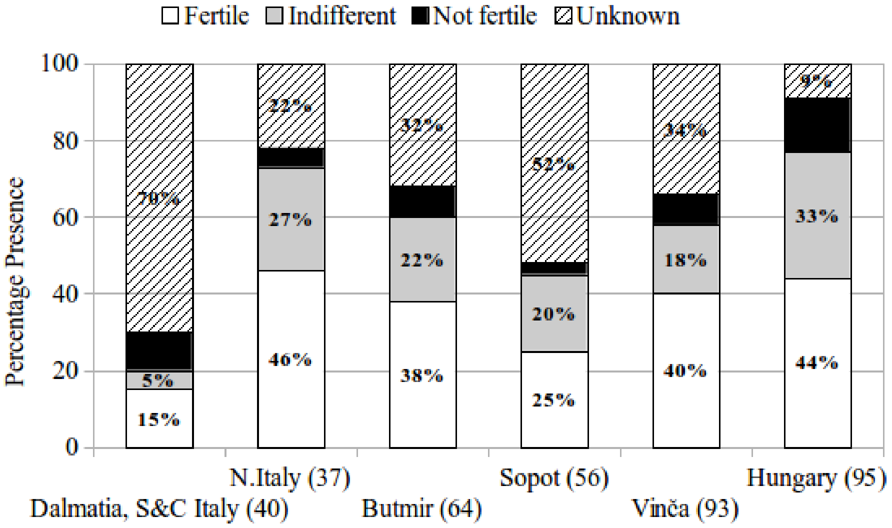


Figure 8.39: Relative proportions of soil fertility levels in the two coastal zones, the three inland cultural groups and Hungary. The percentages represent the minimum number of taxa within each group.

Species indicative of fertile soils were more frequent than those indifferent to fertility levels and those that tolerate infertile soils. The highest representation of fertile soils was found in northern Italy (46%, n=80), followed by Hungary (44%, n=42). The latter also had the highest proportion of species from infertile soils (14%, n=13), followed by the Mediterranean group (10%, n=4). Relative proportions of fertility levels were very similar in the two Vinča groups, and both are comparable to the Butmir, Sopot, Hungarian and northern Italian groups.

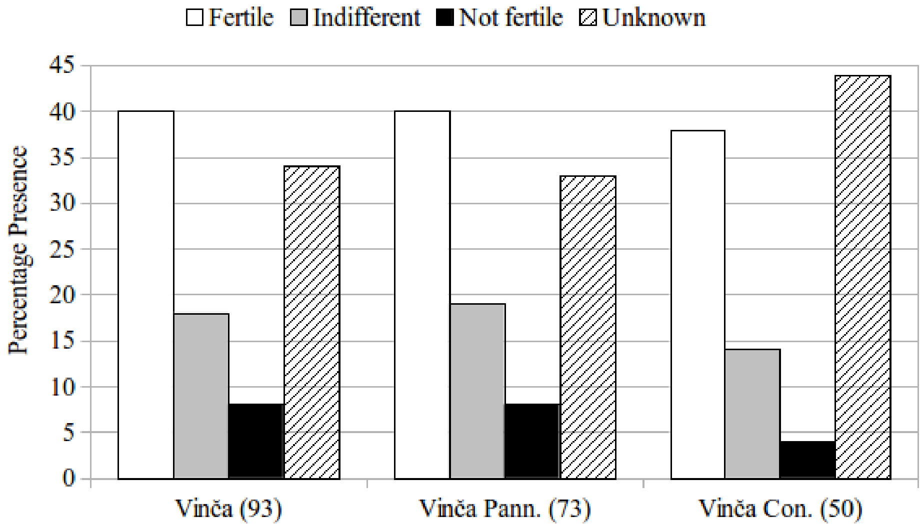


Figure 8.40: Relative proportions of soil fertility levels in the two bioregions of the Vinča cultural group. The percentages represent the minimum number of taxa within each group.

8.5 Summary

Tables 8.36 and 8.37 provide a summary of results. Table 8.36 enables results from the Early and Middle/Late phases of particular areas to be compared more easily, whilst Table 8.37 lists the main results from the additional six Middle/Late areas.

Table 8.36

		Area / Bioregion and number of sites					
		E. Med. (26)	**M/L. Med. (23)**	**E. Con. (14)**	**M/L. Con. (27)**	**E. Pann. (12)**	**M/L. Pann. (45)**
Crops	*Total	16	18	15	17	16	20
	Total excl. poppy & 'contentious' crops	13	14	12	14	12	16
	Highest frequency	92%	100%	79%	85%	83%	69%
	Taxa	Barley, emmer	Barley	Barley	Einkorn	Barley	Barley
	Lowest frequency	4%	4%	7%	4%	8%	4%
	Taxa	Gr. pea, B.vetch, Flax	Rye	C. vetch, Flax	Br. bean	C. vetch, Br.bean, Flax	C. vetch
	Taxa in ≥30% sites	Cereals, Lentil	Cereals (-rye), Lentil	Cereals, Lentil, Pea	Cereals, Lentil, Pea, B. vetch, Flax	Cereals, Lentil, Pea	Cereals, Lentil, Pea
	Taxa in ≤10% sites	Gr.pea, Br. Bean, B. vetch, Flax	Flax, Rye	B. vetch, C.vetch, Flax	Br. bean, Rye	C.vetch, Br. bean, Flax	C. vetch, Br.bean
Edible fruits and nuts	Total	9	15	7	11	10	12
	“Total in >5% of sites	5	7	7	9	5	11
	Highest frequency	15%	26%	50%	44%	58%	33%
	Taxa	Berries	Berries	Corn.cherry	Corn.cherry	Elder	Corn.cherry
	Lowest frequency	4%	4%	7%	4%	8%	2%
	Taxa	Corn.cherry, Elder, Dogwood, Olive, Dog-rose, Caper	Dogwood, Fig, Olive, Pistachio, Juniper, pine	Hazel-nut, Grape, Prunus	Dog-rose, Juniper	Berries, Grape	Pine
	Taxa in ≥30% sites	0	0	Corn.cherry	Corn.cherry, Hazel-nut, Elder, Berries	Corn.cherry, Elder	Corn.cherry, Elder
	Taxa in ≤10% sites	Grape, Corn.cherry, Elder, Dogwood, Olive, Dog-rose, Caper	Hazel-nut, Prunus, Almond, Dogwood, Fig, Olive, Pistachio, Juniper, pine	Hazel-nut, Grape, Prunus	Grape, Dogwood, Dog-rose, Juniper	Berries, Grape	Zazel-nut, Apple/pear, Grape, Acorns, Hawthorn, Pine
	% sites with 'weeds'	58%	87%	57%	81%	83%	80%
	Total taxa	53	56	28	127	69	183
	Total species	14	13	9	57	40	124
	in >1 site	2	2	3	29	9	58
	% annuals	36%	23%	47%	30%	45%	31%
	% perennials	14%	30%	5%	20%	28%	30%
Height	Low, <30cm	11%	2%	0%	6%	11%	4%
	Medium, 30-60cm	8%	5%	11%	11%	17%	7%
	High, >60cm	19%	16%	42%	28%	47%	56%
Most frequent soil attributes	pH	7 to 8	7 to 8	7	7 to 8	7 to 8	7 to 8
	Texture	Medium, light	Medium	Medium	Medium	Medium, light	Medium
	Fertlity	Fertile	Fertile	Fertile	Fertile	Fertile	Fertile
	Moisture	Moist	Moist, dry	Moist	Moist	Moist	Moist, damp
	Most common flowering categories	3 (38%) 2 (31%)	1 & 2 (33%)	2 (56%) 1 & 3 (22%)	2 (47%), 3 (24%)	2 (42%) 1 & 3 (25%)	2 (46%), 3 (23%)

Table 8.36: Summary of results from the Early Neolithic areas and corresponding Middle/Late Neolithic areas.

Table 8.37		**Area / Bioregion and number of sites**					
		Coast- Con. (15)	**Butmir** (9 sites)	**Sopot** (11 sites)	**Vinča** (Con. 14)	**Vinča** (Pan. 5)	**Hungary** (31 sites)
Crops	*Total	15	17	18	15	14	17
	Total excl. poppy & 'contentious' crops	11	14	14	12	11	15
	Highest frequency	87%	89%	82%	86%	100%	71%
	Taxa	Einkorn	Einkorn	Einkorn	Emmer	Einkorn & Emmer	Barley
	Lowest frequency	7%	11%	9%	7%	20%	3%
	Taxa	Gr. pea, B.vetch	Br. bean, Rye	C. vetch, Br.bean	Rye	Br. bean	B. vetch, C.vetch, Br. Bean
	Taxa in ≥30% sites	Cereals (-rye), Lentil, Pea, Flax	Cereals (-rye), Lentil, Pea, Gr.pea, Flax	Cereals (-rye), Lentil, Pea, Flax	Cereals (-rye), Lentil, Pea	Cereals (-rye), Lentil, Pea, B.vetch	Cereals (-rye), Lentil
	Taxa in ≤10% sites	Gr. pea, B.vetch	0	C. vetch, Br.bean	Rye	0	Rye, Flax, B. vetch, C.vetch, Br. Bean
Edible fruits and nuts	Total	14	10	7	7	10	10
	"Total in >5% of sites	14	10	4	7	10	4
	Highest frequency	93%	78%	45%	45%	100%	26%
	Taxa	Hazel-nut	Hazel-nut	Elder, C.cherry	Elder, Corn.cherry	Berries, Elder, Corn. Cherry	Prunus
	Lowest frequency	7%	11%	9%	21%	20%	3%
	Taxa	Wtr.chestnut, Fig, Walnut	Prunus, Juniper	Hawthorn, Prunus	Prunus, Hazel-nut, Apple/pear	Acorn	Grape, Hawthorn, Pine
	Taxa in ≥30% sites	Hazel-nut, Elder, C.cherry, Acorns, Prunus, Apple/Pear	Hazel-nut, C.cherry, Berries, Elder, Apple/Pear, Bl.cherry	Elder, C.cherry	Elder, Corn.cherry	Hazel-nut, C.cherry, Berries, Elder, Apple/Pear, Bl.cherry, Grape, Prunus, Wtr.chestnut	0
	Taxa in ≤10% sites	Wtr.chestnut, Fig, Walnut	0	Hawthorn, Prunus	0	0	Berries, Apple/Pear, Wtr.chestnut, Acorn, Grape, Hawthorn, Pine
	% sites with 'weeds'	47%	100%	91%	36%	100%	74%
	Total taxa	49	83	74	72	94	112
	Total species	29	45	29	28	52	91
	in >1 site	3	22	7	13	15	40
	% annuals	38%	52%	30%	36%	44%	40%
	% perennials	38%	25%	29%	22%	29%	45%
Height	Low, <30cm	6%	6%	5%	4%	9%	11%
	Medium, 30-60cm	12%	16%	7%	7%	14%	17%
	High, >60cm	41%	33%	27%	28%	33%	54%
Most frequent soil attributes	pH	7 to 8	7 to 8	7 to 8	7 to 8	7 to 8	7 to 8
	Texture	Medium	Medium	Medium	Medium	Medium	Medium
	Fertlity	Fertile	Fertile	Fertile	Fertile	Fertile	Fertile
	Moisture	Moist	Moist	Moist, damp	Moist	Moist, damp	Moist, damp
	Most common flowering categories	2 (64%), 1 (22%)	2 (48%), 1&3 (21%)	2 (47%), 3 (35%)	2 (44%), 3 (33%)	2 (53%), 19%)	2 (55%), 3(18%)

Table 8.37: Summary of results from Middle/Late Neolithic Northern Italy, the three inland cultural groups of the western Balkans and Hungary.

The results are summarised in the following points:

-Crops

- The difference in the range of plant taxa recovered from Early and Middle/Late Neolithic sites is more likely to be due to preservation than differences in the importance or relevance of cultivation (section 8.1);
- The presence of four crops needs to be further evaluated: oat was only identified from grains, dating programmes of millet suggest Neolithic finds are intrusive, some spelt may have been wrongly identified, and the 'new' type may be more extensively present;

- Hulled and naked barley, emmer, einkorn, free-threshing wheat, lentil, pea and flax were found across the research area throughout the Neolithic (Table 8.7);
- A reduced diversity in the Early Neolithic crop package is evident compared to the Greek and Bulgarian ones: chickpea was abandoned and grass pea and bitter vetch became less frequent (section 8.2.1);
- This drop in diversity cannot be purely a result of colder temperatures, as temperatures were not reduced along the coast, and inland pulses could have been sown in the spring (section 8.2.4);
- Differences in crop assemblages between the two routes of Neolithisation are not evident in the range of crops, but more in the relative proportions of crops within regions, suggesting that particular crops were preferentially used in different regions (Figure 8.4);
- This difference continues into the Middle/Late phase, where it is also evident between bioregions and cultural groups (section 8.2.2.5);
- Rye first appears during the Middle/Late phase but its scarcity implies it was a crop contaminant (Table 8.8);
- Free-threshing wheat became more common during the Middle/Late phase, particularly along the coast (Figure 8.9);
- The vetches, grass pea, broad bean and flax were also found more regularly during the Middle/Late phase, suggesting delayed adaptations or a (re)-introduction of crops (Table 8.8);
- The difference in diversity indices of crop assemblages between phases is only statistically significant for coastal sites, suggesting that crop richness increased significantly. Inland, the richness in the range of crops did not vary significantly between phases (Figure 8.16);

-Edible Fruits and Nuts

- A drop in diversity between the Early Neolithic of the research area compared to Greece and Bulgaria is also evident in the range of utilised fruits and nuts (section 8.3.1);
- During the Early Neolithic coastal sites seem to have relied more heavily upon cereals than fruits and nuts, whereas the latter were more frequently used on Pannonian sites. A range of exploitation strategies is seen on Continental sites (Figure 8.20, left);
- During the Early Neolithic a greater range of fruits and nuts were more frequently found inland, particularly in Pannonia, than along the coast (Figures 8.22 and 8.23);
- During the Middle/Late Neolithic the range of fruits and nuts increased in Dalmatia and s/c Italy, but remained relatively low compared to inland regions and northern Italy (Section

8.3.3);

- By the Middle/Late Neolithic an increase in the diversity of exploitation strategies is seen within and between bioregions, and no particular strategy can be assigned to a specific area (Figure 8.20, right);
- Differences in the use of fruits and nuts can be seen between the inland cultural groups. Sopot sites used the narrowest range (Figure 8.28);
- The difference in diversity indices of crops and fruit and nut assemblages between phases is only statistically significant for coastal sites, suggesting that richness in crops and fruits and nuts increased significantly (Figure 8.17). This result is influenced by the large assemblage of fruits and nuts used in northern Italy (Figure 8.26). Inland, a similar range of fruits and nuts was used during both phases and so the richness did not vary significantly (Figures 8.18 and 8.19);

-Arable weeds

- Arable weeds from Early Neolithic sites provide some evidence as to the provenance of farmers, and suggest a predominantly Bulgarian origin for the inland weed assemblages. The origin of the smaller coastal weed assemblage is difficult to detect (Tables 8.24-8.26);
- Evidence for woodland clearing and shifting agriculture is missing as the majority of perennials are not woodland species and tolerate a high level of disturbance (Tables 8.22 and 8.28);
- Husbandry practices did not vary noticeably between phases and are characterised by an intensive form of cultivation that involved maintaining high levels of fertility, controlling weeds, and maintaining good soil moisture levels (Figures 8.32-8.40);
- Evidence for both autumn and spring-sowing is present, though spring-sowing may have been less common along the coast (Figures and 8.31 and 8.37). This evidence is corroborated by results from the temperature reconstructions. Despite uniformitarian assumptions on the temperature thresholds of crops, results suggest that in Dalmatia and s/c Italy crops could have been sown in the autumn. In northern Italy and elsewhere inland the pulses would have faired better if sown later in the spring. Lower summer and winter temperatures are recorded for the Middle/Late phase and a greater reliance on spring-sowing inland may have been necessary.

CHAPTER 9

Discussion of the Results of the Literature Survey on Neolithic Archaeobotanical Data in the Research Area

This discussion begins by evaluating the range and usefulness of the various types of data collated in the previous chapter, and the methodology used to overcome difficulties in searching for broad patterns. Differences in the presence of taxa between site types and possible effects of preservation are discussed in section 9.2. Before results are discussed by period, the presence of problematic crops, rye, opium poppy, flax and two-grained einkorn are discussed. These are presented separately as taxa pertain to both phases and more emphasis is placed on the origins, distribution and use of individual taxa. Section 9.4 covers the Early Neolithic of the research area (*c*.6100-5400 cal. BC), and section 9.5 the Middle/Late Neolithic (*c*.5400-4500 cal. BC).

9.1 The dataset

The units of analysis, determined by catchment, bioregion, period and cultural affinities, enable the description of large-scale spatial and diachronic patterns in the cultivation of crops and use of edible fruits and nuts. The aim is not to describe agricultural practices at a site-level (as per Chapter 7), but rather for groups whose boundaries are already defined. As such, effects or influences of ecology, environment and culture can be assessed and results can contribute to ongoing debates about what shaped the Neolithic crop packages (e.g. Bogaard & Halstead 2015; Colledge *et al*. 2004, 2005; Colledge & Conolly 2007; Coward *et al.* 2008; Halstead 1994).

The archaeobotanical records vary considerably in the levels of identification, quantification and details of recovery (Tables 8.1-8.4). Differences in the quantity and quality of archaeobotanical records reflect variations in preservation and archaeological practices. Some countries, such as Croatia and Serbia, have recently seen more detailed publications in easily accessible journals (Filipović 2014; Filipović & Obradović 2013; Reed 2015; Reed & Colledge 2016; Reed & Podrug 2016). Most reports from Hungary show a high level of confidence in the identification of plant remains, but seldom include details of recovery and quantification. Notwithstanding J. Renfrew's (1974) work at Obre, the importance of archaeobotanical investigations has only recently been recognised in BiH. Reports from Italy are usually stored in county museums and only easily accessible in summary format (some are available online). The difficulty of combining and comparing such 'uneven' data is somewhat overcome by using only the presence of taxa by site (Colledge *et al*. 2005: 152). The presence/absence of archaeobotanical data has been successfully used to explore large-scaled diachronic and spatial variations (e.g. Colledge *et al*. 2004; Colledge & Conolly 2007; Coward *et al.* 2008; Hubbard 1975; 1980), even though it could be a truer reflection of where taxa were *found*, rather than where they were *present*. Amalgamating records into larger units of analysis may reduce possible biases present in individual site records, but it is important to remember that results presented here pertain to a group, and not necessarily to individual sites.

9.2 Site types and preservation

The relative paucity of plant remains from Early Neolithic sites (Tables 8.5 and 8.6), does not necessarily suggest that the cultivation of crops was less important or frequent during the initial spread of farmers across the research area (*contra* Barker 2006: 356; Greenfield *et al*. 2014: 27; Zvelebil & Lillie 2000 amongst others). Overall, Early Neolithic sites in the western Balkans appear ephemeral and temporary compared to settlements further south and east, with little evidence for upstanding architecture or storage pits indicative of prolonged occupations (*cf*. Bailey 2000: 57; Barker 2006: 353-56; Chapter 3.3.2). These characteristics have been associated with the rapid spread of people across the western Balkans (Chapter 3.1), and/or the neolithisation of local Mesolithic populations (Chapter 3.2). However, architectural differences with the more substantial contemporary Greek and Bulgarian settlements, and the Middle/Late Neolithic sites of the western Balkans must also be extended to contrasting preservation conditions (Halstead 1989: 26; 2011: 135-36; Perlès 2001: 66-72; Marinova & Krauss 2014). Table 8.6 suggests that plant remains are more common on tell sites, possibly because such sites generate greater archaeological interest, or because the higher concentration of people and plants and the rapid burial of burnt waste led to improved preservation conditions. Some Early Neolithic sites have more taxa than some Middle/Late Neolithic ones, and they have the same range of crops as those from Greece and Bulgaria (the only difference is between broad bean and chickpea – see below). The zooarchaeological data shows that, overall, Early Neolithic communities relied more heavily upon domesticates than wild fauna, and that hunting only increased during the Middle/Late Neolithic (Manning *et al*. 2013a; Orton 2012; Orton *et al*. 2016; Chapter 3.3.2). The same can be said for the use of wild plants which increases during the later Neolithic in all analysed areas. The diversity of crops also increases during the Neolithic but the ubiquity scores do not: barley, emmer and einkorn were more frequently found on Early than Middle/Late sites (compare Figures 8.3 and 8.8). Therefore, rather than indicative of a highly mobile or 'hunter-gatherer' lifestyle (e.g. Forenbaher & Miracle 2005; Tringham 1971) the scanty remains of Early Neolithic settlements could result from small communities building with non-durable, organic materials and using portable ceramic or organic storage vessels. There is no reason why burnt waste would have accumulated on such settlements. The analysed data show that cereals were ubiquitous on Early Neolithic sites, and that the small range of crops at some sites is more likely to result from adverse preservation conditions and inadequate sampling than a 'semi-agricultural' lifestyle.

The similarity in the quantity of taxa between Middle/Late neolithic cave and open-air sites (Table 8.6) is surprising as the former are usually interpreted as seasonal camps or shepherd's shelters where cereal processing or storage is not assumed to have occurred (Bonsall *et al*. 2013: 152; Miracle & Forenbaher 2005; Mlekuž 2003: 146-48; 2009). Plant remains from Grapčeva cave in Dalmatia (site 180) mainly consist of fruits and nuts with a few cereal grains and lentil. Wild/weed seeds and cereal chaff indicative of processing are absent, and the cave has been interpreted as a site that was occasionally visited, possibly for ritual purposes (Borojević *et al*. 2008). Turska pećina, also in Dalmatia (site 184), has been interpreted as a shepherd's shelter from the grey horizon of possible dung (Reed 2015: 615). Numerous charred wild plant seeds, namely consisting of 4,732 fat-hen seeds, were retrieved from the latter layer and interpreted as the burning of dung (Reed 2015: Table 5, 615), despite the absence of dung fragments. Cereal grains, chaff, pulses and fruits (*Prunus* sp.) mixed with wood charcoal were recovered from a different area of the cave (Reed 2015: 615), suggesting that dung was not burnt in domestic fires. The plant remains from Turska pećina seem to suggest that it was occupied by humans and their animals and was more than just a temporary shelter. The three caves in southern Italy (sites 190, 193 and 194) contained cereal grains, pulses and a few cereal grain-like 'weeds' (*Avena* sp and *Bromus* sp.) but no fruits or nuts (Table 8.4). The absence of conclusive evidence for cereal processing may indeed point to occasional or seasonal occupancy. It is interesting to note that at four of the five cave sites whole clean grains were used (rather than/in addition to bread or flour). Raw grain would keep longer than processed food and its presence at temporary/seasonal shelters offers supporting evidence for long-distance transhumance (Mlekuž 2003, 2009).

9.3 'Problematic' crops and other taxa of uncertain status

Oat

Domesticated oat is claimed to have been found at five Neolithic sites in the research area, all in eastern Italy. The identifications are all based on 14 or fewer caryopses however, and must remain contentious. So far, oat awns are the only elements of chaff published (Filipović & Obradović 2013: 44). As noted by van Zeist (2001: 94-95), in the absence of oat floret bases no distinction can be made between the wild and cultivated species. The grains may indeed belong to wild *Avena*, as the earliest evidence for *A. sativa* from the research area come from the Late Bronze Age site of

Mačkovac-Crišnjevi in Croatia, where three deposits of clean grains and spikelets were discovered (Reed 2012: 153). Even the latter finds are considered unusually early, as other secure identifications suggest that oat was not cultivated in Europe until the Iron Age (Bakels 1999: 73; 2009: 101; Buxó *et al*. 1997: 22; Filipović 2014: 199; Gyulai 2010a; Hubbard 1980: 62; Marinova *et al*. 2012: 418; Rösch 1998: 117; Sherratt 1980: 321; van Zeist 1975: 321; 2001: 109).

Millet

The presence of *Panicum miliaceum* seeds in Neolithic assemblages from Europe is contentious. Seeds from Neolithic contexts have been dated to much later periods, highlighting the high propensity for these small, round seeds to move within soil profiles and the necessity to date them directly (Hunt *et al*. 2008; Motuzaite-Matuzeviciute *et al*. 2013). The earliest archaeobotanical seeds come from north-eastern China and date to *c*.6000 BC (Miller *et al*. 2016: 1567; Stevens *et al*. 2016: 1544-5; Zhao 2011). Directly dated seeds indicate that the crop was cultivated in eastern Kazakhstan during the late third millennium BC, and that it began to spread south by the mid-second millennium BC (Miller *et al*. 2016: 1568; Stevens *et al*. 2016: 1545). It is not usually considered to have been cultivated in Europe until the Bronze Age (e.g. Bakels 2009: 100; Colledge *et al.* 2005: 143; Filipović & Obradović 2013: 19; Kroll 1998: Table 1; Reed 2015: 612; Rottoli & Castiglioni 2009: 100; Rösch 1998: 121-2; van Zeist 1975: 320; 2001: 109; Valamoti 2016). Sporadic finds of seeds in Neolithic levels are sometimes described as a crop weed (Boivin *et al*. 2012: 459; Filipović 2014: 199; Kreuz *et al*. 2005: 243), although those from the SKC sites are highly insecure (Filipović 2014: 198; Filipović & Obradović 2013: 18; Chapter 8.2.1.2). The most numerous finds from the research area were found in Hungary where they, along with sporadic Körös finds, have been dubiously interpreted as evidence for the early cultivation of millet in the Carpathian Basin (Gyulai 2014a). In Serbia, Filipović (2014) notes that the “few” seeds from Vinča Belo-Brdo (site 106) “may be intrusive from the layer of Bronze/Iron Age pit-features directly overlying the terminal Neolithic level” (2014: 208). At Gomolova (site 107) 648 seeds across 56% of Vinča samples led van Zeist to conclude that, like hulled barley, “millet had a modest role in Vinča times” (van Zeist 2001: 109). Although the seeds were frequent, concentrations of more than 1.6 seeds/L of sediment were only found in three samples, with 2.9, 5.6 and 5.8 seeds/L (van Zeist 2001: Table 2). The Vinča-Pločnik levels were covered by later phases during which millet was cultivated, and until stratigraphically-older seeds are dated, millet cultivation (to any degree) cannot be assumed to have been practised during the Neolithic (*cf*. Hunt *et al*. 2008; Motuzaite-Matuzeviciute *et al*. 2013). Motuzaite-Matuzeviciute and colleagues (2013: 1081-2) warn that millet impressions (such as those from Middle/Late Adorjánháza-Kenderáztató site (153) and

Zánka-Vasúti bevágás (site 155)) should also be viewed with caution, as they can easily be confused with those of *Setaria* ssp. and *Echinocloa crus-galli* (see also Fuller 2003).

Spelt

Like millet, European spelt was not part of the original Near Eastern crop package (Zohary *et al*. 2012: 49-50). It evolved from an introgression (hybridisation followed by back-crossing) of hexaploid bread wheat and emmer, suggesting that spelt first emerged as a cereal weed (Blatter *et al*. 2004; Dvorak *et al.* 2012). Although sporadic finds of spelt are recorded from Neolithic contexts in Europe (a small number can be expected to occur where both bread wheat and emmer were grown), it does not become an important crop until the Bronze and Iron Ages (Bakels 1999: 73; 2009: 100; Buxó *et al*. 1997: 20; Gyulai 2010a; Hubbard 1980: 61; Jacomet 2006b: 79; Marinova & Valamoti 2014: 68; Nesbitt 2001: 51; Rösch 1998: 115; Rottoli 2006: 245; Rottoli & Castiglioni 2009: 100; Sherratt 1980: 319; Tereso *et al*. 2016: 53; Valamoti 2007: 91). Despite its Bronze Age cultivation in Greece and Bulgaria, spelt is unlikely to have been an important crop in Serbia before the Iron Age (Filipović 2014: 198; Reed 2012: 152; van Zeist 2001: 109). Spelt remains in Neolithic levels are problematic, particularly when identifications are based on a few grains which could in fact be emmer or the 'new' type (*cf.* Hillman 1996: 204-6; Nesbitt & Samuel 1996: 54-56). Identifications of chaff are difficult as spikelets can resemble those of *Aegilops cyclindrica* and *A. tauschii* (Nesbitt 2001: 54). The strong venations on the glumes could also be mistaken for those of the 'new' type (Zohary *et al*. 2012: 50), and all identifications made before the description of the latter should be viewed with caution. Five sites from the research area have records of spelt chaff that post-date the first published description of the 'new' type. These sites are all from the Middle/Late Neolithic and are located in central BiH and eastern Croatia. Finds from Jagnilo (site 71) and Zagrebnice (site 76) were identified by Dr. H. Kroll and those from Ravnjas-Nova Kapela (site 83), Sopot (site 87) and Turska Pécina (site 184) by Dr. K. Reed. None of the sites contained more than four glume bases, and none of the remains, or the assemblages they were retrieved from, were directly radiocarbon dated. Nevertheless, they are not reported to have been retrieved from insecure contexts and the Neolithic presence of spelt in the northern Balkans may point to a new early centre of origin for European spelt.

'New' glume wheat

The 'new' glume wheat was first identified from three Late Neolithic and one Bronze Age site in northern Greece (Jones *et al*. 2001). Calculations of the proportions of diploid and tetraploid spikelets, based on expected grains and glume bases, on the well preserved assemblage from

Assiros suggest that the 'new' type was a tetraploid wheat (Jones *et al.* 2000a: 135-6). Morphological comparisons of spikelet forks and grains have confirmed its similarity to the tetraploid T. timopheevi Zhuk. (Jones *et al.* 2000a: 136-9; Kohler-Schneider 2003: 109-10), that was probably domesticated from *T. araraticum* Jakubz. (Zohary *et al.* 2012: 51). Since its first descriptions it has been found on many more Neolithic and Bronze Age sites, from Turkmenistan and Anatolia, through the Balkans and Bulgaria, to Italy, central and western Europe (e.g. Bogaard *et al.* 2007a; Bogaard *et al.* 2017; Charles & Bogaard 2010; Degasperi *et al.* 2006; Fuller 2007: 908; 2008: Fig.12; Filipović 2014: 198; Marinova & Valamoti 2014: 67-8; Reed 2015; Rottoli 2006: 248; Schaal unpublished). The increase in the 'new' type seen between the Early and Middle/Late periods of the research area may simply reflect the state of investigations, and many assemblages would have to be reviewed before one could confirm its absence from sites excavated before the 21st century. To date, recovered remains from sites in the western Balkans and Italy suggest that it was a minor contaminant of other crops, perhaps grown as a maslin, rather than a cultivated crop in its own right.

Rye

In Europe rye cultivation is associated with the Iron Age and Roman period (e.g. Bakels 1999: 73; 2009: 166; Behre 1992; Küster 2000; Megaloudi 2006: 49; van Zeist 2001: 109). Neolithic and Bronze Age finds are rare, both in South-West Asia and Europe, and those from Europe are usually considered wild or weedy types (Behre 1992: 142-3; Colledge *et al.* 2005: 143; Colledge & Conolly 2007; Filipović 2014: 199; Fuller 2007: 908; 2008: 123; Kohler-Schneider & Caneppele 2009: 72; Lucas *et al.* 2012: Table 4; Megaloudi 2006: 49; Reed 2015: 605-6; van Zeist 1975: 312; 2001: 109). The larger quantities of rye from the research area came from Hungary, where Gyulai (2014b) has made an exceptional claim for its early cultivation as a domesticate from the Fertile Crescent. However, difficulties in its identification have since been published, particularly regarding its similarity to *Dasypyrum villosum*, which led to the re-classification of possible rye grains from the Bronze Age site of Feudvar (Serbia) (Kenéz *et al.* 2014; Reed 2015: 605). Küster (2000) has suggested that European rye was domesticated locally from a weedy variety in the Late Bronze Age or Iron Age (*c.*1000 BC), which would make it a different species to rye reported as cultivated in the Neolithic Near East (Fuller 2007: 908). A wild rye, possibly *S. montanum*, may have been cultivated and even domesticated during the Late Epipaleolithic and Pre-Pottery Neolithic in northern Syria (Hillman *et al.* 2001; Willcox *et al.* 2008), illustrating the variability of weedy rye types and their propensity to thrive under cultivation (Zohary *et al.* 2012: 659-62). Whether a local domestication occurred in the western Balkans or Hungary, or whether rye crops were introduced from elsewhere during the Iron Age/Roman period remains to be ascertained.

Two-grained einkorn

Two-grained einkorn increases from a single find during the Early Neolithic (site 36), to finds from nine sites during the Middle/Late Neolithic (Chapter 8.2.2.1). These findings all represent low concentrations and two-grained einkorn was never more ubiquitous or numerous than the single-grained variety. Experimental cultivation of wild einkorn at Jalès (France) showed that twinned-grained spikelets could be produced under favourable growing conditions (Willcox 1999: 114). Based on these results, Kreuz and Boenke suggested that the emergence of two-grained einkorn during the second phase of the LBK might be indicative of a longer growing season (autumn-sowing) and/or an ameliorated climate (2002: 138). Conversely, further research now supports the hypothesis that the two forms of einkorn were domesticated independently (Fuller *et al*. 2012: 619-20; van Zeist 1999: 354; Willcox 2005: 537). The introduction of two-grained einkorn into Cyprus has been linked to contacts with the mainland and the importation of new crops during the PPN-B (Lucas *et al*. 2012: 122-24). The simultaneous cultivation of 2-grained einkorn in the western Balkans and the LBK (but not in Italy or the western Mediterranean), may either indicate a fresh importation of new crops, or the gradual isolation of a crop already present but not hitherto recognised in its own right.

Flax

Linum usitatissimum is an annual plant that requires nutrient rich, damp to wet soils (McCorriston 2013: 334; Zohary *et al.* 2012: 101). It is a temperate weather crop and can be sown in both winter (November for a May harvest) and summer (March/April for a July/August harvest), depending on winter temperatures (Akin 2010: 89). The ubiquity of flax increased considerably between the Early and Middle/Late Neolithic periods, both inland and along the coast. In the Mediterranean bioregion it increased by 5% and a third of the Middle/Late northern Italian sites contained flax seeds. In the Continental area it rose by 26% and in Pannonia by 10%. In the Butmir and Sopot groups it was as common as lentil and pea, and was much more frequent on Continental Vinča sites than their Pannonian counterparts (Figures 8.12 and 8.13). Although the rise in flax indicates that its importance increased during the Neolithic, it is difficult to know whether that reflects the production of seeds and/or fibres. Flax plants and textiles are very unlikely to be preserved through carbonisation, and their oily seeds also disintegrate rapidly (Märkle & Rösch 2008: S261). Genetic studies have shown that the plant had a single domestication origin from *L. bienne* in the Near East, selecting the production of larger oily seeds first, prior to taller fibrous plants (Allaby *et al.* 2005;

Fu 2011). However, the earliest finds of woven textiles and large seeds indicative of the production of oil both date to the Pre Pottery Neolithic B (Alfaro Giner 2012; van Zeist *et al*. 1975; Zohary *et al*. 2012: 103-5), and the plant may have always been cultivated for both its seeds and fibres (Fuller *et al*. in prep; McCorriston 2013: 334). Flax was extensively grown during the Pre-Pottery Neolithic the Near East, but not in Anatolia where finds are extremely rare (Fuller *et al*. in prep). Nevertheless, a trade in linen textiles may have existed, as is apparent from woven linen discovered at Çatalhöyük, dating to *c*.6500-6400 cal. BC (Fuller *et al*. 2014c: 121-22). Flax was common in the Neolithic of northern Greece, and a reduction in seed size evident at the Early Bronze age site of Archondiko is suggested to reflect the cultivation of a variety selected for its fibres (Valamoti 2011). Large waterlogged concentrations of flax seeds are not uncommon on Late Neolithic sites in Germany, Slovenia and Switzerland (*cf*. Bogaard 2011: 37-8; Herbig 2009: Fig.6; Jacomet 2009: Fig.3; Kreuz 2007: 269-70; Rösch 1998: 116-17), and fibres were also clearly used for textiles (*cf*. Médard 2010). Morphometric analyses of flax seeds from wetland sites around Lake Constance suggest that a variety grown purely for its fibres (with smaller seeds) was only selected in the Late Neolithic (Fuller pers. comm. 16/06/17; Herbig & Maier 2011; see also Maier & Schlichtherle 2011).

In the Neolithic of the Western Balkans flax was seemingly used for both its fibre and nutritive qualities. Waterlogged finds of flax in the research area come from Palù di Livenza (site 216), where seeds and capsules made up 30-40% of the plant macro-remains (Corti *et al*. 1998: 1306). Other finds included in this thesis are all of charred seeds, though impressions of weaved fibres are known from the Early Neolithic site of Győvmaendröd (site 26: Gyulai 2010a: 72), the Late Neolithic site of Vinča Belo-Brdo (site 106: Ninčić unpublished data, cited in Filipović & Tasić 2012: 11) and other Middle/Late Neolithic settlements (Filipović pers. comm. 17/06/17). Flax textiles and cord were found at Opovo (site 108: Tringham *et al*. 1992: 378). Additionally, loom-weights and ceramic vessels possibly associated with the production of flax fibres are also quite common, particularly in the later phases (e.g. Perić 2017: 4; Filipović pers. comm. 17/06/17). Finds suggestive of linen production are also known from Transylvania, where spindle whorls and impressions of textiles made from vegetal fibres have been recovered from Early and Late Neolithic sites (Mazăre 2014). During the Neolithic of the western Balkans flax was evidently grown for both its fibres and its seeds, and the importance of both these commodities are likely to have increased as populations expanded (*cf*. Karg 2011). Varieties cultivated specifically for fibre production seem to have been a later development, and may indicate an intensification and diversification in cultivation practices as plentiful harvests of good quality fibres would have required dense sowing on nutrient-rich, weed-free, damp to wet soils (Akin 2010: 89; McCorriston 2013: 334).

Opium poppy

Opium poppy has not been recovered frequently enough or in sufficient concentrations to suggest that it was cultivated in the research area. The small seeds (*c*.1mm when fresh, Fritsch 1979) would have been eaten whole (perhaps as a culinary ingredient) or crushed to produce oil. These processes do not require the seeds to be directly exposed to fire, and even if charred, the fragile, oily seeds are unlikely to survive (Märkle & Rösch 2008: S261). Like flax therefore, both the processing of the seeds and their susceptibility to destruction by fire mean that their archaeological distribution is heavily biased by levels of preservation. Furthermore, carbonised poppy seeds will only be retrieved via flotation/sieving if a fine mesh, *c*.300μm, is used. Most of the larger assemblages are of waterlogged concentrations (e.g. Herbig 2009: Fig.6; Jacomet 2009: Fig.3; Rösch 1998: 116-17). The identification of poppy to its cultivated form presents an additional difficulty in defining its status as crop or wild/synanthropic weed. The size and seed coat structure of the domesticated poppy seed is highly variable and cannot be conclusively distinguished from its wild form (*P. somniferum* subsp. s*etigerum*), with which it is fully inter-fertile (Fritsch 1979; Hammer 1981). Evidence for its cultivation must therefore depend upon the ubiquity and concentration of finds, as well as on the natural locations of wild form(s). The modern geographical distribution of *P. somniferum* subsp. s*etigerum* encompasses the western Mediterranean Basin (Zohary *et al*. 2012: Map 14), and the absence of Neolithic specimens east of that area does indeed indicate a western and/or central Mediterranean origin (Bakels 1982, 1992, 2009: 56). The exception is the find of a single waterlogged, presumably wild poppy seed (*P. segiterum*) from the Pre Pottery Neolithic C site of Atlit Yam (Israel), which raises the possibility that the distribution of wild forms differed *c*.10,000 years ago (Kislev *et al*. 2004: 1304). Nevertheless, the absence of other wild and indeed domesticated seeds in South-West Asia and the Balkans to pre-date those from Spain, Italy and western Europe indicates that the cultivation of opium poppy began in Europe (Salavert 2010: 9). Large concentrations of seeds and clear evidence for its cultivation have mostly been found on Late LBK sites (5200-5000 cal. BC) (*cf*. Bogaard 2011: 38; Bickle & Whittle 2013: 10-11; Kreuz 2007: 281), and the absence of any wild forms in the area has led to the conclusion that opium poppy was introduced to western Europe from the Mediterranean (perhaps as an adventitious weed) where it was domesticated (Salavert 2010, 2011; see also Coward *et al*. 2008: 52). However, large concentrations of charred and waterlogged seeds indicative of cultivation have also been found at La Marmotta (near Rome, 5800-5000 cal. BC: Rottoli & Pessina 2007: 146), and two Spanish sites: La Draga (NE Spain, 5300-5000 cal. BC; Antolín 2013: 91, 231), and the cave of los Murcielagos de Zuheros (Andalucia, 5300-5000 cal. BC; Peña-Chocarro *et al*. 2017: 10). The latter could be contemporary with, or even pre-date LBK finds, and, along with sporadic remains from three Early Neolithic sites in Spain support earlier suggestions that the crop was domesticated in the Mediterranean, before its cultivation in north-western Europe (Antolín 2013: 420; Bakels 1982, 1992: 66-7, 2009: 56; Peña-Chocarro *et al*. 2017: 10-11). In eastern Italy finds of poppy at Spilamberto (site 207) and Palù di Livenza (site 216) were scarce and post-date LBK finds by several centuries (Table 8.3). The three seeds from Hermanov Vinograd (site 90) also post-date LBK finds but represent the earliest *P. somniferum* in the Balkans, and may be evidence for a southward inland spread of its cultivation. The seed fragment identified to *P.* cf. *somniferum* from the Körös culture site of Ibrány-Nagyerdö (site 21) could be the earliest European find, but must remain questionable until better preserved specimens are uncovered from radiocarbon dated contexts.

9.4 The Early Neolithic – *c*.6100-5400 cal. BC

9.4.1 Crops, gathered plant foods and arable weeds

-Cereals

The three main cereals cultivated in the Early Neolithic of the research area are those of the original crop package from South-West Asia: barley, emmer and einkorn (Zohary *et al*. 2012: 4). Barley was the most ubiquitous cereal in all three analysed areas (Coastal, Continental, Pannonian). Based on the relative paucity of remains compared to those of hulled wheats, it has been suggested that barley was not more than a crop contaminant throughout the course of the Neolithic in Serbia (Filipović 2014: 201). Barley was not cultivated during the LBK, except perhaps in very specific areas (such as at the site of Ludwigsburg-Oβweil; Piening 1982, cited in Bogaard 2011: 37. It was intrusive at Vaihingen; Bogaard 2011:37) (Kreuz 2007: 270; Colledge *et al*. 2005: 143), and its low status in Serbia could be evidence for the origins of its absence in the LBK crop package. However, the high frequencies of barley (Figure 8.5), along with its cultivation from the beginning of the Neolithic in Greece, Bulgaria (Marinova & Valamoti 2014: 66), eastern Italy (Rottoli & Castiglioni 2009), Croatia (Reed 2015) and in particular Hungary (Guylai 2012), implies that it was also a crop in Serbia. The under-representation of barley grains, and particularly chaff has been explained through its differential use, processing and tolerance to heat compared to hulled wheats (van der Veen 1999). As Filipović points out, free-threshing cereal processing waste is less likely to have been burnt in household fires, and barley may have been fermented or used as animal feed rather than stored with wheat (2014: 201). In the research area, hulled barley was more frequently identified than naked barley, particularly from Continental SKC sites (Table 8.7). The more primitive 2-row variety was apparently more common along the coast, whereas 6-row hulled barley prevailed inland.

Emmer was more common than einkorn (of the single-grained variety) along the Adriatic coasts and on Continental sites. The opposite was true for Pannonian sites. Overall, einkorn was only slightly more common than emmer in Greece and Bulgaria (Figure 8.5). During the initial phase of the LBK the two hulled wheats appear equally represented at most sites, after which einkorn became the dominant crop (Kreuz 2007: 271; Kreuz *et al*. 2005: 244). Einkorn has lower yields than tetraploid and hexaploid wheats, but although it does not produce as many tillers, these are less prone to lodging during heavy/persistent rainfall (Kreuz *et al*. 2005: 244; Peterson 1965: 10). This trait has led to the suggestion that increased rainfall during the Atlantic period led to the preferential cultivation of einkorn (Kreuz *et al.* 2005: 244). Figure 2.5b, however, shows that from *c*.6000-4000 BC the LBK area was not wetter than in the previous millennia (Mauri *et al*. 2015). Conversely, at the start of the Neolithic Pannonia experienced heavier precipitation levels, which might explain why it is the only zone where einkorn was clearly predominant at that time. Like emmer, modern landraces of einkorn have a prolonged period of vernalization (up to six weeks; Dr. M. Ambrose pers. comm. 14/12/15, see also Willcox 1999: 106-7), and historically, different types are known to have been sown in both autumn and early spring (Perrino *et al*. 1996: 113; Peterson 1965: 10). Modern einkorn has a higher tolerance to extreme measures of temperature and precipitation, and can produce good yields on poor soils (Castagna *et al*. 1996; Peterson 1965: 10; Zohary *et al*. 2012: 34), suggesting that other agronomic traits, not to mention cultural preferences, may have favoured einkorn over emmer (*cf*. Marinova 2009: 59). During the second half of the 19th century AD in the Carpathian Basin, einkorn was grown for both human and animal consumption and was often the first crop to be sown on newly cleared land due to its tolerance of weedy species (Gunda 1983: 146-47; Perrino *et al*. 1996: 113). Interestingly, Marinova notes that einkorn predominated during the first phases of occupation at Kovačevo, Elešnika and Slatina, after which emmer prevailed (2009: 59). Gunda's ethnographic record continues to describe how land was broken up with a spade before sowing, and how plants were harvested low with a sickle to collect the valued straw (1983: 147). Einkorn flour was mixed with those of other cereals for a leavened bread, or used pure to produce a traditional flat bread; the latter conserves well and was given to shepherds (Gunda 1983: 147).

As described in chapter four, hexaploid and tetraploid free-threshing wheat are thought to have either been very minor crops or contaminants of other crops during the Early Neolithic of Bulgaria, Greece, Adriatic Italy and the western Balkans. In central Europe free-threshing wheat is only attested as scarce finds during the second and later phases of the LBK (Bogaard 2011: 38), despite being better adapted to temperate climates than the hulled wheats (Colledge *et al*. 2005: 150). However, Mauri and colleagues' (2015) recent analysis suggests that at *c*.6000-5000 BC central Europe was dryer and warmer than in more recent times (Figure 2.5). A hexaploid type appears to have been most common across all areas. The reported finds of tetraploid grains and the single tetraploid rachis internode (site 61) suggest this more primitive type, along with its hexaploid derivative (Maier 1996; Wang *et al*. 2013; Zohary *et al*. 2012: 45-6), was part of the first suite of crops to be introduced into the western Balkans and Italy.

-Pulses

Peas, and in particular lentils, were frequently cultivated in the research area (Figure 8.5). Pea is less tolerant of drought than lentil (Andrews & McKenzie 2007: 28), which may explain why it was less frequent in the coastal zone. The Greek and Bulgarian records also demonstrate the importance of both pulses and show that lentil was more common than pea (most of the Greek sites are in the northern territories, which may explain why pea appears to have been more common in Greece than along the Adriatic). Lentil and pea are the only pulses found on LBK I sites (Bogaard 2011: 37; Kreuz 2007: 269). The other pulses recovered from the research area were very infrequent and their status as a crop is questionable. Chick pea, present at two or three sites in Greece and Bulgaria, has not been found in the research area. It has a slightly longer growing season than lentil (90 compared to 70 days) and withstands lower precipitation levels (Table 6.6). Bitter vetch has similar growing requirements to chickpea and was only found at three sites in the research area (one coastal, two Continental). Common vetch, found in Bulgaria but not Greece was only recovered from the inland zones, and its distribution could be indicative of a Bulgarian influence/origin. Compared to bitter vetch it has a slightly shorter growing season and can tolerate higher levels of precipitation. It may, therefore, have been better adapted to Pannonia than bitter vetch. Grass pea has an even longer growing season (100-180 days) and was only found at one site (in Dalmatia), despite being common in Greece and Bulgaria. Broad bean, on the other hand, has only been found in the research area despite also having a long growing season (compared to pea and lentil). Its absence from Greece and Bulgaria is surprising since, although the distribution of its wild ancestor remains uncertain, its early cultivation and domestication in the eastern Mediterranean is attested through archaeological finds (Caracuta *et al*. 2016; 2017; Tanno & Willcox 2006; Zohary *et al*. 2012: 90-1).

Many authors have acknowledged the adverse effects that a cooler, more seasonal climate could have had on the original suite of crops introduced from SW Asia, and particularly on the loss of pulses (e.g. Bogaard *et al*. 2007a: 434-36; Bogaard & Halstead 2015: 391; Colledge & Conolly

2007; Colledge *et al*. 2005: 150; Conolly *et al*. 2008). It is now clear that many pulses stopped being cultivated before reaching central Europe, perhaps as a result of changing ecological/environmental conditions (*cf*. Anderson Stamnes 2016; Fuller & Lucas 2017; Krauss *et al*. 2017; Stevens *et al*. 2016). The most important stage in a crop's development is its flowering time, and in pulses flowering is sensitive to both temperature (accumulated degree-days) and photoperiod (light duration, quality and radiant energy) (Craufurd & Wheeler 2009; Iannucci *et al.* 2008; Summerfield 1981: 93-4). Every pulse and cultivar respond to a unique combination of adequate temperature and photoperiod, leading them to flower and fruit successfully (Iannucci *et al.* 2008: 161; Weller & Ortega 2015). Modern pea and lentil varieties have the shortest growing seasons (pea more so than lentil whose cultivation area is more restricted; Cubero 1981: Fig.2), suggesting that their cultivation over other pulses may have been determined by shorter growing seasons in more northerly latitudes (they would still have had time to fruit if flowering had been delayed by colder temperatures and/or shorter/weaker light hours). Nevertheless, it is surprising that some pulses (e.g. grass pea) could be grown in Bulgaria but not in Dalmatia or southern Italy, and it seems that climatic adaptations were not the only parameters to determine the selection of crops. Vetches and grass pea were commonly grown for fodder (e.g. Jones & Halstead 1995: 103; Zapata *et al*. 2004: 297), and, as such, would be under-represented in the archaeobotanical record. The overall emphasis on caprines during the Early Neolithic (Bartosiecwicz 2005; Manning *et al*. 2013a: 242; Orton *et al*. 2016: Figure 2) may also have reduced the necessity to grow fodder crops.

-Wild fruits and nuts

Ten taxa were gathered in Pannonia, seven in the continent and nine along the coast. The use of wild taxa seems to have been more frequent inland than along the coast, particularly in Pannonia where 80% of taxa were found in more than 10% of sites (Figure 8.23). A similar pattern is evident in the use of wild animals: hunting was least common along the East Adriatic coast, where it was mostly practised at cave sites (Orton *et al*. 2016: 6). It has been argued that the *c*.500 year period of stasis in the Pannonian Basin reflects a time of adaptation for farmers and their crops/herds to ecological and climatic conditions (a mosaic landscape of alternating vegetation and active water-ways: Chapter 2.3.1) different to those under which species were domesticated (e.g. Bánffy 2013a; Bánffy & Sümegi 2011; Krauss 2016: 214-26). Whilst the increased use of wild floral resources may reflect a greater availability of fruits and nuts (Filipović *et al*. 2014), the increase in the range and ubiquity scores could also be indicative of lower crop yields. The absence of some edible species from particular areas may be due to ecological conditions (e.g. olive and fig are strictly Mediterranean species; Zohary *et al*. 2012: Maps 15&16). It is less clear why other species (such as acorn) were not uniformly exploited. As is evident with the pulses, there is a reduction in the range and overall frequency of wild taxa between Greece and Bulgaria and the research area. The four taxa that were not found in the research area could have grown in Dalmatia and southern Italy but do not seem to have been used there (almond, fig, pomegranate and *Pistacia*).

-*Arable weeds*

As arable weeds were inextricably associated with a crop and its method of cultivation, it should be possible to map the spread of farming with the distribution of weedy taxa (e.g. Coward *et al*. 2008; Jones 1988b: 87-88; Chapter 5.4). Whereas the origins of weed taxa found along the Adriatic are unclear all but one of the Continental species, and most (40%) of the Pannonian species were found in Bulgaria (only 13% were also found in Greece). These findings point to Bulgaria as an important, though not exclusive, area of origin for the first farmers that followed the inland route of neolithisation (*contra* Coward *et al*. 2008).

The arable weed spectrum from the Early Neolithic sites contain many species that are also found on LBK sites and recorded as anthropochores. These weeds confirm that crops and cultivation practices in central Europe were introduced from farmers moving along the Danube corridor (*cf*. Coward *et al*. 2008: 53). 'LBK weeds' were also present on coastal sites; however these are very common taxa and cannot be used to indicate a direct link between the Adriatic and central Europe (through northern Italy or north-eastwards into Hungary). Anthropochores that are only found on LBK II or later sites suggest continued migrations of people and/or crops. Of note is *Lapsana communis*, which is very common on LBKII-V sites (Bakels 1999: 75-76; Kreuz & Schäffer 2011: Table 1) and was found at Early Neolithic Kapitan Dimitrievo (Bulgaria) (Marinova 2007: Table 6.4) and four Middle/Late Continental sites. Its tolerance of shady habitats have led Kreuz and colleagues (2005: 251; 2011: 341) to describe it as a winter annual growing on the edges of arable fields rather than an arable weed in autumn-sown crops. However, its presence in the research area puts its origins into question as it now seems likely that it was introduced along with other 'typical LBK weeds' (e.g. G. aparine*, G. spurium, F. convolvulus and B. sterilis/tectorum*).

The records for Early Neolithic arable weeds in the western Mediterranean are scarce, and identified species tend to be the more common taxa found across most areas (Tables 8.24 to 8.26; Antolín & Jacomet 2015; Antolín *et al.* 2015). Contrary to the inland signal, and perhaps because fewer weed seeds have been recovered and identified from Greece than Bulgaria (Table 2.7, Appendix II), a diagnostic maritime weed assemblage is lacking.

The preferred growing conditions for the majority of the weed taxa suggest that, overall, moist soils of medium texture and neutral to slightly alkaline pH were cultivated across the whole research area (Table 8.36). At around 6000 BC the research area was, in both winter and summer, one to two degrees cooler than it was in 1850 AD, and experienced similar or slightly greater levels of seasonal precipitation (Figure 2.5b). Consequently, soil moisture levels may have been maintained naturally, (even along the coast where summer precipitation levels were higher). Nevertheless, artificial watering may best be verified through the measurement of the carbon isotope ($\delta^{13}C$) values of grains and pulses (Styring *et al*. 2016; 2017a; Chapter 5.4.1).

All three areas had more taxa indicative of fertile soils than those that grow well in poor soils (Figure 8.38). The difference is the least obvious in Pannonia where 38% of plants prefer fertile soils whilst 36% can tolerate low levels of fertility. How levels of fertility were managed cannot be answered with the current dataset. The lack of woodland perennials and predominance of those from disturbed habitats indicate that plots were permanently cultivated over several years (*cf*. Bogaard & Halstead 2015: 391), suggesting that the management or control of soil fertility levels would have been necessary. It is possible that levels were maintained through the rotation of cereals with lentils and peas (*cf*. Palmer 1998b; Chapter 5.4.2), or that dung and/or other organic waste was routinely added to arable fields.

All three areas had more identified annual than perennial species. These results further confirm that shifting cultivation was not practised in the research area (Bogaard 2002a; Rösch *et al*. 2002). Instead, the range of taxa suggests a high level of interference through some sort of ploughing and uprooting which would have gradually eliminated all weeds other than annuals with long-term seed banks. There is as yet no direct evidence for the use of ards or the practice of deep ploughing during the Neolithic (*cf*. Borojević 2006: 127; Filipović *et al*. 2017: 20, but ethnographic research has shown that digging sticks can be used to work the soil, even heavy soils (Kreuz & Schäfer 2011: 334; Chapter 3.3.2). Many of the identified perennials are hemicryptophytes with small tubers and would therefore benefit from shallow ploughing. Few have deep tap roots suggesting weeds were also uprooted. Perennials from the coastal and Continental sites can reproduce by seed and so would have been better adapted to the arable cycle than those that can only reproduce vegetatively. Although seed bank types could not be accurately determined for all species, many of the plants produce seeds that can lie dormant in the soil for prolonged periods of time (seed banks 3 and 4). A more intensive/controlled approach to sowing and weeding will gradually eliminate weeds of transient seed banks (as they need to be re-sown every year), and favour those that can produce 'stores' of seeds, particularly if they can ripen before the harvest. Another indication of high levels of disturbance (intensive weeding during cultivation and/or periods of fallow), is the relatively high proportion of plants with prolonged periods of germination and flowering (flowering onset and duration categories 3 and 4; Figure 8.33) (Bogaard *et al.* 1999; 2001; Chapter 5.4.7).

Flowering onset and duration can also be indicative of the sowing season, as can the type of seed bank. All three areas had high proportions of flowering category 2, indicative of spring-sowing. Though less frequent, species of flowering category 1 indicative of autumn-sowing were also present, along with those of category 3 (and of seed bank types 2 and 3) which may also have germinated in the autumn (Bogaard *et al.* 1999; 2001; Stevens 1992: 182-83). It is therefore apparent that both winter and summer crops were cultivated. Emmer and einkorn were winter crops during the LBK (Bogaard 2004: 164; but see Kreuz & Schäfer 2011 who argue for spring-sowing), and both autumn and spring-sowing were apparently practised in Bulgaria (Kreuz *et al*. 2005: 253). Figure 2.5a indicates that during the sixth millennium BC it was warmer in central Europe, where autumn-sown varieties may have been more successful than in Hungary and Serbia. Barley varieties capable of germinating in the spring (through loss of photoperiod sensitivity) were a secondary development after the first westward spread of farming (Jones *et al*. 2008). Varieties in the Mediterranean germinate in the autumn and it is therefore assumed that the first crops to reach the area were the more ancestral ones (Jones *et al*. 2012, 2013). However, it is possible that loss of photoperiod sensitivity and vernalization requirements occurred in the colder highlands of Anatolia before crops were introduced into Bulgaria and Serbia. Information on Neolithic average winter and summer temperatures by site and the requirements of modern crops during their phenological stages suggest that all crops grown along the coast could have germinated during the winter months (Chapter 8.2.4.1). Summer temperatures would have risen above the optimum growing range for barley and wheat, which would therefore have fared better if sown in the autumn allowing seeds to mature before the onset of higher temperatures. Lentils, and in particular peas, have shorter growing seasons and could have been sown in either season, as was traditionally done in Greece (Halstead 2014: 24). Although autumn/winter-sown pulses will produce greater yields and more nutritious straw, they would only have grown as cultivars adapted to winter conditions, particularly inland where winters were coldest (Barrios *et al*. 2016; Kahraman *et al*. 2004; Silim *et al*. 1991). Table 8.11 shows that in the Continental zone, only crops which were able to vernalize over the coldest months could have been successfully sown in the autumn. Consequently, cereals, for which the hottest summer temperatures may have been too hot, could have been autumn-sown, whilst the pulses and flax are more likely to have been sown in the spring. Winters in Pannonia were even colder and some areas may even have struggled to grow winter wheat and barley (Table 8.13). Whilst the above interpretations are based on the temperature requirements of modern crop varieties (and so on uniformitarian assumptions; Chapter 6.5), they do support the weed-based inferences that husbandry regimes included both autumn- and spring-sowing. The crop/climate approach suggests that pulses are likely to have been summer crops (though perhaps sown earlier along the coast than inland). In the coldest areas, particularly during the Middle/Late Neolithic, wheat may also have been sown in the spring, perhaps in addition to autumn crops so as to ensure a plentiful harvest.

The height of mature weed taxa can be indicative of the crop harvesting height (Chapter 5.4.4). The discrepancies between the three height categories of weed heights are least in the coastal area where crops were probably harvested close to ground level (Table 8.36). In the Continental zone there were no 'low' weeds, indicating that crops were cut or grabbed (to uproot) at *c*.30cm above the ground. In Pannonia all categories were represented but the 'high' weeds predominated. It is possible that harvesting height was not uniform across the area, varying by site and/or crop type, or that taller weeds were at a competitive advantage (and therefore more common) in fertile and well-watered conditions (Bogaard *et al*. 1998; Jones *et al*. 2000b). It has been argued that a predominance of medium to tall weeds in LBK.I and Early Neolithic Bulgarian assemblages may be indicative of ear-harvesting (Kreuz *et al*. 2005: 249-50), but this interpretation assumes cereals grew no taller than the medium-height weeds (Chapter 5.4.5).

9.4.2 The two streams: comparing the coastal and inland agricultural regimes

Farming communities migrating along the Danube corridor and the Adriatic coast took with them a core suite of crops consisting of hulled and naked barley, emmer, single-grained einkorn, tetraploid and hexaploid free-threshing wheat, lentil, pea, flax, vetches and grass pea. Slight differences in the proportional presence of taxa is evident between the bioregions, which may relate to climatic variations. In Pannonia, the predominance of einkorn and barley over emmer may reflect difficult growing conditions (shorter growing seasons and heavier precipitation), whilst along the coast barley would have offered a safety net to both humans and their herds during drier and hotter years. It is also possible that barley grew better than other cereals on the thinner karstic coastal soils (Chapter 2.2). A rockier and drier environment is supported by the predominance of caprines along the coast, compared to contemporary sites inland where the importance of caprines and cattle varied by site (Orton 2012: 25-26; Orton *et al*. 2016: 17-18). Pulses were rare on Early Neolithic sites and their distribution seem to follow neither geographical nor clear climatic trends. Cultivating pulses in increasingly colder latitudes with shorter growing seasons may have been difficult. It is interesting to note that the highest ubiquity for bitter vetch coincides with a cattle-dominated area (the Continental zone; Orton 2012: 25), and the possibility that vetches and grass pea were grown for more sedentary herds (cattle rather than caprines) remains to be further elucidated.

Wild fruits and nuts appear to have been less important along the coast than inland, where the greatest range and ubiquity scores were seen in Pannonia. The additional species recovered on Pannonian sites also grew further south, and it seems reasonable to assume that farming groups entering the Pannonian Basin had the same culinary tastes as other SKC groups remaining in the Continental zone. It is therefore logical to explain the increased consumption of wild plant foods, combined with worsened climatic conditions (Figure 2.5), in relation to the greater uncertainty of agricultural yields. The opposite may be true of Adriatic sites which drop four taxa used in Greece and do not appear to have relied heavily upon the more calorific foods, such as hazelnuts and acorns.

The biological and ecological characteristics of the arable weeds indicate that, across all three investigated areas, efforts were made to maintain productive arable fields. How fertility levels and sufficient water levels were maintained cannot be answered by the current dataset, but the predominance of annuals and of taxa tolerant of repeated disturbance indicate that crops were intensively managed. The level of effort to maintain high fertility levels and weed-free fields appears to have been lowest in Pannonia. It may have been harder to invest into long-term plots in a hydrologically active zone, and the relatively high proportion of perennials may simply reflect the short-term cultivation of fields (Bogaard 2004b: 29-30). The use of slightly poorer soils with more weeds in a wetter climate would explain why einkorn was preferentially grown to emmer. The greater range of weed taxa in Pannonia is fitting with an agricultural regime in which long-term plots had not been established or in which less effort was put into weeding. On the other hand, it is possible that more of the grain cleaning was performed inside (and more waste/weeds burnt in household fires) in Pannonia than elsewhere. The harvesting height appears to have been different across all three areas. The same has been noted for sites in central Europe and interpreted as flexible reaping practices rather than differences in sickle form and efficiency (Bogaard 2004b: 120).

Autumn- and spring-sowing were part of the agricultural cycle in both inland and coastal regimes. Pulses are less tolerant of colder temperatures and are more likely to have been sown in the spring. However, if spring-sown cereals were planted as a buffer against the failure of autumn-sown crops

(Halstead 2014: 351; Valamoti 2007: 103), less effort may have been put into weeding them, leading to a higher presence of spring-germinating weeds in the archaeobotanical record. In accordance with the weed assemblage from the Starčevo-Körös culture site Ecsegfalva in Hungary (Bogaard *et al.* 2007a; Bogaard *et al*. 2008 - the only other ecological analysis from the research area), results suggest that at least some autumn-sown crops were cultivated. Temperature values suggest that spring-sowing may have been more successful in more northerly latitudes, and the need for farmers and crops to adapt to new environmental and climatic conditions may indeed have led, not only to periods stasis during the neolithisation of Europe, but also to an increased reliance upon wild food resources.

9.4.3 Origins and spread

In 2007 Colledge and Conolly compared the range of Early Neolithic crops from Greece (12 sites), Bulgaria (10 sites) and Former Yugoslavia/Hungary (9 sites) found as charred remains and impressions (2007: Fig.2; Chapter 4.2). They found that the latter area had a reduced number of crops (n=6) and a lower representation of crops by site (2.44 crops/site; Colledge & Conolly 2007: Table 4). The graph is recreated with data from impressions as well as charred remains from sites within the same areas (Figure 9.1).

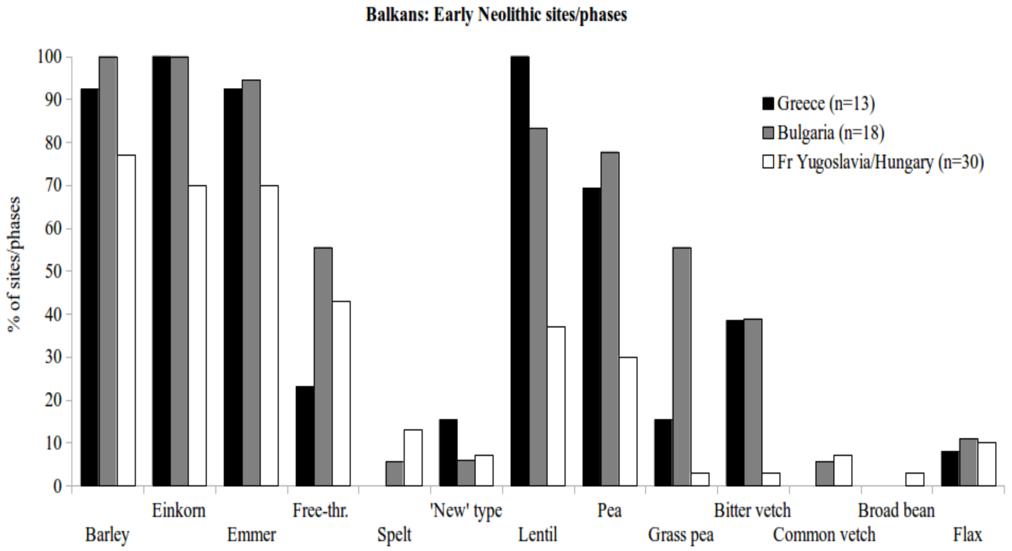


Figure 9.1: Percentage of Early Neolithic sites with evidence for the listed crops. The entry for rye in Colledge & Conolly's graph represents *Secale* sp. (Colledge 2016) and is not included here. Spelt is present in the original graph and is also included here. Other 'problematic' crops are excluded.

Archaeobotanical data from Former Yugoslavia/Hungary is now available from 30 sites and the range of possible crops has increased to 13, surpassing Greece by three and Bulgaria by one. If, however, spelt is excluded and all pulses found in less than ten percent of sites are considered crop contaminants rather than crops in their own right, the full suite is reduced to ten crops, two of which are absent from Former Yugoslavia/Hungary (grass pea and bitter vetch). It is therefore still apparent that fewer crops were cultivated than in Greece and Bulgaria, although the diversity is not as reduced as was previously suggested. Further comparisons with Colledge and Conolly's (2007: Fig.4) study shows that the number of sites with five or more crops has increased from *c*.10% to 43% (n=13) but remains more comparable to the *c*.38% recorded for the LBK than the >60% recorded for the Greek and Bulgarian sites. As has previously been suggested by other authors, the reduced LBK package, at least in terms of pulses, was shaped in the western Balkans (e.g. Bogaard *et al*. 2007a: 434-36; Bogaard & Halstead 2015: 391; Colledge *et al*. 2005: 150). Cultural explanations for the preferred use of hulled over free-threshing wheats during the LBK I (Colledge 2005: 151) could be re-considered in light of new climatic data (Mauri *et al*. 2015), and the fact that free-threshing wheat was only a crop-contaminant when farming reached central Europe.

Differentiating between origins from Greece and/or Bulgaria is not obvious. Although Figure 8.6 illustrates that common vetch was only present in Bulgaria, the pulse has now been found at the Early Neolithic Greek site of Halai (Unpublished, Prof. A.Bogaard pers. comm. 18/01/18). Some 'inland' weeds point to Bulgarian origins, but migrations from Greece into Serbia through the Morava-Vardar corridor cannot be ignored (Perić *et al*. 2015). The maritime route into the Adriatic must have passed via Greece, and yet a possible Bulgarian influence on its crop and weed assemblage cannot be disproved. Rather than suggestive of direct links, the numerous similarities between Greece, Bulgaria and all three zones of the research area must be seen as testimony to a common Near Eastern origin (Colledge *et al*. 2004; Coward *et al*. 2008).

9.5 The Middle/Late Neolithic - *c*.5400-4500 cal. BC

The Middle/Late Neolithic lasted for 1500 years and saw a diversification in cultural trends, both inland and along the coast where farmers continued to spread into northern Italy. The range of crops cultivated during the Early Neolithic continued to be used, with the addition of two species in both the coastal (rye and common vetch) and inland (rye and grass pea) areas. Having discussed the origins of the crop packages and arable farming in the research area, the aim of the following section is to explore the development of established agricultural regimes. The discussion below is thereby structured by geographical, ecological and cultural zones, rather than by taxa.

9.5.1 The Coastal Route

Compared to the Early Neolithic, a slight decrease in the ubiquity of barley and emmer was evident. Barley, however, was found in all of the Dalmatian and s/c Italian sites, suggesting that in the

Mediterranean bioregion its cultivation increased during the Middle/Late Neolithic. It may have been the easiest crop to grow on the thinner karstic soils. Naked barley in particular became more frequent in the Mediterranean bioregion, reflecting a similar contemporary trend for the preference of that variety along the Spanish coast (Antolín *et al.* 2015: Fig.3; Peñha-Chocarro *et al.* 2017: Fig.3). Barley was less frequent in northern Italy, where only the hulled variety has been recorded. Einkorn became more frequent in both bioregions, possibly as it grows well in both poorer soils and areas of high rainfall (northern Italy: Figure 2.5b). The most notable difference was the 21% increase in the ubiquity of free-threshing wheat, which seems to have become a crop in its own right. Free-threshing wheat was also common along the western Mediterranean coast, where at some sites it is seen to replace hulled wheats (Antolín & Buxó 2012; Antolín *et al.* 2015: Fig.3; Peñha-Chocarro *et al.* 2017: Fig.3). The range of pulses increased, and common vetch appeared in northern Italy. Its absence from the rest of the Adriatic coast is perhaps surprising and may be associated with the overall preference for bovines in the Po plain (Gaastra & Vander Linden submitted). The preference of pea in northern Italy may reflect milder and wetter conditions. The difference in diversity in both the range and ubiquity of crops between the Early and Middle/Late Neolithic is statistically valid, demonstrating a significant change in the overall importance of individual taxa.

Both bioregions of the coastal zone saw an increase in the range of wild fruits and nuts (Figure 8.26). Taxa confined to the Early Neolithic of Greece (fig, almond and *Pistacia*) were present in Dalmatia and s/c Italy by the Middle/Late Neolithic. Although a greater range of wild plant foods were used, their ubiquity scores remained low in the Mediterranean bioregion. Conversely, fruits and nuts seem to have been more frequently eaten in northern Italy where calorific hazelnuts were particularly abundant (see below on the cultivation/management of fruit trees). The diversity in the use of crops and wild plant resources between the two analysed phases of the Neolithic is statistically significant (Figure 8.17), which suggests that as the Neolithic developed along the coast there was a real shift in the use of edible plants. Whereas crops continued to form the main part of the plant diet in Dalmatia and s/c Italy, lower frequencies of crops in northern Italy appear to have been substituted with fruits and nuts. Contrary to previous analyses, the frequency of hazelnuts increases (present in 93% of northern Italian sites), suggesting that flax and poppy oil did not substitute hazelnut calories (*contra* Rottoli & Castiglioni 2009: 101). It is difficult to know whether the increase in wild plant foods resulted from poor crop yields in a colder and wetter environment (though note that the Po plain soils would have been richer), or the exploitation of the increased availability of resources. The consumption of hunted versus herd animals, and the importance of caprines, pigs and cattle varied significantly between sites in northern Italy (Gaastra & Vander Linden submitted; Rowley-Conwy *et al*. 2013: Table 9.2). Such details cannot be gained from the plant dataset, but it is possible that the use of wild plants and the efforts spent on the production of crops also varied by site.

Moist and fertile soils of neutral pH and medium texture continued to be preferentially used (Table 8.36). Changes are evident in the higher proportions of perennials and the increase in weeds of flowering category 1 within the Mediterranean bioregion. The latter suggests that more crops became autumn-sown, perhaps reflecting an adaptation of certain pulse crops to be sown earlier in the season so as to benefit from the winter rains (Iannucci *et al.* 2008). Category 2 weeds, indicative of spring sowing, prevailed in northern Italy. Tables 8.15 and 8.16 show that lower summer and winter temperatures may have made cultivation more difficult, particularly at Vela in Trento (site 214). Wheat and barley would have been able to grow over the winter months but the pulses would have fared better in the spring.

The increase in perennials tolerant of disturbance (shallow root systems; Chapter 5.4.5), and evidence for good fertility and moisture levels, suggest a continued intensive approach to cultivation. The time scale of the Middle/Late Neolithic and the expansion onto new areas suggest that soil fertility levels were not simply an outcome of previously intensive manuring/middening (*cf*. Styring *et al*. 2017b: 17).

9.5.2 The Inland Route

Continent

The Middle/Late Neolithic witnessed an 7% and 19% increase in the frequency of emmer and einkorn respectively. Figure 2.5b shows that the area received more precipitation during the Middle/Late Neolithic, particularly around 5000 BC. The importance of einkorn also increased during the Neolithic of Greece and Bulgaria (Kreuz *et al*. 2005: Fig.4; Marinova & Valamoti 2014: 67), during which time both territories became wetter, particularly in the summer (Figure 2.5b). The frequency of barley in the Continental zone remained constant. Similarly to the coast, the frequency of naked barley in both inland bioregions increased, partially replacing, rather than adding to, the cultivation of hulled barley. The frequency of lentil, pea and bitter vetch increased and grass pea and broad bean were added to the range of cultivated pulses (though the latter was only found at one site). Common vetch, however, was dropped and the cultivation of broad bean did not increase. The increased importance of vetches and grass pea could be associated with the surge in cattle-dominated husbandry regimes (Bartosiewicz 2005: 60; Orton *et al.* 2016: Fig. 2), and/or the successful adaptation of pulses to local environmental conditions after their introduction during the Early Neolithic. Finds from Vinča Belo-Brdo suggest they may have been cultivated for human consumption, and not necessarily as a famine food. Although the difference between the diversity indices in the range and frequency of crops from the two Neolithic phases is not statistically significant, the diversity is seen to increase (Figure 8.18). As the Neolithic developed the crop package of the Early period changed, though not uniformly as variations are apparent within specific areas of the Continental zone.

The range in wild fruits and nuts increased from seven to 11 taxa, although the difference in diversity between the two periods is not statistically significant (Figure 8.19). Cornelian cherry continued to be the most ubiquitous taxa, but the frequencies of hazelnut, elder, berries and apple/pear also increased. Evidence for the cultivation/management of wild fruit trees, such as olive, fig, apple, pear and grapes, is contentious as it is difficult to distinguish between early horticulture and gathering (*cf*. Ruas 2016: 291-304; Willcox 2016; Zohary *et al*. 2012: 114-16). Large concentrations of apple/pear seeds at Okolište have led to the suggestion that trees were managed/cultivated by at least the Late Neolithic (Kirleis & Kroll 2010; see also Filipović & Tasić 2012: 14 for abundant finds of *Pyrus amygdaliformis* fruits and seeds at Vinča Belo-Brdo). Finds indicative of the pressing of grapes (like concentrations of crushed seeds and juice residues in ceramics; e.g. Barnard *et al*. 2011) are missing. Such evidence is present at the end of the fifth millennium at Dikili Tash (Greece) and currently represents the earliest clear evidence for the cultivation of grape vines in the Balkans (Valamoti *et al*. 2007).

As is evident with the coastal sites, moist and fertile soils of neutral pH and medium texture continued to be preferentially used (Table 8.36). The main difference compared to the Early Neolithic is the increase in perennials tolerant of disturbance and decrease in annuals. As is mentioned above, these taxa are indicative of a continued, and perhaps even an increase, in the intensity of disturbance (weeding, tilling, etc.). Flowering category 2 remained the most common type within the weed assemblage, suggesting that spring-sowing (of pulses and perhaps cereals, though autumn-sowing is also evident) continued into the Middle/Late Neolithic. The Continental zone appears to have experienced the coldest average temperatures, and many sites would have been unable to cultivate any crops during the peak of winter (Table 8.17).

Pannonia

The Middle/Late Neolithic saw a decrease in the frequency of most crops from sites in the Pannonian Plain. Barley (though see above for naked barley), einkorn, lentil and pea became less common, whilst the ubiquity scores for emmer and free-threshing wheat remained constant. The two additional pulses, grass pea and bitter vetch, coincide with a growing emphasis on cattle herding (Bartosiewicz 2005: 60; Orton *et al*. 2016: Fig.2). It is also possible that these were grown to supplement the crop yields: bitter vetch was more common than pea at Vinča Belo-Brdo and a large concentration of clean seeds were found next to a grinding stone in a burnt house (Filipović 2014: 201; Filipović & Tasić 2012: 11, 13). The shift from caprines to cattle in the Pannonian plain has been described as a staggered adaptation to the damper climate of the northern Balkans (Bartosiewicz 2005: 56; Orton *et al*. 2016: 18; see also Conolly *et al*. 2011; 543-44; 2012: 998; Manning *et al*. 2013b). Overall hunting increased during the Late Neolithic in the Pannonian Plain, being particularly important at specific sites (Bartosiewicz 2005: Fig.6.4; Orton *et al*. 2016: 10). The use of wild plants remained important and an additional two taxa were exploited: pine nuts and hawthorn. The continued overall decline in the frequency of crops and increase in the range and frequency of wild foods may also reflect an adaptation to an environment unconducive to the cultivation of Near-Eastern crops (*cf*. Gulyás & Sümegi 2011). The weed assemblage suggests that, as in the Continental zone, the main change from the Early Neolithic was a decrease in annuals and an increase in perennials from disturbed habitats (Table 8.36). Evidence for both autumn- and spring-sowing is present. Table 8.19 shows that winter temperatures were too cold for even the cultivation of winter wheat and barley at some sites. Cold winters combined with summers slightly too hot for the optimum growth of wheat, barley and vetches would have made cultivation difficult. The difference between the diversity indices of crops and crops and wild plant foods between the Early and Middle/Late periods are not statistically significant (Figure 8.19), and although a slightly greater range of plants were cultivated and consumed, the reliance upon crop production does not seem to have intensified as the Neolithic developed (but see below for differences within the Pannonian Plain).

The Cultural Groups

Although the same range of crops were cultivated within the same soil conditions (medium textured, fertile and well-watered) by Sopot, Vinča and Butmir groups (with the exception of common vetch unique to a single Sopot site), differences in the relative proportion of crops suggest that cultivation was influenced by cultural preferences and/or adaptations to local climatic/ecological conditions (Figure 8.12). Out of the three cultural groups Butmir had the highest proportions of barley and einkorn. Their prevalence over emmer in the alpine zone of central BiH may reflect harsher climatic/ecological conditions. Butmir sites also had the highest proportions of flax and grass pea. The latter pulse, along with pea, can grow in temperatures as low as 10°C in most soil types (Table 6.6), making it better adapted to alpine conditions than the vetches. The very frequent finds of flax seeds in all three cultural groups suggest that they were consumed and/or pressed for oil, which does not exclude the plant's use for fibre. Hazelnuts and cornelian cherry were very common on Butmir sites (Figure 8.28), and the preference of calorific nuts over fruits could indicate that there was a need to supplement the cereal diet. The predominance of annuals and the relatively high proportion of taxa in flowering category 3 indicate a high level of disturbance, and suggest that an intensive form of cultivation was practised at Butmir sites.

The Continental and Pannonian Vinča sites differed more in the frequencies than the relative proportions of crops. Contrary to differences apparent between the larger Continental and Pannonian groups, crops were more frequent in the Pannonian Vinča sites (Figure 8.13). The latter group however, only includes five sites and so may not be wholly representative. The main difference between crops is the very high frequency of free-threshing wheat on Vinča Pannonian sites, which may represent a localised cultivation of the cereal (*cf*. van Zeist 2001). Grass pea, usually considered a fodder crop, was only found in the Continental zone whereas broad-bean, probably grown for human consumption, was only recovered from Pannonia. The differences in the range and frequency in fruits and nuts reflects those seen between the larger Continental and Pannonian groups. Figure 8.27 clearly illustrates how the Pannonian group was more reliant upon wild resources. Despite dietary differences, both groups seem to have had the same approach to cultivation. The maintenance of fertile soils, the predominance of annuals over perennials and the relatively high proportion of taxa in flowering category 3 indicate that fields were intensively managed.

Although Sopot sites are also located on the Pannonian Plain, their use of cereals and wild plant foods is more comparable to Continental Vinča sites. The relatively low frequency of free-threshing wheat, the presence of grass pea and the small range and frequencies of fruits and nuts highlight differences with the other Pannonian sites. Conversely, an intensive form of cultivation also appears to have been practised. The Sopot weed assemblage contained as many annuals as perennials (non-woodland types) and had the lowest number of poor soil indicators (Figure 8.39).

9.6 Summary

As farmers spread out of Greece and Bulgaria into the Danube catchment area and along the Adriatic coast they encountered new climatic and ecological conditions. The drop in the range of cultivated pulses and differences in the relative proportions of cereals, fruits and nuts between bioregions seem to reflect effects of climatic conditions, possible adaptations to animal husbandry regimes and cultural preferences (Fuller & Lucas 2017; Zeder 2017: 287). Although the inland crop package was not as reduced as that of the LBK, a reduction was already evident. The range of crops became more diverse as farming practices were firmly established, and shifts in the relative proportions of crops may reflect generally colder and wetter conditions during the Middle/Late Neolithic. Additional taxa include spelt, rye and opium poppy, though evidence for their cultivation is lacking. Rare finds of spelt in central BiH and eastern Croatia point to early occurrences of this European crop. The considerable increase in flax during the Middle/Late Neolithic is a testimony to its use as an oil crop, though linen was also produced. Free-threshing wheat gained importance in Italy, in accordance to a wider Mediterranean trend, and perhaps also at Vinča Pannonian sites. Differences in the range and proportional use of crops and wild plants between the three cultural groups demonstrate that culture had a significant influence over the formation of agricultural regimes and diet. The same conclusion was drawn from the analyses of the zooarchaeological data, which showed that differences in the importance of particular domesticated taxa, and in the proportion of hunting were not coterminous with specific ecological zones (Gaastra & Vander Linden submitted).

Differences are seen in the use of wild resources between Early Neolithic coastal and inland sites, with cereals taking centre stage along the coast. Inland, and particularly in the Pannonian zone, wild fruits and nuts were a common addition to the diet. The importance of wild plant foods in Pannonia continues into the Middle/Late Neolithic when it is also evident in northern Italy. Relatively low ubiquity scores for cereals (more apparent in Pannonia than northern Italy) may suggest that fruits and nuts were a necessary addition in these more northerly latitudes. Conversely, the greater availability of wild plants may have promoted a relaxation in the scale of cultivation, i.e. wild plants were preferentially consumed rather than gathered out of strict necessity. Either way, increasing population numbers and the development of tell sites suggests that food resources were not lacking. The overall increase in the range and representation of fruits and nuts between the Early and Middle/Late periods may be associated with increased efforts to cultivate/manage wild resources (*cf*. Filipović *et al*. 2014: 9).

Agricultural practices during the Early Neolithic were intensive across the research area. Efforts were made to maintain rich, well-watered soils and plots were regularly weeded. These practices have also been identified in the Near East (Styring *et al*. 2016) and Greece (Bogaard *et al*. 2013b), demonstrating that crops and their methods of cultivation were inextricably linked. Both autumn and spring-sowing were practised throughout the Neolithic, but whether cereals were exclusively winter crops remains uncertain. Colder inland winter temperatures, especially during the Middle/Late Neolithic, and evidence for spring-sowing in Bulgaria (Kreuz *et al*. 2005: 253), could indicate that some cereal varieties had adapted to germinating in the spring. Nevertheless, the association of weeds to pulse or cereal crops needs to be evaluated at a sample level, as do the possible biases incurred through crop-processing, before one can confirm the sowing season of particular crops (Bogaard *et al*. 2005; Jones 1992). An intensive approach to cultivation continued into the Middle/Late Neolithic, with evidence for increased levels of disturbance.

CHAPTER 10

Conclusions

The conclusions for this thesis follow the order of the nine hypotheses listed in Chapter 1, and relate to both the practice of archaeobotany and the results obtained from the analyses of archaeobotanical remains from the western Balkans. It is clear that fewer archaeobotanical samples have been obtained from Early Neolithic compared to Middle/Late Neolithic sites. The latter are not only more numerous, but tend to present better levels of preservation and are usually more heavily sampled. These discrepancies have led to the assumption that Early Neolithic farmers in the western Balkans were not as reliant upon crop agriculture as farmers from later periods (e.g. Bánffy 2008; Greenfield *et al*. 2014; Tringham 2000). Intensive sampling programmes, such as have been applied at Ecsegfalva (Bogaard *et al*. 2007a) and AtII, have demonstrated that plant macro-remains indicative of past agricultural regimes do exist, and that Early Neolithic sites should be routinely and comprehensively sampled (*cf*. Filipović & Marić 2013; Reed 2016). The first migrant farmers may have been more mobile than subsequent groups, but, as this thesis demonstrates, they did not lead a 'hunter-gatherer-like' lifestyle. Both botanical and zoological (Manning *et al*. 2013a; Orton 2012; Orton *et al*. 2016) remains show that people depended more upon domestic than wild species, and that an increase in the use of wild taxa is only seen during the Middle/Late Neolithic.

The first farmers to follow the coastal Adriatic and the inland Danube routes across the western Balkans cultivated hulled and naked barley, emmer, einkorn, lentil, pea and flax (for both its oil and fibre). Hexaploid and tetraploid free-threshing wheat, though present, seem to have been crop-contaminants, and grass pea, vetches and broad bean were rare. Although the range of crops used along the coastal and inland routes are comparable, differences are evident in the relative frequencies of crops and gathered wild taxa, pointing to both climatic adaptations and cultural preferences.

Bulgarian origins for the inland agricultural regimes were seen in some of the arable weed taxa. Migrations from mainland Greece, though less obvious, are also probable. The wild/weed spectrum from the Adriatic coast is narrower than that seen for the inland sites and, although the distribution of Impressed Ware sites includes the western coast of Greece (Perlès 2001: 86), specific ties with Greece were not detected. A reduction in the range and frequencies of crops from Greece and Bulgaria into the research area was evident: chickpea ceased to be cultivated, and vetches and grass pea became rarer. Whilst these species may have been less adaptable to northerly latitudes, other reasons for their absence/reduced presence must also be considered. Species cultivated in Greece would also have grown in the Mediterranean climate of the Adriatic, suggesting that a reduction in taxa can be an inherent consequence of an expanding population, whereby diversity is lost through a series of founder effects (Drost & Vander Linden submitted). The loss of bitter vetch between the Continental and Pannonian zone illustrates an additional reduction in the crop package as farming expanded northwards. These results contribute to previous discussions on the reduced diversity evident in the early LBK crop package (e.g. Bogaard *et al*. 2007a: 434-36; Bogaard & Halstead 2015: 391; Colledge & Conolly 2007; Colledge *et al*. 2005: 150; Conolly *et al*. 2008; Coward *et al*. 2008), and demonstrate that both environmental and cultural influences shaped the crop package throughout the Neolithisation process. Barley was the only important crop in the western Balkans whose cultivation was dropped by the LBK.

The Middle/Late Neolithic saw a diversification in the crop packages. These were supplemented by common vetch along the coast, and grass pea inland. Rye was also found in both areas during the second half of the Neolithic, but was probably a weed rather than a crop. The frequency of free-threshing wheat greatly increased along the coast, as did the frequency of naked barley in the Mediterranean bioregion of the Adriatic. The use of these crops reflects a contemporary trend along the southern Spanish coast (Antolín *et al*. 2015: Fig.3; Peñha-Chocarro *et al*. 2017: Fig.3), but not within Europe, and point to the continued maritime expansion. Within the Adriatic, differences between northern Italy and the rest of the coastline (the Mediterranean bioregion) are apparent: gathering of wild taxa was more important in northern Italy, where finds of barley, lentil and pea were less frequent. As is described below for the Pannonian Plain, changes in the use of wild and domestic plants, as well as stronger evidence for spring-sown crops (with continued use of winter crops), probably reflect adaptations to colder and wetter environmental conditions.

The lowest frequencies for crops and the greatest range of wild taxa were seen in Pannonia, suggesting that the economy was perhaps less reliant upon domesticates than at other sites further inland and particularly along the coast. Necessary adaptations to a more northerly climate and wetter landscapes of the Pannonian Plain seem to have involved (or necessitated) increased efforts on gathering. Coastal and inland crops were sown in both the spring and the autumn, although the planting season of specific crops remains to be determined.

Nevertheless, climate and ecology were not the sole parameters to determine the composition of the plant diet. During the Middle/Late Neolithic the three inland cultural groups (Butmir, Sopot and

Vinča) relied more or less heavily upon particular crops and wild plants. Despite their differences, two of the groups occupied the same bioregions, demonstrating that cultural pressures also shaped the agricultural regime. Cultural differences are exemplified by remains from the two analysed settlements in the Pannonian Plain: Hermanov Vingorad (Sopot site) and Potporanj (Vinča site). Although the two sites cultivated the same main crops, a greater range of pulses was found at Hermanov Vinograd. Both autumn- and spring-sowing, and harvesting low on the culm were practised at the latter site, whereas evidence for uprooting and autumn sowing was more prevalent at Potporanj. Conversely, the Vinča group extended over two bioregions and unique signatures of plant use were seen in each. One notable difference is the localised increased use of free-threshing wheat by Vinča sites in Pannonia.

Whilst the combination of a climate/crop approach and one based on weed ecology has strengthened the evidence for both autumn- and spring-sowing, further tests on individual samples are necessary before the hypothesis that cereals, at least emmer and einkorn, became summer crops during the colder Middle/Late phase can be tested. Additionally, it was not possible to confirm the seventh hypothesis as the extent to which spring-sowing became more or less common could not be evaluated with the available data. All that can be ascertained is that there is evidence for both autumn- and spring-sowing in all researched areas during the Neolithic.

The analyses of individual sites indicated that methods and techniques used during crop production varied slightly between sites (Chapter 7). Nevertheless, the western Balkans and Adriatic Italy were united in the level of effort that was applied to cultivation, as the intensive form identified for the Early Neolithic continued into the Middle/Late period. Good fertility and moisture levels were maintained, and an increase in perennials of disturbed habitats during the Middle/Late phase indicate an increase in the intensity and/or regularity of weeding, tilling and perhaps ploughing.

Similarly, there is no evidence for shifting cultivation, and plots appear to have been permanent, probably over several years. This result contributes to the growing archaeobotanical evidence for the intensive cultivation of fixed plots during the Neolithic (e.g. Bogaard 2002a,b, 2004a,b, 2011, Bogaard & Halstead 2015; Bogaard *et al*. 2007A; Jacomet *et al*. 2016). The idea that Early Neolithic groups spread across Europe relying on a slash-and-burn cultivation regime, as first suggested by Childe (1929: 45-46), can no longer be upheld (*contra*, for example, Milisauskas & Kruk 1989; Whittle 1996, 1997).

Although this thesis cannot conclusively define the interplay between the animal and crop components, the maintenance of good soil fertility levels and the apparent correlation between areas with traditional fodder crops and cattle, suggest an integrated farming approach. Indeed, evidence for milking during the SKC (Craig *et al*. 2007; Ethier *et al*. 2017) illustrates how animals and their products must have been as much a part of the farmers' daily routines and diet as crop production, processing and consumption. Further comparisons between patterns in the archaeobotanical and zooarchaeological data from the western Balkans (currently under investigation by myself and my colleague Dr. J. Gaastra) will elucidate finer details on the Neolithic farming economy.

The discovery of 'new' glume wheat at AtII and opium poppy at Hermanov Vinograd provide additional points to the geographical and temporal distributions of these species. Likewise, finds of flax, spelt, rye and 2-grained einkorn contribute to our understanding of the development and cultivation of these species.

The statistical techniques used to evaluate the composition and diversity of assemblages allowed for more confident and robust analyses and interpretations of the presence/absence data. It is hoped that this thesis demonstrates the importance of such approaches, particularly when records of plant macro-remains are collated over large geographical or temporal units. The coastal and inland comparisons could be made to describe the neolithisation of other areas, such as Western Europe, where the influences of cultural and environmental factors could also be assessed. It would be interesting to see how the reduction in crop species associated with the initial spread of farmers is replicated during advances across Europe (*cf*. Stevens *et al*. 2016), and what adaptations were necessary to enable the (re)introduction of crops during later periods of the Neolithic and Bronze Age.

Finally, this thesis could lead to further work on extrapolating finer details of the intensive cultivation regimes identified. Such an approach would benefit from a greater understanding of the formation processes of samples, and from other techniques such as the measurement of crop carbon and nitrogen isotope values (*cf*. Styring *et al*. 2017a, 2017b).

Bibliography

Akin, D.E. 2010. Flax - structure, chemistry, retting and processing. In: J. Müssig (ed.), *Industrial Applications of Natural Fibres: Structure, Properties and Technical Applications. Part II: Vegetable Fibres*, Chichester: John Wiley & Sons, 89–108.

Albrecht, H. and Auerswald, K. 2009. Seed traits in arable weed seed banks and their relationship to land-use changes. *Basic and Applied Ecology 10*/6, 516–524.

Alfaro Giner, C. 2012. Textiles from the Pre-Pottery Neolithic Site of Tell Halula (Euphrates Valley, Syria). *Paléorient 38*/1–2, 41–54.

Allaby, R. Peterson, G. Merriwether, D. and Fu, Y. B. 2005. Evidence for the domestication history of flax (*Linum usitatissimum* L.) from genetic diversity of the sad2 locus. *Theoretical and Applied Genetics 112*, 58–65.

Alley, R.B. and Ágústsdóttir, A. M. 2005. The 8k event: Cause and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews 24*, 1123–1149.

Ammerman, A. and Cavalli-Sforza, L. 1971. Measuring the Rate of Spread of Early Farming in Europe. *Man 6*/4, 674–688.

Anderberg, A-L. 1994. *Atlas of seeds and small fruits of Northwest-European plant species, with morphological descriptions. Part 4 Resedaceae - Umbelliferae*, Stockholm: Swedish Natural Science Research Council.

Anderson, S. and Ertuğ-Yaraş, F. 1998. Fuel, fodder and faeces: an ethnographic and botanical study of dung fuel use in Central Anatolia. *Environmental Archaeology 1*, 99–109.

Andrews, M. and McKenzie, B. A. 2007. Adaptation and Ecology. In: S. S. Yadav, D. L. McNiel, and S. . Stevenson (eds.), *Lentil: an Ancient Crop for Modern Times*, Dordrecht: Springer, 23–32.

Antolín, F. 2013. *Of cereals, poppy, acorns and hazelnuts. Plant economy among early farmers (5500-2300 cal BC) in the NE of the Iberian Peninsula. An archaeobotanical approach.* Ph.D. Thesis, Dept. De Prehistòria, Universitat Autònoma de Barcelona.

Antolín, F. and Jacomet, S. 2015. Wild fruit use among early farmers in the Neolithic (5400–2300 cal BC) in the north-east of the Iberian Peninsula: an intensive practice. *Vegetation History and Archaeobotany 24*, 19–33.

Antolín, F. Jacomet, S. and Buxó, R. 2015. The hard knock life. Archaeobotanical data on farming practices during the Neolithic (5400-2300 cal BC) in the NE of the Iberian Peninsula. *Journal of Archaeological Science 61*, 90–104.

Antolín, F. Steiner, B. Akeret, Ö. Brombacher, C. *et al.* 2017. Studying the preservation of plant macro-remains from waterlogged archaeological deposits for an assessment of layer taphonomy. *Review of Palaeobotany and Palynology 246*, 120–145.

Arbogast, R-M. Jacomet, S. Magny, M. and Schibler, J. 2006. The significance of climate fluctuations for lake level changes and shifts in subsistence economy during the late Neolithic (4300–2400 B.C.) in central Europe. *Vegetation History and Archaeobotany 15*, 403–418.

Asouti, E. and Fuller, D.Q. 2013. A Contextual Approach to the Emergence of Agriculture in Southwest Asia. *Current Anthropology 54*, 299–345.

Astaloş, C. Sommer, U. and Virag, C. 2013. Excavations of an Early Neolithic site at Tăşnad. *Archaeology International 16*/47–53.

Bailey, D. W. 2000. *Balkan prehistory. Exclusion, Incorporation and Identity.*, London and New York: Routledge.

Bakels, C. 1982. Der Mohn, die Linearbandkeramic und das westliche Mittlemeergebiet. *Archeologisches Korrespondenzblatt 12*, 11–13.

Bakels, C. 1992. Fruits and seeds from the Linearbandkeramik settlement at Meindling, Germany, with special reference to Papaver somniferum. *Analecta Praehistorica Leidensia 25*, 55–68.

Bakels, C. 2009. *The Western European Loess Belt: Agrarian History, 5300 BC–AD 1000*, Dordrecht: Springer.

Balbo, A.L. Andrič, M. Rubinić, J. Moscariello, A. and Miracle, P. 2006. Palaeoenvironmental and Archaeological Implications of a Sediment Core from Poije Čepić , Istria, Croatia. *Geologia Croatica 59*, 109–124.

Ballantyne, R. 2013. Charred plant remains and small artefactual debris. In: C. Evans, G. Appleby, S. Lucy, and R. Regan (eds.), *Process and history. Romano-British Communities at Colne Fen, Earith*, Cambridge: Cambridge Archaeological Unit, 391–413.

Bánffy, E. 2000. The Late Starčevo and the earliest Linear Pottery groups in western Transdanubia. *Documenta Praehistorica 27*, 173–185.

Bánffy, E. 2004a. Advances in the research of the Neolithic transition in the Carpathian Basin. In: A. Lukes and M. Zvelebil (eds.), *LBK Dialogues. Studies in the formation of the Linear Pottery Culture*, Oxford: Archaeopress. BAR international series 1304, 49–70.

Bánffy, E. 2004b. *The 6th millennium BC boundary in western Transdanubia and its role in the Central European Neolithic transition (the Szentgyörgyvölgy-Pityerdomb settlement)*, Budapest: Archaeological Institute of the Hungarian Academy of Sciences.

Bánffy, E. 2008. The boundary in western Transdanubia: variations of migration and adaptation. In: D. Bailey, A. Whittle, and D. Hofmann (eds.), *Living well together? Settlement and materiality in the Neolithic of south-east and central Europe.*, Oxford: Oxbow Books, 151–163.

Bánffy, E. 2013. The Körös culture in the southern Danube valley and in the Kalocsa Sárköz region. In: E. Bánffy (ed.), *The Early Neolithic in the Danube-Tisza interfluve,* Oxford: Archaeopress. BAR international series 2584, 11–14.

Bánffy, E. and Oross, K. 2010. The earliest and earlier phase of the LBK in Transdanubia. In: D. Gronenborn and J. Petrasch (eds.), *The spread of the Neolithic to central Europe: international symposium, Mainz 24-26 June 2005 spread of the Neolithic to central Europe*, Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 255–272.

Bánffy, E. and Sümegi, P. 2011. The (environ-) mental context of earliest Neolithic settlement and architecture in western Hungary. In: A. Hadjikoumis, E. Robinson, and S. Viner (eds.), *The Dynamics of neolithisation in Europe*, Oxford and Oakville: Oxbow Books, 231–265.

Bánffy, E. Eichmann, W. and Marton, T. 2007. Mesolithic foragers and the spread of agriculture in Western Hungary. In: J. Kozłowski and M. Nowak (eds.), *Mesolithic/Neolithic interactions in the Balkans and in the Middle Danube Basin*, Oxford: Archaeopress. BAR international series 1726, 53–62.

Barker, G. 1985. *Prehistoric farming in Europe*, Cambridge: Cambridge University Press.

Barker, G. 2006. *The Agricultural Revolution in Prehistory. Why did foragers become farmers*, Oxford: Oxford University Press.

Barnard, H. Dooley, A. N. Areshian, G. Gasparyan, B. and Faull, K. F. 2011. Chemical evidence for wine production around 4000 BCE in the Late Chalcolithic Near Eastern highlands. *Journal of Archaeological Science 38*/5, 977–984.

Barrios, A. Aparicio, T. Rodríguez, M. J. Pérez de la Vega, M. and Caminero, C. 2016. Winter sowing of adapted lines as a potential yield increase strategy in lentil (*Lens culinaris* Medik.). *Spanish Journal of Agricultural Research 14*/2, e0702.

Barton, H. and Torrence, R. 2015. Cooking up recipes for ancient starch: Assessing current methodologies and looking to the future. *Journal of Archaeological Science 56*, 194–201.

Bartosiewicz, L. 2005. Plain talk: animals, environment and culture in the Neolithic of the Carpathian Basin and adjacent areas. In: D. Bailey, A. Whittle, and V. Cummings (eds.), *(Un)Settling the Neolithic*, Oxford: Oxbow Books, 51–63.

Baum, T. Nendel, C. Jacomet, S. Colobran, M. *et al*. 2016. "'Slash and burn'" or "'weed and manure'"? A modelling approach to explore hypotheses of late Neolithic crop cultivation in pre- alpine wetland sites. *Vegetation History and Archaeobotany 25*, 611–627.

Behre, K.E. 1992. The history of rye cultivation in Europe. *Vegetation History and Archaeobotany 1*, 141–156.

Behre, K.E. 2008. Collected seeds and fruits from herbs as prehistoric food. *Vegetation History and Archaeobotany 17*/1, 65–73.

Behre, K.E. and Jacomet, S. 1991. The ecological interpretation of archaeobotanical data. In: W. van Zeist, K. Wasylikowa, and K. E. Behre (eds.), *Progress in Old World palaeoethnobotany*, Rotterdam: A.A. Balkema, 81–108.

Berger, J-F. and Guilaine, J. 2009. The 8200 cal. BP abrupt environmental change and the Neolithic transition: A Mediterranean perspective. *Quaternary International 200*, 31–49.

Berger, J-F., Metallinou, G., and Guilaine, J. 2014. Vers une révision de la transition méso-néolithique sur le site do Sidari (Corfu, Grèce). Nouvelles données géoarchaéologiques et radiocarbone, évaluation des processus post-dépositionels. In: C. Manen,T. Perrin and J. Guilaine (eds.). *La transition Néolithiques en Mediterranée*. Museum de Toulouse: édition errance: 213-232.

Berggren, G. 1969. *Atlas of seeds and small fruits of Northwest-European plant species, with morphological descriptions. Part 2 Cyperaceae*, Stockholm: Swedish Natural Science Research Council.

Berggren, G. 1981. *Atlas of seeds and small fruits of Northwestern-European plant species, with morphological descriptions. Part 3 Salicaceae - Cruciferae*, Stockholm: Swedish Natural Science Research Council.

Berzsényi, B. and Dálnoki, O. 2005. Plant cultivation and crop processing at the formative LBK settlement of Szentgyörgyvölgy-Pityerdomb. *Antaeus 28*, 261–270.

Bharucha, Z. and Pretty, J. 2010. The roles and values of wild foods in agricultural systems. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences 365*/1554, 2913–2926.

Biagi, P. 2003. A review of the Late Mesolithic in Italy and its implications for the Neolithic transition. In: A. J. Ammerman and P. Biagi (eds.), *The widening harvest. The Neolithic transition in Europe: looking back, looking forward.*, Boston: Archaeological Institute of America, 133–155.

Biagi, P. and Spataro, M. 2001. Plotting the evidence: some aspects of the radiocarbon chronology on the Mesolithic-Neolithic transition in the Mediterranean basin. *Atti della Società per la Preistoria e Protostoria della Regione Friuli 12*, 15–54.

Biagi, P. and Spataro, M. 2005. New observations on the radiocarbon chronology of the Starčevo-Criş and Körös cultures. *Prehistoric archaeology and anthropological theory and education. Reports of prehistoric research projects 6–7*, 35–40.

Biagi, P. Shennan, S. and Spataro, M. 2005. Rapid rivers and slow seas? New data for the radiocarbon chronology of the Balkan Peninsula. *Prehistoric archaeology and anthropological theory and education. Reports of prehistoric research projects 6–7*, 41–52.

Bickle, P. and Whittle, A. 2013. LBK lifeways: a search for difference. In: P. Bickle and A. Whittle (eds.), *The first farmers of Central Europe. Diversity in LBK lifeways*, Oxford and Oakville: Oxbow Books, 1–27.

Binford, L. R. 1964. A consideration of archaeological research design. *American Antiquity 29*, 425–441.

Binford, L. R. 1983. *In pursuit of the past: decoding the archaeological record*, London: Thames and Hudson.

Binford, L. R. 2001. *Constructing frames of reference: an analytical method for archaeological theory building using hunter-gatherer and environmental data sets*, Berkeley: University of California Press.

Blatter, R.H. Jacomet, S. and Schlumbaum, A. 2004. About the origin of European spelt (*Triticum spelta* L.): allelic differentiation of the HMW Glutenin B1-1 and A1-2 subunit genes. *Theoretical and applied genetics. 108*/2, 360–7.

Boardman, S. and Jones, G. 1990. Experiments on the effects of charring on cereal plant components. *Journal of Archaeological Science*, 1–11.

Bocquet-Appel, J-P. 2005. La transtition démographique néolithique. In: J. Guilaine (ed.), *Population Néolithique et environnements*, Paris: Errance, 11–20.

Bocquet-Appel, J-P. Naji, S. Vander Linden, M. and Kozłowski, J. 2012. Understanding the rates of expansion of the farming system in Europe. *Journal of Archaeological Science 39*, 531–546.

Bocquet-Appel, J-P. Naji, S. Vander Linden, M. and Kozłowski, J. K. 2009. Detection of diffusion and contact zones of early farming in Europe from the space-time distribution of 14C dates. *Journal of Archaeological Science 36*, 807–820.

Bogaard, A. 2002a. Questioning the relevance of shifting cultivation to Neolithic farming in the loess belt of Europe: evidence from the Hambach Forest experiment. *Vegetation History and Archaeobotany 11*/1, 155–168.

Bogaard, A. 2002b. *The permanence, intensity and seasonality of early crop cultivation in western-central Europe.* Ph.D. Thesis, University of Sheffield.

Bogaard, A. 2004a. *Neolithic farming in central Europe: an archaeobotanical study of crop husbandry practices*, London and New York: Routledge.

Bogaard, A. 2004b. The nature of early farming in Central and South-east Europe Amy. *Documenta Praehistorica XXXI*, 49–58.

Bogaard, A. 2005. "Garden agriculture" and the nature of early farming in Europe and the Near East. *World Archaeology*, 177–196.

Bogaard, A. 2011. *Plant use and crop husbandry in an early Neolithic village. Vaihingen an der Enz, Baden-Württemberg*. Bonn: Dr.Rudolf Habelt GmbH.

Bogaard, A. 2012. Middening and manuring in Neolithic Europe: Issues of plausibility, intensity and archaeological method. In: R. Jones (ed.), *Manure Matters: Historical, Archaeological and Ethnographic Perspectives*, Farnham: Ashgate Publishing Ltd., 25–39.

Bogaard, A. and Halstead P. 2015. Subsistence practices and social routine in Neolithic southern Europe. In: C. Fowler, J. Harding and D. Hofmann (eds.), *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, 385-410.

Bogaard, A. and Walker, A. 2011. *Plant use and management at Măgura-Buduiasca (Teleor 003), southern Romania: Preliminary report on the archaeobotanical analysis.* Available at: http://www.magurapastpresent.eu/files/resources/Bogaard_Walker_EU_report_May_2011_compiled.pdf. Accessed 15th August 2015.

Bogaard, A. Hodgson, J. G. Wilson, P. J. and Band, S. R. 1998. An index of weed size for assessing the soil productivity of ancient crop fields. *Vegetation History and Archaeobotany 7*/1, 17–22.

Bogaard, A. Palmer, C. Jones, G. Charles, M. and Hodgson, J. G. 1999. A FIBS Approach to the Use of Weed Ecology for the Archaeobotanical Recognition of Crop Rotation Regimes. *Journal of Archaeological Science 26*/9, 1211–1224.

Bogaard, A. Jones, G. and Charles, M. 2001. On the Archaeobotanical Inference of Crop Sowing Time using the FIBS Method. *Journal of Archaeological Science 28*, 1171–1183.

Bogaard, A. Jones, G. and Charles, M. 2005. The impact of crop processing on the reconstruction of crop sowing time and cultivation intensity from archaeobotanical weed evidence. Vegetation History and Archaeobotany 14: 505-509. DOI:10.1007/s00334-005-0061-3.

Bogaard, A. Bending, J. and Jones, G. 2007a. Archaeobotanical evidence for plant husbandry and use. In: A. Whittle (ed.), *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös culture site of Ecsegfalva, county Békés. Volume II*, Budapest: Archaeological Institute of the Hungarian Academy of Sciences, 421–445.

Bogaard, A. Heaton, T.H. Poulton, P. and Merbach, I. 2007b. The impact of manuring on nitrogen isotope ratios in cereals: archaeological implications for reconstruction of diet and crop management practices. *Journal of Archaeological Science*, 335–343.

Bogaard, A. Bending, J. and Jones, G. 2008. Crop husbandry and its social significance in the Körös and LBK cultures. In: D. Bailey, A. Whittle, and D. Hofmann (eds.), *Living well together? Settlement and materiality in the Neolithic of south-east and central Europe.*, Oxford: Oxbow Books, 131–138.

Bogaard, A. Charles, M. Livarda, A. Ergun, M. Filipović, D. and Glynis, J. 2013a. The archaeobotany of mid-later occupation levels at Neolithic Çatalhöyük. In: I. Hodder (ed.), *Humans and landscapes of Çatalhöyük. Reports from the 2000-2008 excavation seasons. Çatalhöyük Research Project Series Volume 8*, Ankara: British Institute at Ankara: BIAA Monograph no. 47, 93–128.

Bogaard, A. Fraser, R. Heaton, T.H. Wallace, M. *et al*. 2013b. Crop manuring and intensive land management by Europe's first farmers. *Proceedings of the National Academy of Sciences of the United States of America 110*, 12589–94.

Bogaard, A. Hodgson, J. Nitsch, E. Glynis, J. *et al.* 2016a. Combining functional weed ecology and crop stable isotope ratios to identify cultivation intensity: a comparison of cereal production regimes in Haute Provence, France and Asturias, Spain. *Vegetation History and Archaeobotany 25*/1, 57–73.

Bogaard, A. Styring, A. Ater, M. Hmimsa, Y. *et al*. 2016b. From Traditional Farming in Morocco to Early Urban Agroecology in Northern Mesopotamia: Combining Present-day Arable Weed Surveys and Crop Isotope Analysis to Reconstruct Past Agrosystems in (Semi-)arid Regions. *Environmental Archaeology*, 1–20. DOI:10.1080/14614103.2016.1261217.

Bogaard, A. Filipović, D. Fairbairn, A. Green, L. *et al*. 2017. Agricultural innovation and resilience in a long-lived early farming community: the 1,500-year sequence at Neolithic to early Chalcolithic Çatalhöyük, central Anatolia. *Anatolian Studies 67*, 1–28.

Bogucki, P. 1996. The spread of early farming in Europe. *American Scientist 84*, 242–253.

Boivin, N. Fuller, D. Q. and Crowther, A. 2012. Old World globalization and the Columbian exchange: comparison and contrast. *World Archaeology 44*/3, 452–469.

Bojňanský, V. and Fargašová, A. 2007. *Atlas of seeds and fruits of Central and East-European flora. The Carpathian Mountains region*, Dordrecht: Springer.

Bol, R. Eriksen, J. Smith, P. Garnett, M.H. *et al*. 2005. The natural abundance of 13C, 15N, 34S and 14C in archived (1923-2000) plant and soil samples from the Askov long-term experiments on animal manure and mineral fertilizer. In: *Rapid Communications in Mass Spectrometry*, 3216–3226.

Bonga, L.A. 2013. *Late Neolithic pottery from mainland Greece, ca. 5,300–4,300 B.C.*, Ph.D. Thesis. Temple University, Philadelphia. ProQuest Dissertations Publishing.

Bonhomme, R. 2000. Bases and limits to using “degree.day” units. *European Journal of Agronomy 13*, 1–10.

Bonsall, C. 2008. The Mesolithic of the Iron Gates. In: G. Bailey and P. Spikins (eds.), *Mesolithic Europe*, Cambridge: Cambridge University Press, 238–279.

Bonsall, C. Lennon, R. McSweeney, K. Stewart, C. *et al.* 1997. Mesolithic and Early Neolithic in the Iron Gates: a palaeodietary perspective. *Journal of European Archaeology 5*/1, 50–92.

Bonsall, C. Macklin, M. Payton, R. and Boroneant, A. 2002. Climate, floods and river gods: environmental change and the Meso-Neolithic transition in southeast Europe. *Hunter Gatherer Research 2*/3–4, 1–15.

Bonsall, C. Mlekuž, D. Bartosiewicz, L. and Pickard, C. 2013. Early farming adaptations of the northeast Adriatic karst. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic animals in southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 145–160.

Bonsall, C. Cook, G. T. Pickard, C. McSweeney, K. *et al*. 2015. Food for Thought: Re-Assessing Mesolithic Diets in the Iron Gates. *Radiocarbon 57*/4, 689–699.

Bordon, A. Peyron, O. Lézine, A-M. Brewer, S. and Fouache, E. 2009. Pollen-inferred Late-Glacial and Holocene climate in southern Balkans (Lake Maliq). *Quaternary International 200*, 19–30.

Borić, D. 2007. Mesolithic-Neolithic interactions in the Danube Gorges. In: J. Kozłowski and M. Nowak (eds.), *Mesolithic/Neolithic interactions in the Balkans and in the Middle Danube Basin*, Oxford: Archaeopress. BAR international series 1726, 31–46.

Borić, D. 2009. Absolute dating of metallurgical innovations in the Vinča culture of the Balkans. In: T. L. Kienlin and B. W. Roberts (eds.), *Metals and societies: studies in honour of Barbara S. Ottaway*, Bonn: Habelt, 191–245.

Borić, D. 2011. New research in the appearance of the Neolithic between Northwest Anatolia and the Carpathian Basin. In: R. Krause (ed.), *Adaptations and transformations of the Danube Gorges foragers (c.1300 - 5500 BC): an overview. Papers of the international workshop.*, Rahden: Leidorf, 158–203.

Borić, D. and Price, T. D. 2013. Strontium isotopes document greater human mobility at the start of the Balkan Neolithic. *Proceedings of the National Academy of Sciences 110*, 3298–3303.

Borić, D. French, C. Stefanović, S. Dimitrijević, V. Cristiani, E. *et al*. 2014. Late Mesolithic lifeways and deathways at Vlasac (Serbia). *Journal of Field Archaeology 39*, 4–31.

Borojević, K. 2013. *New plant evidence from the Middle and Late Neolithic in the central Balkans*, Paper presented at the 16th conference of the International Work Group for Palaeoethnobotany, Thessaloniki, Greece. Available at: http://iwgp-2013.web.auth.gr/images/abstract%20book%20revised.pdf. Accessed 21st June 2015.

Borojević, K. 2006. *Terra and silva in the Pannonian Plain. Opovo agro-gathering in the Late Neolithic*, Oxford: Archaeopress. BAR international series 1563.

Borojević, K. Forenbaher, S. Kaiser, T. and Berna, F. 2008. Plant use at Grapčeva Cave and in the Eastern Adriatic Neolithic. *Journal of Field Archaeology 33*/3, 279–303.

Boroneant, V. Bonsall, C. McSweeney, K. Payton, R. and Macklin, M. 1999. A Mesolithic burial area at Schela Cladovei, Romania. In: A. Thévenin (ed.), *L'Europe des derniers chasseurs*, Paris: CTHS, 385–390.

Botanical.com A Modern Herbal. 1995-2017. Available at: www.botanical.com. Accessed 1st December 2015.

Bouby, L. and Billaud, Y. 2005. Identifying prehistoric collected wild plants: a case study from late Bronze Age settlements in the French Alps (Gresine, Bourget Lake, Savoie). *Economic Botany 59*/3, 255–267.

Boyadzhiev, Y. 2009. Early Neolithic cultures on the territory of Bulgaria. In: I. Gatsov and Y. Boyadzhiev (eds.), *The first Neolithic sites in Central/South-East European Transect. 1 Early Neolithic sites on the territory of Bulgaria*, Oxford: Archaeopress. BAR international series 2048, 7–44.

Bozilova, E. D. and Tonkov, S. B. 2000. Pollen from Lake Sedmo Rilsko reveals southeast European postglacial vegetation in the highest mountain area of the Balkans. *New Phytologist 148*, 315–325.

Braadbaart, F. 2008. Carbonisation and morphological changes in modern dehusked and husked *Triticum dicoccum* and *Triticum aestivum* grains. *Vegetation History and Archaeobotany 17*/1, 155–166.

Braadbaart, F. Van Der Horst, J. Boon, J. J. and Van Bergen, P. F. 2004. Laboratory simulations of the transformation of emmer wheat as a result of heating. *Journal of Thermal Analysis and Calorimetry 77*/3, 957–973.

Braadbaart, F. Bakels, C. Boon, J. and Van Bergen, P. 2005. Heating experiments under anoxic conditions on varieties of wheat. *Archaeometry 47*/1, 103–114.

Bramanti, B. Thomas, M.G. Haak, W. Unterlaender, M. *et al*. 2009. Genetic discontinuity between local hunter-gatherers and central Europe's first farmers. *Science (New York, N.Y.) 326*, 137–140.

Brantingham, P. J. Surovell, T. A. and Waguespack, N. M. 2007. Modeling post-depositional mixing of archaeological deposits. *Journal of Anthropological Archaeology 26*/4, 517–540.

Braun-Blanquet, J. 1932. *Plant sociology*, New York: McGraw-Hill.

Brennan, J. C. 2009. *Detection and identification of bioactive polyphenolic compounds in Polygonum dumetorum through bioassay directed fractionation.* M.Sc. Dissertation, University of California.

Bridges, E. M. 1990. *World Geomorphology*, Cambridge: Cambridge University Press.

Bronk Ramsey, C. 2009. Bayesian analysis of radiocarbon dates. *Radiocarbon 51*/1, 337–360.

Broodbank, C. 2006. The origins and early development of Mediterranean maritime activity. *Journal of Mediterranean Archaeology 19*/2, 199–230.

Broushaki, F. Thomas, M.G. Link, V. López, S. *et al*. 2016. Early Neolithic genomes from the eastern Fertile Crescent. *Science*.

Brown, T.A. Allaby, R. Sallares, R. and Jones, G. 1998. Ancient DNA in charred wheats: taxonomic identification of mixed and single grains. *Ancient Biomolecules 2*, 185–193.

Brückner, H. Kelterbaum, D. Marunchak, O. Porotov, A. and Vött, A. 2010. The Holocene sea level story since 7500 BP - Lessons from the Eastern Mediterranean, the Black and the Azov Seas. *Quaternary International 225*/2, 160–177.

Burić, M. 2009. Crtice o povijesti arheološkog istraživanja Gradca u Bapskoj i njegovih istraživača. *VAMZ, 3.s XLII*, 489–507.

Burić, M. 2011. *Gradac u Bapskoj – slika života istočne Hrvatske prije 7000 godina*, Zagreb: Faculty of Phylosophy, Department of Archaeology.

Burić, M. and Težak-Gregl, T. 2009. Bapska, a Late Neolithic settlement in Eastern Croatia – a new project. In: F. Draşovean, D. L. Ciobotaru, and M. Maddison (eds.), *Ten years after: the Neolithic of the Balkans as uncovered by the last decade of research*, Timisoara: Editura Marineasa, 85–100.

Butler, A. 1999. Pulse agronomy: traditional systems and implications. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 33–41.

Buxo, R. Capdevila, I. Alonso, N. Canal, D. *et al*. 1997. Archaeobotanical remains of hulled and naked cereals in the Iberian peninsula. *Vegetation History and Archaeobotany 6*, 16–23.

CABI. Invasive Species Compendium. 2008. *Bromus sterilis (barren brome)*. Available at: http://www.cabi.org/isc/datasheet/10035. Accessed 12th August. 2016.

CABI. Invasive Species Compendium. 2008. *Cuscuta europapea (European dodder)*. Available at: http://www.cabi.org/isc/datasheet/17113. Accessed 12th August. 2016.

CABI. Invasive Species Compendium. 2014. *Melilotus albus (honey clover)*. Available at: http://www.cabi.org/isc/datasheet/33693. Accessed 22nd August 2016.

CABI. Invasive Species Compendium. 2015. *Echinochloa crus-galli (barnyard grass)*. Available at: http://www.cabi.org/isc/datasheet/20367. Accessed 17th August 2016.

CABI. Invasive Species Compendium. 2015. *Lamium amplexicaule (henbit deadnettle)*. Available at: http://www.cabi.org/isc/datasheet/29728. Accessed 20th August 2016.

CABI. Invasive Species Compendium. 2016. *Avena fatua (wild oat)*. Available at: http://www.cabi.org/isc/datasheet/8058. Accessed 17th August 2016.

CABI. Invasive Species Compendium. 2016. Available at: *Xanthium strumarium (cocklebur)*. http://www.cabi.org/isc/datasheet/56864. Accessed 25th September 2016.

CABI. Invasive Species Compendium. 2017. *Brassica nigra (black mustard)*. Available at: http://www.cabi.org/isc/datasheet/10097. Accessed 17th August 2016.

Caldara, M. Muntoni, I. M. Fiorentino, G. Primavera, M. and Radina, F. 2011. A hidden Neolithic landscape in Apulia (southern Italy) Massimo. In: M. van Leusen, G. Pizziolo, and L. Sarti (eds.), *Hidden landscapes of Mediterranean Europe. Cultural and methodological biases in pre- and protohistoric landscape studies*, Oxford: Archaeopress. BAR international series 2320, 183–191.

Campo, B. Amorosi, A. and Bruno, L. 2016. Contrasting alluvial architecture of Late Pleistocene and Holocene deposits along a 120-km transect from the central Po Plain (northern Italy). *Sedimentary Geology 341*, 265–275.

Caracuta, V. Weinstein-Evron, M. Kaufman, D. Yeshurun, R. *et al*. 2016. 14,000-year-old seeds indicate the Levantine origin of the lost progenitor of faba bean. *Scientific Reports 6*, 1–6.

Caracuta, V. Vardi, J. Paz, Y. and Boarreto, E. 2017. Farming legumes in the pre-pottery Neolithic: New discoveries from the site of Ahihud (Israel). *PloS one 12*/5, 1–28.

Cârciumaru, M. 1973. Compte rendu de l’analyse polynique des coprolithes d’Icoana - Portes de Fer. In: M. Garašanin, A. Benac, and N. Tasić (eds.), *Actes du VIIIe congrès internationale des sciences préhistoriques et protohistoriques. Volume II*, Belgrade: Union internationale des Sciences préhistoriques et protohistoriques, 172–173.

Cârciumaru, M. 1978. L’analyse pollinique des coprolithes de la station archeologique de Vlasac. In: D. Srejović and Z. Letica (eds.), *Vlasac. A Mesolithic settlement in the Iron Gates. Volume II*, Belgrade: Serbian Academy of Social Sciences, 31–34.

Cârciumaru, M. 1991. Etude paléobotanic pour les habitats néolithiques et énéolithiques de Roumanie. In: *Palaeoethnobotany and archaeology : International Work-Group for Palaeoethnobotany, 8th Symposium, Nitra-Nové Vozokany 1989*, Nitra: Archaeological Institute of the Slovak Academy of Sciences; Acta interdisciplinaria archaeologica ; t. 7, 61–73.

Cârciumaru, M. 1996. *Paleoetnobotanica. Studii în preistoria şi ptrotoistoria României*, Bucharest: Academia Romană, Institutul de Arheologie “Vasile Parvan.”

Carolan, J. Hook, I. Chase, M. Kadereit, J. and Hodkinson, T. 2006. Phylogenetics of Papaver and related genera based on DNA sequences from ITS nuclear ribosomal DNA and plastid trnL intron and trnL–F intergenic spacers. *Annals of Botany 98*, 141–155.

Carruthers, W. J. 1986. The Late Bronze Age midden at Potterne. *Circaea 4*, 16–17.

Carruthers, W. J. 2005. Mineralised plant remains. In: V. Birbeck, R. Smith, P. Andrews, and N. Stoodley (eds.), *The origins of Mid-Saxon Southampton: excavations at the Friends Provident St Mary's Stadium 1998-2000. Wessex Archaeology report 20*, Salisbury: Wessex Archaeology, 157–184.

Carugati, M.G. 1993. Il Neolitico Antico in Friuli attraverso lo studio dei resti vegetali carbonizzati di tre siti: Fagnigola (Pn), Valer (PN) e Sammardenchia (UD). *Quaderni Friulani di Archeologia III*, 15–22.

Castagna, R. Borghi, B. Heun, F. and Salamini, F. 1996. Integrated approach to einkorn wheat breeding. In: S. Padulosi, K. Hammer, and J. Heller (eds.), *Hulled wheats. Promoting the conservation and use of underutilized and neglected crops. Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*, Rome: International Plant Genetic Resources Institute, 183–192.

Castelletti, L. and Maspero, A. 1992. Analisi di resti vegetali di campo ceresole del Vhò di Piadena e di altri siti neolitici padani. *Natura Bresciana 27*, 289–305.

Cauvin, J. 1994. *Naissance des divinités, naissance de l'agriculture : la révolution des symboles au Néolithique*, Paris: CNRS.

Cauwe, N. Dolukhanov, P. Kozłowski, J. and Van Berg, P-L. 2007. *Le Néolithique en Europe*, Paris: Armand Colin.

Chapman, J. 1981. *The Vinča culture of South-East Europe: studies in chronology, economy and society*, Oxford: Archaeopress. BAR international series 117(ii).

Chapman, J. 1994. The origins of farming in South East Europe. *Préhistoire Européenne 6*, 133–155.

Chapman, J. 2003. From Franchti to the Tiszazug: two Early Neolithic worlds. In: E. Jerem and P. Raczky (eds.), *Morgenrot der Kulturen. Frühe Etappen der Menschheitsgeschichte in Mittle- und Südosteuropa*, Budapest: Archaeolingua, 89–108.

Chapman, J. 2008. Meet the ancestors: settlement histories in the Neolithic. In: D. W. Bailey, A. Whittle, and D. Hofmann (eds.), *Living well together? Settlement and materiality in the Neolithic of south-east and central Europe.*, Oxford: Oxbow Books, 68–80.

Chapman, J. and Müller, J. 1990. Early farmers in the Mediterranean basin: the Dalmatian evidence. *Antiquity 64*/242, 127–134.

Charles, M. 1998. Fodder From Dung: the Recognition and Interpretation of Dung-Derived Plant Material from Archaeological Sites. *Environmental Archaeology 1*, 111–122.

Charles, M. and Bogaard, A. 2001. Third-millenium BC charred plant remains from Tell Brak. In: D. Oates, J. Oates, and H. McDonald (eds.), *Excavations at Tell Brak, Vol 2: Nagar in the 3rd millenium BC*, Cambridge: McDonald Institute Monograph, 301–326.

Charles, M. and Bogaard, A. 2005. Identifying livestock diet from charred plant remains: a Neolithic case study from Turkmenistan. In: J. Davies, M. Fabis, I. Mainland, M. Richards, and R. Thomas (eds.), *Diet and health in past animal populations: current research and future* *directions. Proceedings of the 9th ICAZ Conference, Durham 2002*, Oxford: Oxbow Books, 93–103.

Charles, M. and Bogaard, A. 2010. Charred plant macro-remains from Jeitun: implications for early cultivation and herding practices in western Central Asia. In: D. R. Harris (ed.), *Origins of agriculture in Western Central Asia : an environmental and archaeological study*, Philadelphia: University of Pennsylvania, 150–165.

Charles, M. and Hoppé, C. 2003. The effects of irrigation on weed floras of winter cereal crops in the Wadi Ibn Hamad (southern Jordan). *Levant 35*, 213–230.

Charles, M. Jones, G. and Hodgson, J. G. 1997. FIBS in Archaeobotany: Functional Interpretation of Weed Floras in Relation to Husbandry Practices. *Journal of Archaeological Science 24*/12, 1151–1161.

Charles, M. Bogaard, A. Jones, G. Hodgson, J. and Halstead, P. 2002. Towards the archaeobotanical identification of intensive cereal cultivation: Present-day ecological investigation in the mountains of Asturias, northwest Spain. *Vegetation History and Archaeobotany 11*/1–2, 133–142.

Charles, M. Hoppé, C. Jones, G. Bogaard, A. and Hodgson, J. G. 2003. Using weed functional attributes for the identification of irrigation regimes in Jordan. *Journal of Archaeological Science 30*/11, 1429–1441.

Childe, V. G. 1929. *The Danube in prehistory*, Oxford: Clarendon Press.

Childe, V. G. 1957. *The dawn of European civilization.*, St. Albans: Paladin, 6th ed.

Chu, W. Mihailović, D. Pantović, I. Zeeden, C. *et al*. 2016. Archaeological investigations at the site of At (Vršac, Serbia). *Antiquity + 332*.

Clark, J. G. D. 1952. *Prehistoric Europe: the economic basis*, London: Methuen.

Cochran, W. 1950. The comparison of percentages in matched samples. *Biometrika 37*/3/4, 256–266.

Colledge, S. 2001. *plant exploitation on Epipalaeolithic and Early Neolithic sites in the Levant*, Oxford: Archaeopress. BAR international series 986.

Colledge, S. 2016. The Cultural Evolution of Neolithic Europe. EUROEVOL Dataset 3: Archaeobotanical Data. *Journal of Open Archaeology Data 5*/e1. DOI: 10.5334/joad.42.

Colledge, S. and Conolly, J. 2007. The neolithisation of the Balkans: a review of the archaeobotanical evidence. In: M. Spataro and P. Biagi (eds.), *A short walk through the Balkans: the first farmers of the Carpathian Basin and adjacent regions*, Trieste: Società Preistoria Protostoria Friuli-V.G., 25–38.

Colledge, S. and Conolly, J. 2014. Wild plant use in European Neolithic subsistence economies: a formal assessment of preservation bias in archaeobotanical assemblages and the implications for understanding changes in plant diet breadth. *Quaternary Science Reviews 101*, 193–206.

Colledge, S. Conolly, J. and Shennan, S. 2004. Archaeobotanical Evidence for the Spread of Farming in the Eastern Mediterranean. *Current Anthropology 45*/S4, 35–58.

Colledge, S. Conolly, J. and Shennan, S. 2005. The evolution of Neolithic farming from SW Asian origins to NW European limits. *European Journal of Archaeology 8*/2, 137–156.

Coltorti, M. 1997. Human impact in the Holocene fluvial and coastal evolution of the Marche region, Central Italy. *Catena 30*, 311–355.

Coltorti, M. and Farabollini, P. 2008. Late Pleistocene and Holocene fluvial–coastal evolution of an uplifting area: The Tronto River (Central Eastern Italy). *Quaternary International 189*, 39–55.

Combourieu-Nebout, N. Peyron, O. Bout-Roumazeilles, V. Goring, S. *et al*. 2013. Holocene vegetation and climate changes in the central Mediterranean inferred from a high-resolution marine pollen record. *Climate of the Past 9*, 2023–2042.

Connor, S.E. Ross, S.A. Sobotkova, A. Herries, A. *et al*. 2013. Environmental conditions in the SE Balkans since the Last Glacial Maximum and their influence on the spread of agriculture into Europe. *Quaternary Science Reviews 68*, 200–215.

Conolly, J. Colledge, S. and Shennan, S. 2008. Founder effect, drift, and adaptive change in domestic crop use in early Neolithic Europe. *Journal of Archaeological Science 35*, 2797–2804.

Conolly, J. Colledge, S. Dobney, K. Vigne, J-D. *et al.* 2011. Meta-analysis of zooarchaeological data from SW Asia and SE Europe provides insight into the origins and spread of animal husbandry. *Journal of Archaeological Science 38*, 538–545.

Conolly, J. Manning, K. Colledge, S. Dobney, K. and Shennan, S. 2012. Species distribution modelling of ancient cattle from early Neolithic sites in SW Asia and Europe. *The Holocene*, 997–1010.

Coppola, D. and Costantini, L. 1987. Le Néolithique ancien littoral et la diffusion de céréales dans les Pouilles durant le VIe millenaire: les sites de Fontanelle, Torre Canne et Le Macchie. In: J. Guilaine, J. Courtin, J-L. Roudil, and J-L. Vernet (eds.), *Premiéres communautés paysannes en Méditerranée occidentale. Actes du colloque international du CNRS, 26-29 Avril, 1983*, Paris: Centre national de la recherche scientifique, 249–255.

Corti, P. Martinelli, N. Micheli, R. Montagrani Kokelj, E. *et al*. 1998. Siti umidi tardoneolitici: nuovi dati da Palù di Livenza (Friuli-Venezia Giulia, Italia). In: *Atti del XIII Congresso dell'Unione Internazionale delle Scienze Preistoriche e Protostoriche, Forlì 8–14 settembre 1996, vol 6, tomo II*, Forlì: A.B.A.C.O. Edizioni, 1379–1391.

Costantini, L. 1983. The beginning of agriculture in the Kachi Plain: The evidence of Mehrgarh. In: B. Allchin (ed.), *South Asian Archaeology*, Cambridge: Cambridge University Press, 29–33.

Costantini, L. 2002. Italia Centro-meridionale. In: G. Forni and A. Marcone (eds.), *Storia Dell'agricoltura Italiana. L'età Antica*, Florence: Edizioni Polistampa, 221–234.

Costantini, L. and Lentini, A. 2003. Indagini archeobotaniche sugli intonaci Neolitici di Torre Sabea. In: J. Guilaine and G. Cremonesi (eds.), *Torre Sabea. Un establissement du Néolithique* *ancien en Salento*, Rome: École Française de Rome, 234–245.

Costantini, L. and Stancanelli, M. 1994. La preistoria agricola dell'Italia centro-meridionale: il contributo delle indagini archeobotaniche. *Origini 18*, 149–244.

Coward, F. Shennan, S. Colledge, S. Conolly, J. and Collard, M. 2008. The spread of Neolithic plant economies from the Near East to northwest Europe: a phylogenetic analysis. *Journal of Archaeological Science 35*, 42–56.

Craig, O. E. Heron, C. Willis, L. H. Yusof, N. and Taylor, G. 2007. Organic residue analysis of pottery vessels. In: A. Whittle (ed.), *The Early Neolithic on the Great Hungarian Plain: Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*, Budapest: Archaeological Institute of the Hungarian Academy of Sciences, 349–360.

Craufurd, P.Q. and Wheeler, T. R. 2009. Climate change and the flowering time of annual crops. *Journal of Experimental Botany*, 2529–2539.

Cristiani, E. and Borić, D. 2016. Mesolithic harpoons from Odmut, Montenegro: chronological, contextual and techno-functional analysis. *Quaternary International*.

Cristiani, E. Radini, A. Edinborough, M. and Borić, D. 2016. Dental calculus reveals Mesolithic foragers in the Balkans consumed domesticated plant foods. *PNAS 113*/37, 10298–10303.

Crowther, A. Haslam, M. Oakden, N. Walde, D. and Mercader, J. 2014. Documenting contamination in ancient starch laboratories. *Journal of Archaeological Science 49*/1, 90–104.

Cubero, J. 1981. Origin, taxonomy and domestication. In: C. Webb and G. Hawtin (eds.), *Lentils*, Slough: Commonwealth Agricultural Bureaux, 15–38.

Cudney, D. Elmore, C. and Molinar, R. 2007. *Common purslane. Integrated pest management for home gardeners and landscape professionals*. *Pest Notes*, California.

d'Alpoim Guedes, J. Lu, H. Li, Y. Spengler, R. *et al*. 2014. Moving agriculture onto the Tibetan plateau: the archaeobotanical evidence. *Archaeological and Anthropological Sciences 6*, 255–269.

d'Alpoim Guedes, J. Lu, H. Hein, A. and Schmidt, A. H. 2015. Early evidence for the use of wheat and barley as staple crops on the margins of the Tibetan Plateau. *Proceedings of the National Academy of Sciences 112*/18, 5625–5630.

D'Andrea, A. and Haile, M. 2002. Traditional emmer processing in highland Ethiopia. *Journal of Ethnobiology 22*/2, 179–217.

Davis, B.A. Brewer, S. Stevenson, A. and Guiot, J. 2003. The temperature of Europe during the Holocene reconstructed from pollen data. *Quaternary Science Reviews 22*/15–17, 1701–1716.

Davison, K. Dolukhanov, P. Sarson, G. and Shukurov, A. 2006. The role of waterways in the spread of the Neolithic. *Journal of Archaeological Science 33*, 641–652.

Degasperi, N. Mottes, E. and Rottoli, M. 2006. Recenti indagini nel sito Neolitico de La Vela di Trento. In: A. Pessina and P. Visentini (eds.), *Preistoria dell'Italia settentrionale. Studi in ricordo di Bernardino Bagolini Atti del Convegno, Udine settembre 2005*, Udine: Museo

Friulano di Storia Naturale, 143–168.

Demoule, J-P. 1993. Anatolie et Balkans: la logique évolutive du Néolithique égéen. *Anatolica XIX*, 1–13.

Demoule, J-P. and Perlès, C. 1993. The Greek Neolithic: a new review. *Journal of World Prehistory 7*/4, 355–416.

Dennell, R. 1972. The interpretation of plant remains: Bulgaria. In: E. S. Higgs (ed.), *Papers in economic prehistory*, Cambridge: Cambridge University Press, 149–160.

Dennell, R. 1974. Botanical evidence for prehistoric plant processing activities. *Journal of Archaeological Science 1*, 275–284.

Dennell, R. 1976. The economic importance of plant resources represented on archaeological sites. *Journal of Archaeological Science 3*, 229–247.

Dennell, R. 1978. *Early farming in South Bulgaria from the VI to the III millennia B.C.*, Oxford: British Archaeological Reports: BAR International Series (Supplementary) 45.

Dennell, R. 1992. The origins of crop agriculture in Europe. In: W. C. C. and W. P. J. (eds.), *The Origins of Agriculture: An International Perspective*, Washington: Smithsonian Institution, 71–100.

Diacono, M. and Montemurro, F. 2010. Long-term effects of organic amendments on soil fertility. A review. *Agronomy for Sustainable Development 30*/2, 401–422.

Dolukhanov, P. 2008. The Mesolithic of European Russia, Belarus and the Ukrain. In: G. Bailey and P. Spikins (eds.), *Mesolithic Europe*, Cambridge: Cambridge University Press, 280–301.

D'Oronzo, C. and Fiorentino, G. 2006. Analisi preliminare dei resti carpologici rinvenuti nel villaggio neolitico di Foggia (località ex-Ippodromo). In: A. Gravina (ed.), *Atti del 26 convegno sulla preistoria - protostoria e storia della Daunia. 10-11 Dicembre 2005*, San Severo: Archeoclub d'Italia, 33–38.

D'Oronzo, C. Gaglione, L. and Fiorentino, G. 2008. L'analisi archeobotanica in località Monte Calvello (Fg): fasi neolitica e dauna. In: A. Gravina (ed.), *Atti del 28 convegno sulla preistoria - protostoria e storia della Daunia. 25-26 Novembre 2007*, San Severo: Archeoclub d'Italia, 49–59.

Douka, K., Efstratiou, N., Halde, M.M., Henriksen, P.S. and Karetsou, A. 2017. Dating Knossos and the arrival of the earliest Neolithic in the southern Aegean. *Antiquity 91* (356): 304-321. DOI: 10.15184/aqy.2017.29.

Drost, C. and Vander Linden, M. Submitted. The fall and rise of cultural diversity during episodes of demic expansion. *Royal Society Open Science*.

Dvorak, J. Deal, K. Luo, M. You, F. *et al*. 2012. The origin of spelt and free-threshing hexaploid wheat. *Journal of Heredity 103*/3, 426–441.

Eastwood, W. J. 2004. East Mediterranean vegetation and climate change. In: H. I. Griffiths, B. Kryštufek, and J. Reed (eds.), *Balkan Biodiversity. Pattern and process in the European* *hotspot*, Dordrecht, Boston, London: Kluwer Academic publishers, 25–48.

Eddowes, M. 1976. *Crop production in Europe*, Oxford: Oxford University Press.

Edinborough, K. and Vander Linden, M. 2015. Radiocarbon chronology. In: I. Pandžić and M. Vander Linden (eds.), *The Neolithic site of Kočićevo in the lower Vrbas Valley (Republika Srpska, Bosnia and Herzegovina): report of the 2009-2014 field seasons*, Banja Luka: Univeristy of Banja Luka.

Efstratiou, N. 2005. Tracing the story of the first farmers in Greece . A long and widening road. In: C. Lichter and R. Meric (eds.), *How did Farming Reach Europe? Anatolian-European Relations from the Second Half of the Seventh through the First Half of the Sixth Millennium calBC. International Workshop, Istanbul, 20 – 22 May 2004*, Istanbul: Ege Yayınları, 141–155.

Efstratiou, N. Karestou, A. Nanou, E. and Morgomenou, D. 2004. The Neolithic settlement of Knossos . New Light on an old picture. In: G. Cadogan, E. Hatzaki, and A. . Vasiliakis (eds.), *Knossos, palace, city, state*, London: The British School of Athens, Supplements 12, 39–49.

Ehrmann, O. Biester, H. Bogenrieder, A. and Rosch, M. 2014. Fifteen years of the Forchtenberg experiment-results and implications for the understanding of Neolithic land use. *Vegetation History and Archaeobotany 23*/S1, 5–18.

Eichmann, W. Kertész, R. and Marton, T. 2010. Mesolithic in the LBK Heartland of Transdanubia, Western Hungary. In: D. Gronenborn and J. Petrasch (eds.), *The spread of the Neolithic to central Europe: international symposium, Mainz 24-26 June 2005 spread of the Neolithic to central Europe. Interna- tional Symposium, Mainz 24 June – 26 June 2005*, Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 211–233.

Ellenberg, H. 1988. *Vegetation ecology of central Europe*. 4Th Edition. Cambridge: Cambridge University Press.

European Environment Agency, 2016. Biogeographical regions. Available at: //http:www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe. Accessed 2nd December 2016.

Ethier, J. Bánffy, E. Vuković, J. Leshtakov, K. *et al*. 2017. Earliest expansion of animal husbandry beyond the Mediterranean zone in the sixth millennium BC. *Scientific Reports 7*/7146, 1–10.

Evans, J. 1994. The early millennia, continuity and change in the farming settlement. In: D. Evely, H. Hughes-Brock, and M. Momigliano (eds.), *Knossos. A Labyrinth of History*, Athens: British School of Athens, 1–20.

Evett, D. and Renfrew, J. 1971. L'agricoltura neolitica italiana: una nota sui cereali. *Rivista di Scienze Preistoriche 26*/2, 403–409.

FAO and UNESCO. 1981. *Soil map of the world. Volume 5. Europe*, Paris: UNESCO.

Favaretto, S. Asioli, A. Miola, A. and Piva, A. 2008. Preboreal climatic oscillations recorded by pollen and foraminifera in the southern Adriatic Sea. *Quaternary International 190*/1, 89–102.

Feurdean, A. Perşoiu, A. Tanţău, I. Stevens, T. *et al*. 2014. Climate variability and associated vegetation response throughout Central and Eastern Europe (CEE) between 60 and 8 ka.

Quaternary Science Reviews 106, 206–224.

Filipović, D. Forthcoming. Charred seed and fruit remains. In: D. Borić (ed.), *Vlasac revisited: a Mesolithic site in the Danube Gorges*, Oxford: Oxbow Books.

Filipović, D. Submitted-a. Archaeobotanical analysis of the Neolithic-Early Chalcolithic site of Pločnik, Serbia. In: M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović-Cvetković, and T. Rehren (eds.), *The Rise of Metallurgy in Eurasia: The Archaeology of Early Metallurgy and Society in the Central Balkans*, London: UCL Press.

Filipović, D. Submitted-b. Plant use at Neolithic-Early Chalcolithic Belovode, Serbia. In: M. Radivojević, B. W. Roberts, M. Marić, J. Kuzmanović-Cvetković, and T. Rehren (eds.), *The Rise of Metallurgy in Eurasia: The Archaeology of Early Metallurgy and Society in the Central Balkans*, London: UCL Press.

Filipović, D. 2004. *Archaeobotanical analysis. Recovery and identification of macro-botanical remains from the site of Vinča-Belo Brdo 2001-2003*. MSc Dissertation. Department of Archaeology, Faculty of Philosophy, University of Belgrade.

Filipović, D. 2014. *Early farming in Central Anatolia. An archaeobotanical study of crop husbandry, animal diet and land use at Neolithic Çatalhöyük.*, Oxford: Archaeopress. BAR international series 2667.

Filipović, D. and Marić, M. 2013. Одвајање археоботаничких узорака на археолошким локалитетима у Србији - предлог стратегије. *Journal of Serbian Archaeological Society 29*, 297–328.

Filipović, D. and Obradović, Đ. 2013. Archaeobotany at Neolithic sites in Serbia: a critical overview of the methods and results. In: S. Vitezović and N. Miladinović (eds.), *Bioarchaeology 1. Developments and trends in bioarchaeological research in the Balkans.*, Belgrade: Srpsko Arheološko Društvo, 25–55.

Filipović, D. and Obradović, Đ. 2016. *Exploring variations in crop storage and discard practices across Neolithic sites in Serbia*, Poster presented at the 17th conference of the International Work Group for Palaeoethnobotany, Pairs, France. Available at: https://iwgp2016paris.sciencesconf.org.

Filipović, D. and Tasić, N. 2012. Vinča-Belo Brdo, a Late Neolithic site in Serbia: consideration of the macro-botanical remains as indicators of dietary habits. *Balcanica XLIII*, 7–28.

Filipović, D. Challinor, D. and Andrič, M. 2017. Vinča tell in southeast Europe: multi-proxy palaeobotanical evidence from Late Neolithic levels and the implications for the environment and economy. *Quaternary International 429*, 13–23.

Fiorentino, G. Caldara, M. De Santis, V. D'Oronzo, C. *et al*. 2013. Climate changes and human-environment interactions in the Apulia region of southeastern Italy during the Neolithic period. *The Holocene 23*/9, 1297–1316.

Fischer, E. and Rösch, M. 2004. Archäobotanische Untersuchungen, In: Schier, W., Draşovean, F. (eds.). Vorbericht uber die rumänisch-deutschen Pros pektionen und Ausgrabungen in der befes tigten Tellsiedlung von Uivar, jud. Timiş, Rumänien (1998-2002). *Praehistorische Zeitschrift*

79/2, 209–220.

Flannery, K. 1976. *The early Mesoamerican village,* New York, London: Academic press.

Follieri, M. 1987. L'Agriculture des plus anciennes communautés rurales d'Italie. In: J. Guilaine, J. Courtin, J-L. Roudil, and J-L. Vernet (eds.), *Premiéres communautés paysannes en Méditerranée occidentale. Actes du colloque international du CNRS, 26-29 Avril, 1983*, Paris: CNRS, 243–248.

Forenbaher, S. and Miracle, P. 2005. The spread of farming in the Eastern Adriatic. *Antiquity 79,* 514–528.

Forenbaher, S. and Perhoč, Z. 2015. Lithic artifacts from Nakovana (Pelješac): Continuity and change from Early Neolithic until the end of Prehistory. *Prilozi. Instituta za Arheologija u Zagrebu 32,* 5–74.

Forenbaher, S. Kaiser, T. and Miracle, P. 2013. Dating the East Adriatic Neolithic. *European Journal of Archaeology 16,* 589–609.

Fort, J. Pujol, T. and Linden, M. Vander. 2012. Modelling the Neolithic Transition in the Near East and Europe. *American Antiquity*, 203–219.

Francis, S. A. 2009. *British field crops. A pocket guide to the identification, history and uses of arable crops in Great Britain.*, Bury St Edmunds: Sally Francis, 2nd ed.

Franco, C. 2011. La fine del Mesolitico in Italia. Identità culturale e distribuzione territoriale degli ultimi cacciatori-raccoglitori. *Società per la preistoria e protostoria della regione Friuli-Venezia Giulia 13,* 1–280.

Fraser, R., Bogaard, A., Charles, M., Styring, A. K., *et al*. 2013. Assessing natural variation and the effects of charring, burial and pre-treatment on the stable carbon and nitrogen isotope values of archaeobotanical cereals and pulses. *Journal of Archaeological Science 40,* 4754–4766.

Fraser, R., Bogaard, A., Heaton, T., Charles, M., *et al*. 2011. Manuring and stable nitrogen isotope ratios in cereals and pulses: Towards a new archaeobotanical approach to the inference of land use and dietary practices. *Journal of Archaeological Science 38,* 2790–2804.

French, C. 2003. *Geoarchaeology in action*, London and New York: Routledge.

Fritsch, R. 1979. Zur samenmorphologie des kulturmohns (*Papaver somniferum* L.). *Kulturpflanze 27*, 217–227.

Fritz, G. and Nesbitt, M. 2014. Laboratory analysis and identification of plant macroremains. In: J. M. Marston, J. d'Alpoim Guedes, and C. Warinner (eds.), *Method and theory in paleoethnobotany*, Boulder: University Press of Colorado, 115–146.

Fu, Y. B. 2011. Genetic evidence for early flax domestication with capsular dehiscence. *Genetic Resources and Crop Evolution 58*/8, 1119–1128.

Fuller, D. Q. 2003. African crops in prehistoric South Asia: a critical review. In: K. Neumann, A. Butler, and S. Kahlheber (eds.), *Food, fuel and fields: progress in African archaeobotany (Africa Praehistorica 15),* Cologne: Heinrich-Barth Institute, 239–271.

Fuller, D. Q. 2007. Contrasting patterns in crop domestication and domestication rates: recent archaeobotanical insights from the Old World. *Annals of Botany 100*, 903–924.

Fuller, D. Q. 2008. Recent lessons from Near Eastern archaeobotany: wild cereal use, pre-domestication cultivation and tracing multiple origins and dispersals. Pragdhara (Journal of the Uttar Pradesh State Archaeology Department). *Pragdhara (Journal of the Uttar Pradesh State Archaeology Department) 18*, 105–134.

Fuller, D. Q. and Lucas, L. 2017. Adapting crops, landscapes and food choices: patterns in the dispersal of domesticated plants across Eurasia. In: M. Petraglia, N. Boivin, and R. Crassard (eds.), *Human Dispersal and Species Movement: from Prehistory to the Present*, Cambridge: Cambridge University Press, 304–331.

Fuller, D. Q. and Stevens, C. 2009. Agriculture and the development of complex societies: an archaeobotanical agenda. In: A. S. Fairbairn and E. Weiss (eds.), *From foragers to farmers. Papers in honour of Gordon C. Hillman*, Oxford: Oxbow Books, 37–57.

Fuller, D. Q., Haddow, S., Hadad, R., Killackey, K., *et al.* In prep. The earliest evidence for textile trade: a linen shrouded infant burial from 7th Millennium BC at Neolithic Çatalhöyük, Turkey.

Fuller, D. Q. Willcox, G. and Allaby, R. G. 2012. Early agricultural pathways: Moving outside the “core area” hypothesis in Southwest Asia. *Journal of Experimental Botany*, 617–633.

Fuller, D. Q. Stevens, C. and McClatchie, M. 2014a. Routine activities, tertiary refuse and labour organisation: social inferences from everyday archaeobotany. In: M. Madella, C. Lancelotti, and M. Savard (eds.), *Ancient plants and people. Contemporary trends in archaeobotany*, United States of America: University of Arizona Press, 174–217.

Fuller, D. Q., Denham, T., Arroyo-Kalin, M., Lucas, L., *et al.* 2014b. Convergent evolution and parallelism in plant domestication revealed by an expanding archaeological record. *Proceedings of the National Academy of Sciences of the United States of America 111*/17, 6147–6152.

Fuller, D. Q. Bogaard, A. Charles, M. and Filipović, D. 2014c. Macro- and Micro botanical remains from the 2013 and 2014 seasons. In: *Çatalhöyük Archive Report 2014 by members of the Çatalhöyük Research Project*, Available online: http://www.catalhoyuk.com/sites/default/files/media/pdf/Archive_Report_2014_0.pdf, 118–135.

Fuller, D. Q. Colledge, S. Murphy, C. and Stevens, C. J. 2017. Sizing up cereal variation: patterns in grain evolution revealed in chronological and geographical comparisons. In: J.Fernández Eraso,ujika Alustiza, A.Arrizabalaga Valbuena and M.García Díez (eds.). Miscelánea en homenaje a Lydia Zapata Peña, 1965-2015, 131-149.

Gaastra, J. Unpublished-a. *At 2015: fauna from Starčevo and Vinča D contexts*, Written in 2015 for the site report.

Gaastra, J. Unpublished-b. *Potporanj: fauna from the 2011-2014 excavations*, Written in 2015 for the site report.

Gaastra, J. Unpublished-c. *Osijek Filipovica - Hermanov Vinograd: fauna from the 1998 and 2007 excavations*, Written in 2016 for the site report.

Gaastra, J. and Vander Linden, M. Submitted. Farming data: meta-analysis of zooarchaeological assemblages across the Adriatic Neolithic. *The Holocene*.

Gallagher, D. E. 2014. Formation processes of the macrobotanical record. In: J. M. Marston, J. d'Alpoim Guedes, and C. Warinner (eds.), *Method and theory in paleoethnobotany*, Boulder: University of Colorado Press, 19–34.

Gamba, C. Fernández, E. Tirado, M. Deguilloux, M.F. *et al*. 2012. Ancient DNA from an Early Neolithic Iberian population supports a pioneer colonization by first farmers. *Molecular ecology 21*, 45–56.

Gamba, C. Jones, E.R. Teasdale, M. McLaughlin, R. *et al*. 2014. Genome flux and stasis in a five millennium transect of European prehistory. *Nature Communications 5*, 5257.

Gardener, M. 2014. *Community ecology. Analytical methods using R and Excel*, Exeter: Pelagic Publishing.

Gatsov, I. and Nedelcheva, P. 2016. The Mesolithic/Neolithic transition in Bulgaria and Western Anatolia – an overview. In: R. Krauss and H. Floss (eds.), *Southeast Europe before neolithisation. Proceedings of the international workshop within the collaborative research centres sfb 1070 "RessourcenKulturen", Schloss Hohentübingen, 9th of May 2014*, Tübingen: Universität Tübingen, 65–71.

Gealey, W. K. 1988. Plate tectonic evolution of the Mediterranean-Middle East region. *Tectonophysics 155*, 285–306.

Gobbo, I. 2010. *Archeobotanica di siti mesolitici, neolitici ed eneolitici di pianura dell'Emilia Romagna.* Ph.D. Thesis, Department of Archaeology, Università degli Studi di Ferrara.

Green, F. J. 1979. Phosphatic mineralization of seeds from archaeological sites. *Journal of Archaeological Science 6*/3, 279–284.

Greenfield, H. 2008. The vertebrate fauna from Hajdučka Vodenica in the Danubian Iron Gates: subsistence and taphonomy from the Early Neolithic and Mesolithic. In: *The Iron Gates in Prehistory : New perspectives*, 205–226.

Greenfield, H. Jongsma Greenfield, T. and Jezik, S. 2014. Subsistence and settlement in the Early Neolithic of temperate SE Europe: a view from Blagotin, Serbia. *Archaeologia Bulgarica XVIII*/1.

Greig, J. 1988. Some evidence of the development of grassland plant communities. In: M. Jones (ed.), *Archaeology and the flora of the British Isles: human influence on the evolution of plant communities*, Oxford: Oxford University Committee, 39–54.

Grigg, D. 1995. *An introduction to agricultural geography*, London and New York: Routledge, second edi.

Grime, J. Hodgson, J. and Hunt, R. 1988. *Comparative Plant Ecology. A functional approach to common British species*, London: Unwin Hyman.

Grüger, E. and Beug, H.J. 1988. Botanical Investigations at Divostin and Grivac. In McPherron, A. and Srejović , D. (eds.), *Divostin and Neolithic of Central Serbia*. Pittsburgh, Pennsylvania: Department of Anthropology, University of Pittsburgh, 415-418.

Guilaine, J. 2001. La diffusion de l'agriculture en Europe: une hypothèse arythmique. *Zephyrus* 53/*54*, 267–272.

Gulyás, S. and Sümegi, P. 2011. Farming and/or foraging? New environmental data to the life and economic transformation of Late Neolithic tell communities (Tisza Culture) in SE Hungary. *Journal of Archaeological Science 38*/12, 3323–3339.

Gunda, B. 1983. Cultural ecology of old cultivated plants in the Carpathian area. *Ethnologia Europaea 13*/2, 145–179.

Gunton, R. M. Petit, S. and Gaba, S. 2011. Functional traits relating arable weed communities to crop characteristics. *Journal of Vegetation Science 22*/3, 541–550.

Gyulai, F. 2007. Seed and fruit remains associated with neolithic origins in the Carpathian Basin. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 125–139.

Gyulai, F. 2010a. *Archaeobotany in Hungary. Seed, Fruit, Food and Beverage Remains in the Carpathian Basin from the Neolithic to the Late Middle Ages*, Budapest: Archaeolingua.

Gyulai, F. 2010b. Archaeobotanical research at the Körös culture site Ibrány-Nagyerdő and its relationship to plant remains from contemporaneous sites in Hungary. In: K. J. Kozłowski and P. Raczky (eds.), *Neolithization of the Carpathian Basin: nothernmost distribution of the Starčevo/Körös culture*, Kraków: Polska Akademia Umiejętności; Budapest : Institute of Archaeological Sciences of the Eötvös Loránd University, 219–237.

Gyulai, F. 2010c. The plant remains. In: J. Chapman, M. Vicze, R. Shiel, S. Cousins, B. Gaydarska, and C. Bond (eds.), *The Upper Tisza Project: studies in Hungarian landscape archaeology. Book 5: Upland settlement in North East Hungary: excavations at the multi-period site of Regéc-95*, Oxford: Archaeopress. BAR international series 2090, 211–212.

Gyulai, F. 2010d. The plant remains. In: J. Chapman, M. Gillings, R. Shiel, B. Gaydarska, and C. Bond (eds.), *The Upper Tisza Project: studies in Hungarian landscape archaeology. Book 4: Lowland settlement in North East Hungary: excavations at the Neolithic settlement site of Polgár-10*, Oxford: Archaeopress. BAR international series 2089, 303–304.

Gyulai, F. 2012. The archaeobotanical characterization of the Körös culture. In: A. Anders and Z. Siklósi (eds.), *The Körös culture in Eastern Hungary*, Oxford: Archaeopress. BAR international series 2334, 223–230.

Gyulai, F. 2014a. Archaeobotanical overview of rye (*Secale cereale* L.) in the Carpathian-Basin I: from the beginning until the Roman Age. *Columella - Journal of Agricultural and Environmental Sciences 1*/2, 25–35.

Gyulai, F. 2014b. The history of broomcorn millet (*Panicum miliaceum* L.) in the Carpathian-Basin in the mirror of archaeobotanical remains I: from the beginning until the Roman Age. *Columella - Journal of Agricultural and Environmental Sciences 1*, 31–40.

Halstead, P. 1987. Traditional and Ancient Rural Economy in Mediterranean Europe: Plus ça Change? *The Journal of Hellenic Studies 107*/1987, 77–87.

Halstead, P. 1989. Like rising damp? An ecological approach to the spread of farming in south east and central Europe. In: A. Milles, D. Williams, and N. Gardner (eds.), *The beginnings of agriculture*, Oxford: Archaeopress. BAR international series 496, 23–53.

Halstead, P. 1994. The north-south divide: regional paths to complexity in prehistoric Greece. In: C. Mathers and S.Stoddart (eds.). *Development and decline in the Mediterranean Bronze Age*. Sheffield: J.R. Collins Publications, 195-220.

Halstead, P. 1996. Pastoralism or household herding? Problems of scale and specialization in early Greek animal husbandry. *World Archaeology 28*/1, 20–42.

Halstead, P. 2006. Sheep in the garden: the integration of crop and livestock husbandry in the early farming regimes of Greece and southern Europe. In: D. Serjeantson and D. Field (eds.), *Animals in the Neolithic of Britain and Europe,* Oxford and Philadelphia: Oxbow Books, 42–55.

Halstead, P. 2011. Farming, material culture and ideology: repackaging the Neolithic of Greece (and Europe). In: A. Hadjikoumis, E. Robinson, and S. Viner (eds.), *Dynamics of neolithisation in Europe,* Oxford and Oakville: Oxbow Books, 131–151.

Halstead, P. 2014. *Two oxen ahead: pre-mechanized farming in the Mediterranean*, Chichester: Wiley Blackwell.

Hammer, K. 1981. Problems of Papaver somniferum-classification and some remarks on recently collected European poppy land-races. *Kulturpflanze 29*, 287–296.

Hanf, M. 1983. *The arable weeds of Europe with their seeldings and seeds*, Ludwigshafen: BASF.

Hansen, J. 1999. Franchti Cave and the beginnings of agriculture in Greece and the Aegean. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 156–168.

Hather, J. 2000. *Archaeological Parenchyma*, London: UCL Institute of Archaeology Publications.

Helbaek, H. 1952. Early crops in southern England. *Proceedings of the Prehistoric Society 18*, 194–233.

Helbaek, H. 1959. The domestication of food plants in the old world. *Science 130*, 365–372.

Henderson, D. Baggaley, A. Shukurov, A. Boys, R. *et al*. 2014. Regional variations in the European Neolithic dispersal: the role of the coastlines. *Antiquity 88*, 1291–1302.

Herbig, C. 2009. Recent archaeobotanical investigations into the range and abundance of Neolithic crop plants in settlements around Lake Constance and in Upper Swabia (south-west Germany) in relation to cultural influence. *Journal of Archaeological Science 36*, 1277–1285.

Herbig, C. and Maier, U. 2011. Flax for oil or fibre? Morphometric analysis of flax seeds and new aspects of flax cultivation in Late Neolithic wetland settlements in southwest Germany. *Vegetation History and Archaeobotany 20*, 527–533.

Hertelendi, E. and Horváth, F. 1992. Radiocarbon Chronology of Late Neolithic Settlements in the Tisza-Maros Region, Hungary. *Radiocarbon 34*/3, 859–866.

Hervella, M. Rotea, M. Izagirre, N. Constantinescu, M. *et al*. 2015. Ancient DNA from South-East Europe Reveals Different Events during Early and Middle Neolithic Influencing the European Genetic Heritage. *PLoS One 10*/6, e0128810.

Hillman, G. 1981. Reconstructing crop husbandry practices from charred remains of crops. In: R. Mercer (ed.), *Farming Practice in British Prehistory*, Edinburgh: Edinburgh University Press, 123–162.

Hillman, G. 1984a. Interpretation of archaeological plant remains: the application of ethnographic models from Turkey. In: W. Van Zeist and W. A. Casparie (eds.), *Plants and Ancient Man: Studies in Palaeoethnobotany*, Rotterdam: A.A. Balkema, 1–41.

Hillman, G. 1984b. Traditional husbandry and processing of archaic cereals in recent times: the operations, products and equipment which might feature in Sumerian texts. Part I: The glume wheats. *Bulletin of Sumerian Agriculture 1*, 114–152.

Hillman, G. 1985. Traditional husbandry and processing of archaic cereals in recent times: the operations, products and equipment that might feature in Sumerian texts. Part II: the free-threshing cereals. *Bulletin of Sumerian Agriculture II*, 1–31.

Hillman, G. 1991. Phytosociology and ancient weed floras: taking account of taphonomy and changes in cultivation methods. In: D. R. Harris and K. D. Thomas (eds.), *Modelling ecological change*, London: Institute of Archaeology, University College London, 27–40.

Hillman, G. Wales, S. McLaren, F. Evans, J. and Butler, A. 1993. Identifying problematic remains of ancient plant foods: a comparison of the role of chemical, histological and morphological criteria. *World archaeology 25*/1, 94–121.

Hillman, G. Mason, S. de Moulin, D. and Nesbitt, M. 1996. Identification of archaeological remains of wheat: the 1992 London workshop. *Circaea 12*/2, 195–209.

Hillman, G. Hedges, R. Moore, A. Colledge, S. and Pettitt, P. 2001. New evidence of Lateglacial cereal cultivation at Abu Hureyra on the Euphrates. *The Holocene 11*/4, 383–393.

Hilton, M.R. 2003. Quantifying postdepositional redistribution of the archaeological record produced by freeze-thaw and other mechanisms: an experimental approach. *Journal of Archaeological Method and Theory 10*/No. 3, 165–202.

Hoekman-Sites, H. and Giblin, J. 2012. Prehistoric animal use on the Great Hungarian Plain: A synthesis of isotope and residue analyses from the Neolithic and Copper Age. *Journal of Anthropological Archaeology 31*/4, 515–527.

Hofmann, D. 2014. What Have Genetics Ever Done for Us? The Implications of aDNA Data for Interpreting Identity in Early Neolithic Central Europe. *European Journal of Archaeology*, 1–23.

Hofmann, R. 2012. Style and function of pottery in relation to the development of Late Neolithic settlement patterns in Central Bosnia. In: R. Hofmann, F. K. Moetz, and J. Müller (eds.), *Tells: Social and Environmental Space.* Proceedings of the International Workshop “Socio-Environmental Dynamics over the Last 12,000 Years: The Creation of Landscapes II (14th–18th March 2011)” in Kiel. Volume 3, Bonn: Dr. Rudolf Habelt GmbH, 181–202.

Hofmanová, Z., Kreutzer, S., Hellenthal, G., Sell, C. *et al*. 2016. Early farmers from across Europe directly descended from Neolithic Aegeans. *PNAS 113* (25): 6886-6891. DOI: 10.1073/pnas.1523951113.

Hopf, M. 1958. Neolithische getreidefunde aus Bosnien und der Hercegovina. *Glasnik zemalskog museja Bosne I Hercegovine, nova serija XIII*, 97–103.

Hopf, M. 1967. Untersuchungsbericht über die botanischen reste aus der Neolithiscen ansiedlung in Gornja Tuzla. *Glasnik zemalskog museja Bosne I Hercegovine XXI/XXII*, 169–171.

Hopf, M. 1974. Pflanzenreste aus Siedlungen der Vinča – Kultur in Jugoslawien. *Jahrbuch des RGZM 21*, 1–11.

Horejs, B. Milić, B. Ostmann, F. Thanheiser, U. *et al*. 2015. The Aegean in the early 7th millennium BC: maritime networks and colonization. *Journal of World Prehistory 28,* 289–330.

Hubbard, R. N. 1975. Assessing the botanical component of human paleo-economics. *Bulletin of the Institute of Archaeology 12,* 197–205.

Hubbard, R. N. 1980. Development of agriculture in Europe and the Near East: evidence from quantitative studies. *Economic Botany 34*/1, 51–67.

Hubbard, R.N. and Al Azm, A. 1990. Quantifying preservation and distortion in carbonized seeds; and investigating the history of friké production. *Journal of Archaeological Science*, 103–106.

Hubbard, R.N. and Clapham, A. 1992. Quantifying macroscopic plant remains. *Review of Palaeobotany and Palynology 73,* 117–132.

Huiru, L. 2015. *Rice harvesting, processing, storage and charring at Mojiaoshan Site, Liangzhu Culture.* MA, Institute of Archaeology, University College London.

Hunt, H. Vander Linden, M. Liu, X. Motuzaite-Matuzeviciute, G. and Jones, M.K. 2008. Millets across Eurasia: chronology and context of early records of the genera Panicum and Setaria from archaeological sites in the Old World. *Vegetation History and Archaeobotany 17*/Supplement 1, S5–S18.

Hunt, J. R. Cousens, R. D. and Knights, S. E. 2009. Heliotropium europaeum only germinates following sufficient rainfall to allow reproduction. *Journal of Arid Environments 73,* 602–610.

Huntley, J. 1996. The plant remains. In: J. Chapman, R. Shiel, and Š. Batović (eds.), *The changing face of Dalmatia. Archaeological and Ecological studies in a Mediterranean landscape,* Leicester: Leicester University Press, 187–189.

Iannucci, A. Terribile, M. R. and Martiniello, P. 2008. Effects of temperature and photoperiod on flowering time of forage legumes in a Mediterranean environment. *Field Crops Research 106*/2, 156–162.

Jacomet, S. 2004. Archaeobotany: a vital tool in the investigation of lake dwellings. In: F. Menotti (ed.), *Living on the Lake in Prehistoric Europe: 150 years of lake-dwelling research*, London: Routledge, 162–177.

Jacomet, S. 2006a. *Identification of cereal remains from archaeological sites*, Basel: IPAS Basel University, 2nd ed. Available at: https://ipna.unibas.ch/archbot/pdf/Cereal_Id_Manual_engl.pdf

Jacomet, S. 2006b. Plant economy of the northern Alpine lake dwellings — 3500–2400 cal. BC. *Environmental Archaeology 11*/1, 65–85.

Jacomet, S. 2009. Plant economy and village life in Neolithic lake dwellings at the time of the Alpine Iceman. *Vegetation History and Archaeobotany 18*, 47–59.

Jacomet, S. and Brombacher, C. 2005. Reconstructing intra-site patterns in Neolithic lakeshore settlements: the state of archaeobotanical research and future prospects. In: P. Della Casa and M. Trachsel (eds.), *WES'04. Wetland economies and societies: proceedings of the International Conference in Zurich, 10-13 March 2004*, Zurich: Chronos, 69–94.

Jahns, S. and Bogaard, C. 1998. New palynological and tephrostratigraphical investigations of two salt lagoons on the island of Mljet, south Dalmatia, Croatia. *Vegetation History and Archaeobotany 7*/4, 219–234.

Jarman, M.R., Bailey, G.N. and Jarman, H.N (eds.). 1982. *Early European Agriculture: its foundations and developments, being the third volume of Papers in Economic Prehistory by members and associates of the British Academy Major Research Project in the Early History of Agriculture*. Cambridge: Cambridge University Press.

Jeraj, M. Velušček, A. and Jacomet, S. 2009. The diet of Eneolithic (Copper Age, Fourth millennium cal B.C.) pile dwellers and the early formation of the cultural landscape south of the Alps: a case study from Slovenia. *Vegetation History and Archaeobotany 18*/1, 75–89.

Jezik, S. 1998. *The origins of agriculture in temperate Europe: an exploration into the subsistence strategies of two Early Neolithic groups in the central Balkans, Foeni-Salas and Blagotin.* MA dissertation, University of Manitoba.

Johnston, M.B. Olivares, A. and Calderón, C. 2009. Effect of quantity and distribution of rainfall on *Hordeum murinum* L. growth and development. *Chilean Journal of Agricultural Research 69*/2, 188–197.

Jones, G. 1984. Interpretation of archaeological plant remains: ethnographic models from Greece. In: W. Van Zeist and W. A. Casparie (eds.), *Plants and ancient man,* Rotterdam: A.A. Balkema, 43–61.

Jones, G. 1987a. A statistical approach to the archaeological identification of crop processing. *Journal of Archaeological Science 14*/3, 311–323.

Jones, G. 1987b. Botanical remains, in Lagnano da Piede I - an early Neolithic village in the Tavoliere. *Origini 13*, 270.

Jones, G. 1991. Numerical analysis in archaeobotany. In: W. Van Zeist, K. Wasylikowa, and K. E. Behre (eds.), *Progress in Old World palaeoethnobotany*, Rotterdam: A.A. Balkema, 63–80.

Jones, G. 1992. Weed phytosociology and crop husbandry: identifying a contrast between ancient and modern practice. *Review of Palaeobotany and Palynology*, 133–143.

Jones, G. 1998. Wheat gain identification - why bother? *Environmental Archaeology 2*/1, 29–34.

Jones, G. 2002. Weed ecology as a method for the archaeobotanical recognition of crop husbandry practices. *Acta Palaeobotanica 42*, 185–193.

Jones, G. 2005. Garden cultivation of staple crops and its implications for settlement location and continuity. *World Archaeology 37*/2, 164–176.

Jones, G. and Halstead, P. 1995. Maslins, mixtures and monocrops: On the interpretation ofarchaeobotanical crop samples of heterogeneous composition. *Journal of Archaeological Science 22*/1, 103–114.

Jones, G. Charles, M. Colledge, S. and Halstead, P. 1995. Towards the archaeobotanical recognition of winter-cereal irrigation: an investigation of modern weed ecology in northern Spain. In: H. Kroll and R. Pasternak (eds.), *Res Archaeobotanicae - 9th Symposium IWGP,* Kiel: Institut für Ur- und Frühgeschichte der Christian Albrecht Universität, 49–68.

Jones, G. Bogaard, A. Halstead, P. and Charles, M. 1999. Identifying the intensity of crop husbandry practices on the basis of weed floras. *The Annual of the British School at Athens 94*, 167–189.

Jones, G. Valamoti, S. and Charles, M. 2000a. Early crop diversity: A “new” glume wheat from northern Greece. *Vegetation History and Archaeobotany*, 133–146.

Jones, G. Bogaard, A. and Charles, M. 2000b. Distinguishing the effects of agricultural practices relating to fertility and disturbance: a functional ecological approach in archaeobotany. *Journal of Archaeological Science 27*, 1073–1084.

Jones, G. Charles, M. Bogaard, A. Hodgson, J. G. and Palmer, C. 2005. The functional ecology of present-day arable weed floras and its applicability for the identification of past crop husbandry. *Vegetation History and Archaeobotany 14*/4, 493–504.

Jones, G. Charles, M. Bogaard, A. and Hodgson, J. 2010. Crops and weeds: the role of weed functional ecology in the identification of crop husbandry methods. *Journal of Archaeological Science 37*, 70–77.

Jones, G. Jones, H. Charles, M. Jones, M.K. *et al*. 2012. Phylogeographic analysis of barley DNA as evidence for the spread of Neolithic agriculture through Europe. *Journal of Archaeological Science 39*, 3230–3238.

Jones, G. Charles, M. Jones, M.K. Colledge, S. *et al.* 2013. DNA evidence for multiple introductions of barley into Europe following dispersed domestications in Western Asia. *Antiquity 87*/May 2016, 701–713.

Jones, H. Leigh, F.J. Mackay, I. Bower, M. *et al*. 2008. Population based re-sequencing reveals that the flowering time adaptation of cultivated barley originated east of the Fertile Crescent. *Molecular Biology and Evolution 25*/10, 2211–2219.

Jones, H. Lister, D.L. Cai, D. Kneal, C.J. *et al*. 2016. The trans-Eurasian crop exchange in prehistory: discerning pathways from barley phylogeography. *Quaternary International 426*, 26–32.

Jones, M.K. 1985a. Archaeobotany beyond subsistence reconstruction. In: G. Barker and C. Gamble (eds.), *Beyond domestication in prehistoric Europe. Investigations in subsistence archaeology and social complexity*, London: Academic press, 107–128.

Jones, M.K. 1985b. *The archaeological and ecological implications of selected arable weed assemblages in Britain.* Ph.D. Thesis, School of Botany, University of Oxford.

Jones, M.K. 1988a. The arable field: a botanical battleground. In: M. Jones (ed.), *Archaeology and the flora of the British Isles: human influence on the evolution of plant communities*, Oxford: Oxford University Committee, 86–92.

Jones, M.K. 1988b. The phytosociology of early arable weed communities with special reference to southern England. In: H. Kiister (ed.), *Kiister, H. (ed.), Der Priihistoriche Mensch und Seine Umwelt. Forschungen und Berichtezur vor- und Friih- geschichte in Baden-Wiirttemberg 31*, Stuttgart: Theiss, 43–51.

Jones, M.K. 1991. Sampling in palaeoethnobotany. In: W. van Zeist, K. Wasylikowa, and K. E. Behre (eds.), *Progress in Old World palaeoethnobotany*, Rotterdam: A.A. Balkema, 53–62.

Jordan-Bychkov, T. and Bychkova-Jordan, B. 2001. *The European Culture Area: a systematic geography*, Lanham, MD: Rowman & Littlefield, 4th ed.

Kahraman, A. Kusmenoglu, I. Aydin, N. Aydogan, A. *et al*. 2004. Genetics of Winter Hardiness in 10 Lentil Recombinant Inbred Line Populations. *Crop Science 44*/1, 5–12.

Kalis, A. Merkt, J. and Wunderlich, J. 2003. Environmental changes during the Holocene climatic optimum in central Europe - Human impact and natural causes. *Quaternary Science Reviews*, 33–79.

Karamitrou-Mentessidi, G. Efstratiou, N. Kozłowski, J.K. Kaczanowska, M. *et al*. 2013. New evidence on the beginning of farming in Greece: the Early Neolithic settlement of Mavropigi in western Macedonia (Greece). *Antiquity + 87/*336.

Karg, S. 2011. New research on the cultural history of the useful plant *Linum usitatissimum* L. (flax), a resource for food and textiles for 8,000 years. *Vegetation History and Archaeobotany 20*/6, 507–508.

Karg, S. and Müller, J. 1990. Neolithische getreidefunde aus Pokrovnik, Dalmatien. *Archäologisches korrenpondenzblatt 20*, 373–386.

Keepax, C. 1977. Contamination of archaeological deposits by seeds of modern origin with particular reference to the use of flotation machines. *Journal of Archaeological Science 4*/3, 221–229.

Kenéz, Á. Pető, Á. and Gyulai, F. 2014. Evidence of “new glume wheat” from the Late Neolithic (Copper Age) of south-eastern Hungary (4th millennium cal. b.c.). *Vegetation History and Archaeobotany 23*/5, 551–566.

Kirleis, W. and Kroll, H. Unpublished. *The orchards in the Neolithic: Malus in Central Europe*, Wilhelmshaven: Paper presented at the 15th Conference of the International Work Group for Palaeoethnobotany (2010), Wilhelmshaven, Germany. Available at: https://e-docs.geo-leo.de/bitstream/handle/11858/6368/TN%202010-2.pdf. Accessed 4th April 2015.

Kislev, M.E. 1989. Origin and cultivation of *Lathyrus sativus* and *L. cicera* (Fabaceae). Economic Botany 43: 262-270. DOI:10.1007/BF02859868.

Kohler-Schneider, M. 2003. Contents of a storage pit from late Bronze Age Stillfried, Austria: another record of the "new" glume wheat. *Vegetation History and Archaeobotany 12*, 105–111.

Kohler-Schneider, M. and Caneppele, A. 2009. Late Neolithic agriculture in eastern Austria: archaeobotanical results from sites of the Baden and Jevišovice cultures (3600–2800 B.C.). *Vegetation History and Archaeobotany 18*, 61–74.

Komšo, D. 2005. Kargadur. In: J. Mesić (ed.), *Hrvatski arheološki godišnjak, Vol 2*, Ministarstvo Kulture, 212–214.

Korona, M. Smith Demo, B. and Marušić, M. 2009. *Crno Vrilo 1. Crno Vilo.*

Kosorić, M. 1972. Sondažno rekognosciranje lokaliteta Korića Han u Gračanici. *Članci i građa. Za kulturnu istoriju istočne Bosne IX*, 5–9.

Kosorić, M. 1980. Praistorijska naselja na području Spreče. *Članci i građa. Za kulturnu istoriju istočne Bosne XIII*, 103–116.

Kozłowski, J.K. 2016. The Mesolithic of the Aegean Basin: cultural variability, subsistence economy, interregional links and seafaring. In: R. Krauss and H. Floss (eds.), *Southeast Europe before neolithisation.* Proceedings of the international workshop "RessourcenKulturen", Schloss Hohentübingen, 9th of May 2014, Tübingen: Universität Tübingen, 41–64.

Kozłowski, J.K. and Kozłowski, S. 1986. Foragers of Central Europe and their acculturation. In: M. Zvelebil (ed.), *Hunters in transition. Mesolithic societies of temperate Eurasia and their transition to farming*, Cambridge: Cambridge University Press, 95–108.

Kozłowski, J.K. and Nowak, M. 2007. Neolithisation of the Upper Tisza Basin. In: J. K. Kozłowski and M. Nowak (eds.), *Mesolithic/Neolithic interactions in the Balkans and in the Middle Danube Basin*, Oxford: Archaeopress. BAR international series 1726, 77–102.

Krauss, R. 2008. Karanovo und das südosteuropäische Chronologiesystem aus heutiger Sicht. *Eurasia Antiqua 14*, 117–149.

Krauss, R. 2016. The Mesolithic-Neolithic transition in the Carpathian Basin. In: R. Krauss and H. Floss (eds.), *Southeast Europe before neolithisation. Proceedings of the international workshop "RessourcenKulturen", Schloss Hohentübingen, 9th of May 2014*, Tübingen: Universität Tübingen, 193–222.

Krauss, R. Marinova, E. De Brue, H. and Weninger, B. 2017. The rapid spread of early farming from the Aegean into the Balkans via the Sub-Mediterranean-Aegean Vegetation Zone. *Quaternary International*, 1–18.

Kreuz, A. 2007. Archaeobotanical perspectives on the beginning of agriculture north of the Alps. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 259–294.

Kreuz, A. Marinova, E. Schäfer, E. and Wiethold, J. 2005. A comparison of early Neolithic crop and weed assemblages from the Linearbandkeramik and the Bulgarian Neolithic cultures: differences and similarities. *Vegetation History and Archaeobotany 14*/4, 237–258.

Kreuz, A. and Schäfer, E. 2011. Weed finds as indicators for the cultivation regime of the early Neolithic Bandkeramik culture? *Vegetation History and Archaeobotany 20*, 333–348.

Kroll, H. Unpublished. Plant remains from the Middle/Late Neolithic site of Jagnilo, central Bosnia i Herzegovina.

Kroll, H. In press. Die Pflanzenfunde von Okolište. In: J. Müller, K. Rassmann, and Z. Kujundžić-Vejzagić (eds.), *Okolište – Neolithikum und Chalkolithikum in Zentralbosnien V.3*, Bonn: Universitätsforschungen zur prähistorischen Archäologie.

Kroll, H. 1992. Einkorn from Feudvar, Vojvodina, II. What is the difference between emmer-like two-seeded einkorn and emmer? *Review of Palaeobotany and Palynology 73*, 181–185.

Kroll, H. 1998. Die Kulturlandschaft und Naturlandschaft des Titeler Plateaus im Spiegel der metallzeitlichen Pflanzenreste von Feudvar. In: B. Hänsel and P. Medović (eds.), *Feudvar 1. Das Plateau von Titel und Šajkaška. Prähistorische Archäologie in Südosteuropa 13*, Kiel: Institut für Ur- und Frühgeschichte der Christian-Albrecht-Universität, 305–317.

Kroll, H. 2013a. Bericht über die Pflanzenfunde aus Okolište Haus 38. In: J. Müller, K. Rassmann, and Z. Kujundžić-Vejzagić (eds.), *Okolište 1 - Untersuchungen einer spätneolithischen Siedlungskammer in Zentralbosnien*, Kiel: Universitätsforschungen zur prähistorischen Archäologie, 113–122.

Kroll, H. 2013b. Die Wirtschaft des Umfelds von Okolište: Zagrebnice, Kundruci und Donje Moštre. In: J. Müller, K. Rassmann, and Z. Kujundžić-Vejzagić (eds.), *Okolište 1 - Untersuchungen einer spätneolithischen Siedlungskammer in Zentralbosnien*, Kiel: Universitätsforschungen zur prähistorischen Archäologie, 231–237.

Küster, H. 1991. Phytosociology and archaeobotany. In: D. R. Harris and K. D. Thomas (eds.), *Modelling ecological change*, London: Institute of Archaeology, University College London, 17–26.

Küster, H. 2000. Rye. In: K. F. Kiple and K. C. Ornelas (eds.), *Cambridge world history of food*, Cambridge: Cambridge University Press, 149–152.

Lambeck, K. Antonioli, F. Purcell, A. and Silenzi, S. 2004. Sea-level change along the Italian coast for the past 10,000 yr. *Quaternary Science Reviews 23*/14–15, 1567–1598.

Lange, A.G. 1990. *De Horden near Wijk bij Duurstede: Plant Remains from a Native Settlement at the Roman Frontier. A Numerical Approach*, Amersfoot: Rijksdienst voor het Oudheidkundig Bodemonderzoek.

Larson, G. and Fuller, D. 2014. The evolution of animal domestication. *Annual Review of Ecology,* *Evolution, and Systematics45 (1):* 115-136. DOI: 10.1146/annurev-ecolsys-110512-135813.

Larson, G. Albarella, U. Dobney, K. Rowley-Conwy, P. *et al.* 2007. Ancient DNA, pig domestication, and the spread of the Neolithic into Europe. *Proceedings of the National Academy of Sciences of the United States of America 104*/39, 15276–81.

Lazaridis, I., Nadel, D., Rollefson, G., Merrett, D.C. *et al*. 2017. Genomic insights into the origins or farming in the ancient Near East. *Nature 536* (7617): 419-424. DOI: 10.1038/nature19310.

Legge, T. and Moore, A. 2011. Clutching at straw: the Early Neolithic and the dispersal of agriculture. In: A. Hadjikoumis, E. Robinson, and S. Viner (eds.), *The dynamics of Neolithisation in Europe: studies in honour of Andrew Sherratt*, Oxford: Oxbow Books, 176–195.

Leković, V. 1990. The vinčanization of the Starčevo culture. In: D. Srejović and N. Tasić (eds.), *Vinča and its World*, Belgrade: Serbian Academy of Sciences and Arts, 67–74.

Liebman, M. and Dyck, E. 1993. Crop rotation and intercropping strategies for weed management. *Ecological Applications 3*/1, 92–122.

Lightfoot, E. Boneva, B. Miracle, P. Šlaus, M. and T. O'Connell 2011. Exploring the Mesolithic and Neolithic transition in Croatia through isotopic investigations. *Antiquity 85*, Online supplement.

Lightfoot, E., Przelomska, N., Craven, M., O’Connell, T., *et al.* 2016. Intraspecific carbon and nitrogen isotopic variability in foxtail millet (Setaria italica). *Rapid Communications in Mass Spectrometry 30*, 1475–1487.

Limbrey, S. 1975. *Soil science and archaeology*, London: Academic press.

Lipson, M., Szécsényi-Nagy, A., Mallick, S., Pósa, A. *et al*. 2017. Parallel palaeogenomic transects reveal complex genetic history of early European farmers. *Nature 551* (7680): 368-372. DOI: 10.1038/nature24476.

Lister, D.L. Bower, M. and Jones, M.K. 2010. Herbarium specimens expand the geographical and temporal range of germplasm data in phylogeographic studies. *Taxon 59*, 1321–1323.

Lister, D.L. and Jones, M.K. 2013. Is naked barley an eastern or a western crop? The combined evidence of archaeobotany and genetics. *Vegetation History and Archaeobotany*, 439–446.

Los, D. Unpublished. *Preliminarni izvještaj o zaštitnom arheološkom istraživanju na lokalitetima AN6 Hermanov Vinograd 1 i AN7 Hermanov Vinograd 2 na trasi južne zaobilaznice grada Osijeka.* Unpublished preliminary report.

Luca, S. A. Suciu, C. and Dumitrescu-Chioar, F. 2011. Catalogue of the Early Neolithic settlements in western part of Romania-Transylvania, Banat, Crişana, Maramures, Oltenia and western Muntenia. In: S. A. Luca and C. Suciu (eds.), *Early Neolithic (Starčevo-Criş) sites on the territory of Romania*, Oxford: Archaeopress. BAR international series 2188, 79–132.

Lucas, L. Colledge, S. Simmons, A. and Fuller, D. Q. 2012. Crop introduction and accelerated island evolution: Archaeobotanical evidence from ’Ais Yiorkis and Pre-Pottery Neolithic Cyprus. *Vegetation History and Archaeobotany 21*/2, 117–129.

Magny, M. Bégeot, C. Guiot, J. and Peyron, O. 2003. Contrasting patterns of hydrological changes in Europe in response to holocene climate cooling phases. *Quaternary Science Reviews 22*, 1589–1596.

Magny, M., Joannin, S., Galop, D., Vannière, B. *et al.* 2012. Holocene palaeohydrological changes in the northern Mediterranean borderlands as reflected by the lake-level record of Lake Ledro, northeastern Italy. *Quaternary Research 77*, 382–396.

Magyari, E. Shiel, R. and Passmore, D. 2010. The palaeo-environment and settlement context of Polgár-10. In: J. Chapman, M. Gillings, R. Shiel, B. Gaydarska, and C. Bond (eds.), *The Upper Tisza Project: studies in Hungarian landscape archaeology. Book 4: Lowland settlement in North East Hungary: excavations at the Neolithic settlement site of Polgár-10*, Oxford: Archaeopress. BAR international series 2089, 8–16.

Magyari, E. Chapman, J. Fairbairn, A. Francis, M. and de Guzman, M. 2012. Neolithic human impact on the landscapes of North-East Hungary inferred from pollen and settlement records. *Vegetation History and Archaeobotany 21*, 279–302.

Maier, U. 1996. Morphological studies of free-freshing wheat ears from a Neolithic site in southwest Germany. and the history of naked wheats. *Vegetation History and Archaeobotany 5*, 39–55.

Maier, U. and Schlichtherle, H. 2011. Flax cultivation and textile production in Neolithic wetland settlements on Lake Constance and in Upper Swabia (south-west Germany). *Vegetation History and Archaeobotany*, 567–578.

Manning, K. Stopp, B. Colledge, S. Downey, S. *et al*. 2013a. Animal exploitation in the Early Neolithic of the Balkans and central Europe. In: S. Colledge, J. Conolly, K. Dobney, K. Manning, and S. Shennan (eds.), *The origins and spread of domestic animals in southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 237–252.

Manning, K. Downey, S. Colledge, S. Conolloy, J. *et al*. 2013b. The origins and spread of stock-keeping: the role of cultural and environmental influences on early Neolithic animal exploitation in Europe. *Antiquity 87*, 1046–1059.

Manning, K. Timpson, A. Colledge, S. Crema, S. and Shennan, S. 2015. *The cultural evolution of Neolithic Europe. EUROEVOL Dataset*, available at UCL Discovery: http://discovery.ucl.ac.uk/1469811/. Accessed in January 2016.

Manson, J. 1995. Starčevo pottery and Neolithic development in the central Balkans. In: W. Barnett and J. Hoopes (eds.), *The emergence of pottery: technology and innovation in ancient societies*, Washington: Smithsonian Institution, 65–77.

Marijanović, B. 2009. *Crno Vrilo 1*, Zadar: Sveučilišteu Zadru.

Marinova, E. 2006. *Vergleichende paläoethnobotanische Untersuchung zur Vegetationsgeschichte und zur Entwicklung der prähistorischen Landnutzung in Bulgarien*, Stuttgart: Science, Dissertationes Botanicae vol: 401.

Marinova, E. 2007. Archaeobotanical data from the early Neolithic of Bulgaria. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 93–109.

Marinova, E. 2009. Plant economy and vegetation during the Early Neolithic of Bulgaria. In: I. Gatsov and Y. Boyadzhiev (eds.), *The First Neolithic Sites in Central/South-East European Transect. Volume I: Early Neolithic Sites on the Territory of Bulgaria*, Oxford: Archaeopress. BAR international series 2048, 59–62.

Marinova, E. and Krauss, R. 2014. Archaeobotanical evidence on the Neolithisation of Northeast Bulgaria in the Balkan-Anatolian context: chronological framework, plant economy and land use. *Bulgarian e-journal of archaeology 4*/2, 179–194.

Marinova, E. and Valamoti, S-M. 2014. Crop diversity and choices in the Prehistory of SE Europe: cultural and environmental factors shaping the archaeobotanical record of northern Greece and Bulgaria. In: A. Chevalier, E. Mrinova, and L. Peña-Chocarro (eds.), *Plants and people. Choices and diversity through time*, Oxford: Oxbow Books, 64–74.

Marinova, E. Tchakalova, E. Stoyanova, D. Grozeva, S. and Dočeva, E. 2002. Ergebnisse archäobotanischer Untersuchungen aus dem Neolithikum und Chalkolithikum in Südwestbulgarien. *Archaeologia Bulgarica 4*/3, 1–12.

Marinova, E. Tonkov, S. Bozilova, E. and Vajsov, I. 2012. Holocene anthropogenic landscapes in the Balkans: The palaeobotanical evidence from southwestern Bulgaria. *Vegetation History and Archaeobotany*, 413–427.

Marinova, E. Filipović, D. Obradović, Đ. and Allué, E. 2013. Wild plant resources and land use in Mesolithic and Early Neolithic South-East Europe. Archaeobotanical evidence from the Danube catchment of Bulgaria and Serbia. In: A. Wesse and H. Dieterich (eds.), *Berichte und Mitteilungen zur Urgeschichte, Frühgeschichte und Mittelalterarchäologie*, Neumünster: Wachholtz Verlag, 467–478.

Marinval, P. 2003. Les paléo-semences carbonisées de Torre Sabea: méthodologie et résultats. In: J. Guilaine and G. Cremonesi (eds.), *Torre Sabea. Un establissement du Néolithique ancien en Salento*, Rome: École Française de Rome, 228–233.

Märkle, T. and Rösch, M. 2008. Experiments on the effects of carbonization on some cultivated plant seeds. *Vegetation History and Archaeobotany 17*/S1, S257–S263.

Marković, Z. 2012. Neuere Betrachtungen über bestimmte Aspekte der Sopot-Kultur in Nordkroatien. *Priloži Instituta za Arheologija u Zagrebu 29*, 57–70.

Marriner, G. French, C. and Rajkovača, T. 2015. Geoarchaeology. In: I. Pandžić and M. Vander Linden (eds.), *The Neolithic site of Kočićevo in the lower Vrbas Valley (Republika Srpska, Bosnia and Herzegovina): report of the 2009-2014 field seasons*, Banja Luka: University of Banja Luka, 34–62.

Marriner, G. Rajkovača, T. and French, C. 2011. Geoarchaeological reconnaissance of the Banja Luka and Doboj area of northern Bosnia and Herzegovina. *Godišnjak. Centar za balkanološka ispitivanja 40*, 7–44.

Marston, J.M. 2014. Ratios and simple statistics in paleoethnobotanical analysis: data exploration and hypothesis testing. In: J. M. Marston, J. d'Alpoim Guedes, and C. Warinner (eds.), *Method and theory in paleoethnobotany*, Boulder: University of Colorado Press, 163–180.

Mason, J. 1995. Starčevo pottery and Neolithic development in the central Balkans. In: W. Barnett and J. Hoopes (eds.), *The emergence of pottery*, Washington: Smithsonian Institution, 65–77.

Mateiciucová, I. 2004. Mesolithic traditions and the origin of the Linear Pottery Culture (LBK). In: A. Lukes and M. Zvelebil (eds.), *LBK Dialogues. Studies in the formation of the Linear Pottery Culture*, Oxford: Archaeopress. BAR international series 1304, 91–108.

Mathieson, I., Lazaridis, I. Rohland, N., Mallick, S. *et al*. 2015. Genome-wide patterns of selection in 230 ancient Eurasians. Nature 528 (7583): 499-503. DOI: 10.1038/nature16152.

Mauri, A. Davis, B.A. Collins, P.M. and Kaplan, J. 2015. The climate of Europe during the Holocene: a gridded pollen-based reconstruction and its multi-proxy evaluation. *Quaternary Science Reviews 112*, 109–127.

Măzare, P. 2014. Investigating Neolithic and Copper Age textile production in Transylvania (Romania). Applied methods and results. In: M. Harlow, C. Michel, and M-L. Nosch (eds.), *Prehistoric, Ancient Near Eastern and Aegean textiles and dress*, Oxford and Philadelphia: Oxbow Books, 1–42.

McClatchie, M. and Fuller, D.Q. 2014. Leaving a lasting impression. Arable economies and cereal impressions in Africa and Europe. In: C. J. Stevens, S. Nixon, M. A. Murray, and D. Q. Fuller (eds.), *Archaeology of African plant use*, Walnut Creek, CA: Left Coast Press, 259–265.

McCobb, L. Briggs, D. Carruthers, W. and Evershed, R. 2003. Phosphatisation of seeds and roots in a Late Bronze Age deposit at Potterne, Wiltshire, UK. *Journal of Archaeological Science 30*/10, 1269–1281.

McCorriston. 2013. Comment on Asouti & Fuller. *Current Anthropology 54*/3, 334–335.

Médard, F. 2010. *L'art du tissage au Néolithique: IVe-IIIe millénaires avant J-C en Suisse*, Paris: Collection CRA Monographies. CNRS Editions.

Megaloudi, F. 2006. *Plants and diet in Greece from Neolithic to Classic periods: the archaeobotanical remains*, Oxford: Archaeopress. BAR international series 1516.

Mercuri, A. Allevato, E. Arobba, D. Bandini Mazzanti, M. *et al*. 2015. Pollen and macroremains from Holocene archaeological sites: A dataset for the understanding of the bio-cultural diversity of the Italian landscape. *Review of Palaeobotany and Palynology 218*, 250–266.

Merou, T. and Papanastasis, V. 2009. Factors affecting the establishment and growth of annual legumes in semi-arid mediterranean grasslands. *Plant Ecology 201*, 491–500.

Meurers-Balke, J. and Lüning, J. 1999. Some aspects and experiments concerning the processing of glume wheats. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 238–253.

Mihailović, D. 1992. *Aurignacian flint industry from the site Crvenka-At near Vršac*, Belgrade:

Univerzitet u Beogradu, Filozofski fakultet.

Mihailović, D. 2007a. Late Mesolithic of Serbia and Montenegro. In: J. Kozłowski and M. Nowak (eds.), *Mesolithic/Neolithic interactions in the Balkans and in the Middle Danube Basin*, Oxford: Archaeopress. BAR international series 1726, 21–30.

Mihailović, D. 2007b. Social aspects of the transition to farming in the Balkans. *Documenta Praehistorica 34*, 73–88.

Mihailović, D. and Dimitrijević, V. 1999. Late Upper Palaeolithic and Mesolithic of Montenegro - changes in technology and subsistence. In: A. Thévenin (ed.), *L'Europe des derniers chasseurs*, Paris: CTHS, 391–398.

Milisauskas, S. and Kruk, J. 1989. Neolithic economy in central Europe. *Journal of World Prehistory 3*: 403-446. DOI:10.1007/BF00975110.

Miller, N. 1984. The use of dung as fuel: an ethnographic example and an archaeological application. *Paléorient 10*/2, 71–79.

Miller, N. and Smart, T. 1984. Intentional burning of dung as fule: a mechanism for the incorporation of charred seeds into the archaeological record. *Journal of Ethnobiology 4*/1, 15–28.

Miller, N. Spengler, R. and Frachetti, M. 2016. Millet cultivation across Eurasia: Origins, spread, and the influence of seasonal climate. *The Holocene 26*/10, 1566–1575.

Miracle, P. and Forenbaher, S. 2005. Neolithic and Bronze-Age Herders of Pupićina Cave, Croatia. *Journal of Field Archaeology*, 255–581.

Mlekuž, D. 2003. Early herders of the eastern Adriatic. *Documenta Praehistorica XXX*, 139–151.

Mlekuž, D. 2009. The materiality of dung: the manipulation of dung in Neolithic Mediterranean caves. *Documenta Praehistorica XXXVI*, 219–225.

Monk, M.A. and Kelleher, E. 2009. Aspects of the archaeology of Irish keyhole-shaped corn-drying kiln with particular reference to archaeobotanical studies and archaeological experiments. In: A. S. Fairbairn and E. Weiss (eds.), *From foragers to farmers. Papers in honour of Gordon C. Hillman*, Oxford and Oakville: Oxbow books, 138–152.

Motuzaite-Matuzeviciute, G. Staff, R. Hunt, H. Liu, X. and Jones, M.K. 2013. The early chronology of broomcorn millet (Panicum miliaceum) in Europe. *Antiquity 87*, 1–5.

Müller, J. 1988. Cultural definition of the early Neolithic and its interaction in the Eastern Adriatic. *Berytus 36*, 101–125.

Müller, J. 1994. *Das Ostadiatische Frühneolithikum*, Berlin: Wissenschaftsverlag volker spiess.

Murrumbidgee Catchment Management Annual Report. 2008. *Best Management Practices for Dryland Cropping Systems. Annual ryegrass (Lolium rigidum)*, Retrieved on 19/01/17 at: http://archive.lls.nsw.gov.au/__data/assets/pdf_file/0008/495332/archive-annual-ryegrass.pdf.

Nenadić, O and Greenacre, M. 2007. Correspondence Analysis in R, with two- and three-dimensional graphics: the ca package. *Journal of Statistical Software, 20 (3)*: 1–13.

Nesbitt, M. 2001. Wheat evolution: integrating archaeological and biological evidence. In: P. D. S. Caligari and P. E. Brandham (eds.), *Wheat taxonomy: the legacy of John Percival. Volume 3*, London: Linnean Society, 37–59.

Nesbitt, M. and Samuel, D. 1996. From staple crop to extinction? The archaeology and history of the hulled wheats. In: S. Padulosi, K. Hammer, and J. Heller (eds.), *Hulled wheats. Promoting the conservation and use of underutilized and neglected crops. Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*, Rome: International Plant Genetic Resources Institute, 41–101.

Nesbitt, M. Hillman, G. Peña-Chocarro, L. Samuel, D. and Szabó, A. T. 1996. Checklist for recording the cultivation and uses of hulled wheats. In: S. Padulosi, K. Hammer, and J. Heller (eds.), *Hulled wheats. Promoting the conservation and use of underutilized and neglected crops. Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*, Rome: International Plant Genetic Resources Institute, 234–246.

Neustupný, E. 2004. Remarks on the origin of the Linear Pottery Culture. In: A. Lukes and M. Zvelebil (eds.), *LBK Dialogues. Studies in the formation of the Linear Pottery Culture*, Oxford: Archaeopress. BAR international series 1304, 3–6.

Nisbet, R. 1982. Le analisi archeobotaniche del villaggio neolitico della villa Comunale (Foggia). *Origini 11*, 175–182.

Nisbet, R. 1995. I resti macrobotanici. In: P. Biagi (ed.), *L'insediamento neolitico di Ostiano-Dugali Alti (Cremona) nel suo contesto ambientale ed economico*, Brescia: Museo Civico di Scienze Naturale di Brescia. Monografie di «Natura Bresciana» 22, 104–106.

Nitsch, E.K., Charles, M. and Bogaard, A. 2015. Calculating a statistically robust δ 13 C and δ 15 N offset for charred cereal and pulse seeds. *STAR: Science and Technology of Archaeological Research 1 (1)*: 1-8. DOI:10.1179/2054892315Y.0000000001.

O'Connor, T. P. and Evans, J. G. 2005. *Environmental archaeology: principles and methods*, Stroud: Sutton, 2nd ed.

Obelić, B. Škrivanko, M. K. Marijan, B. and Bronić, I. K. 2004. Radiocarbon dating of Sopot culture sites (Late Neolithic) in eastern Croatia. *Radiocarbon 46*/1, 245–258.

Obradović, Đ. 2013. *New data on early agriculture in the Central Balkans: archaeobotanical investigations at Early and Late Neolithic sites in the Morava Valley, Serbia*, Poster presented at the 16th conference of the International Work Group for Palaeoethnobotany, Thessaloniki, Greece. Available at: http://iwgp-2013.web.auth.gr/images/abstract%20book%20revised.pdf. Accessed ^{2nd} July 2015

Obradović, Đ. 2016. *Storage practice and the problem with pests*, Poster presented at the 17th conference of the International Work Group for Palaeoethnobotany, Pairs, France. Available at: https://iwgp2016paris.sciencesconf.org/.

Obradović, Đ. and Bajčev, O. 2016. Neolithic land use in Central Pomoralvje - arable potential of soils and argriculture. In: S. Perić (ed.), *The Neolithic in the Middle Morava Valley: new insights into settlements and economy, №2*, Belgrade: Institute of Archaeology, University of Belgrade, 61–78.

Oksanen, J., Blanchet, F.G., Friendly, M., Kindt, R. *et al*. 2017. *vegan: Community Ecology Package. R package version 2.4-4.* Available at: https://CRAN.R-project.org/package=vegan. Accessed 20th January 2017.

Oross, K. Bánffy, E. Osztás, A. Marton, T. *et al*. 2016. The early days of Neolithic Alsónyék: the Starčevo occupation. *Bericht der Römisch-Germanischen Kommission 94*, 93–121.

Orton, D. 2008. *Beyond hunting and herding: humans animals and the political economy of the Vinča period.* Ph.D. Thesis, Department of Archaeology, University of Cambridge.

Orton, D. 2012. Herding, settlement, and chronology in the Balkan Neolithic. *European Journal of Archaeology 15*/1, 5–40.

Orton, D. Gaastra, J. and Vander Linden, M. 2016. Between the Danube and the Deep Blue Sea: zooarchaeological meta-analysis reveals variability in the spread and development of Neolithic farming across the western Balkans. *Open Quaternary 2*/6, 1–26.

Özdoğan, M. 2000. The appearance of Early Neolithic cultures in Northwestern Turkey. Some problems. In: S. Hiller and V. Nikolov (eds.), *Karanovo III: Beiträge zum Neolithikum in Südosteuropa*, Wien: Ferdinand Berger & Söhne, 165–170.

Özdoğan, M. 2011. Archaeological evidence on the westward expansion of farming communities from eastern Anatolia to the Aegean and the Balkans. *Current Anthropology 52*/S4, 415–30.

Palmer, C. 1998a. An exploration of the effects of crop rotation regime on modern weed floras. *Environmental Archaeology 2*/1, 35–48.

Palmer, C. 1998b. “Following the plough”: the agricultural environment of northern Jordan. *Levant 30*, 129–165.

Paluch, T. 2012. Catalogue of the Körös culture sites in Csongrád county. In: A. Anders and Z. Siklósi (eds.), *The Körös culture in Eastern Hungary*, Oxford: Archaeopress. BAR international series 2334, 297–322.

Pandžić, I. 2014. Project of archaeological research in northern Bosnia 2006-2013. *Archaeological journal of Paleolithic research*, 57–80.

Pandžić, I. and Vander Linden, M. 2015. *The Neolithic site of Kočićevo in the lower Vrbas Valley (Republika Srpska, Bosnia and Herzegovina): report of the 2009-2014 field seasons*, Banja Luka: Univeristy of Banja Luka.

Pantović, I. Unpublished-a. *Field report on the excavations of At in May 2014 and May 2015 (Vršac, Serbia).*

Pantović, I. Unpublished-b. *Field report on the recent excavations of Potporanj (Vršac, Serbia).*

Pearsall, D. 2015. *Paleoethnobotany: a handbook of procedures. Third Edition.*, Walnut Creek, CA: Left Coast Press.

Peev, P. 2009. The Neolithisation of the Eastern Balkan Peninsula and fluctuations of the Black Sea level. *Quaternary International 197*/1–2, 87–92.

Peix, A. Ramírez-Bahena, M. H. Velázquez, E. and Bedmar, E. J. 2015. Bacterial associations with legumes. *Critical Reviews in Plant Sciences 34*/1–3, 17–42.

Peña-Chocarro, L. 1996. In situ conservation of hulled wheat species: the case of Spain. In: S. Padulosi, K. Hammer, and J. Heller (eds.), *Hulled wheats. Promoting the conservation and use of underutilized and neglected crops. Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy,* Rome: International Plant Genetic Resources Institute, 128–146.

Peña-Chocarro, L. 1999. *Prehistoric agriculture in southern Spain during the Neolithic and the Bronze Age: the application of ethnographic models,* Oxford: Archaeopress. BAR international series 818.

Peña-Chocarro, L. and Zapata Peña, L. 2003. Post-harvesting processing of hulled wheats. An ethnoarchaeological approach. In: P. Anderson, L. Cummings, T. Schippers, and B. Simonel (eds.), *Le traitement des récoltes: un regard sur la diversité, du Néolithique au présent. Actes des rencontres 17-19 octobre 2002,* Antibes: APDCA, 99–113.

Peña-Chocarro, L. Zapata Peña, L. González Urquijo, J. and Ibáñez Estévez, J. 2009. Einkorn (*Triticum monococcum* L.) cultivation in mountain communities of the western Rif (Morocco): an ethnoarchaeological project. In: A. Fairbairn and E. Weiss (eds.), *From foragers to farmers. Papers in honour of Gordon C. Hillman,* Oxford: Oxbow Books, 103–111.

Peña-Chocarro, L. Pérez-Jordá, G. and Morales, J. 2017. Crops of the first farming communities in the Iberian Peninsula. *Quaternary International*, 1–14.

Pennington, H. and Weber, S. 2004. Paleoethnobotany: modern research connecting ancient plants and ancient peoples. *Critical Reviews in Plant Sciences 23*/1, 13–20.

Pérez-Losada, J. and Fort, J. 2011. Spatial dimensions increase the effect of cultural drift. *Journal of Archaeological Science 38*/6, 1294–1299.

Perić, O. Obradović, Đ. and Stojanović, I. 2015. A new perspective on the Neolithic settlement and economic patterns in the Middle Morava Valley emerging from the renewed archaeological research. In: G. von Bülow and N. Baumann (eds.), *Kontaktzone Balkan. Kolloquien zur Vor- und Frühgeschichte. Band 20,* Frankfurt: Römisch-Germanische Kommission des Deutschen Archäologischen Instituts, 33–44.

Perić, S. 2017. Drenovac: a Neolithic settlement in the Middle Morava Valley, Serbia. *Antiquity 91*/357, 1–7.

Perić, S. and Obradović, Đ. 2012. Arheološka radionica: istraživanja u Drenovcu 2011. godine. In: V. Bikić, S. Golubović, and D. Antonović (eds.), *Arheologija u Srbiji. Projekti arheološki instituta u 2011 godini,* Belgrade: Arheološki institut Beograd, 17–18.

Perlès, C. 2001. *The Early Neolithic in Greece,* Cambridge: Cambridge University Press.

Perlès, C. 2003. An alternate (and old-fashioned) view of Neolithisation in Greece. *Documenta*

Praehistorica XXX, 99–113.

Perlès, C. 2005. From the Near East to Greece: let's reverse the focus. Cultural elements that didn't transfer. In: C. Lichter (ed.), *How did farming reach Europe (BYZAS 2)*, Istanbul: German Archaeological Institute, 275–290.

Perlès, C. 2010. Grèce et Balkans: deux voies de pénétration distinctes en Europe? In: J. P. Demoule (ed.), *La révolution néolithique dans le monde*, Paris: CNRS Éditions, 267–285.

Perlès, C. Quiles, A. and Valladas, H. 2013. Early seventh-millennium AMS dates from domestic seeds in the Initial Neolithic at Franchthi Cave (Argolid, Greece). *Antiquity 87*, 1001–15.

Perrino, P. Laghetti, G. D'Antuono, L. Al Ajlouni, M. *et al*. 1996. Ecogeographical distribution of hulled wheat species. In: S. Padulosi, K. Hammer, and J. Heller (eds.), *Hulled wheats. Promoting the conservation and use of underutilized and neglected crops. Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*, Rome: International Plant Genetic Resources Institute, 102–120.

Peyron, O. Goring, S. Dormoy, I. Kotthoff, U. *et al*. 2011. Holocene seasonality changes in the central Mediterranean region reconstructed from the pollen sequences of Lake Accesa (Italy) and Tenaghi Philippon (Greece). *The Holocene 21*/1, 131–146.

Peyron, O. Guiot, J. Cheddadi, R. Tarasov, P. *et al*. 1998. Climatic Reconstruction in Europe for 18,000 YR B.P. from Pollen Data. *Quaternary Research 49*/2, 183–196.

Pilaar Birch, S. and Vander Linden, M. 2018. A long hard road... Reviewing the evidence for environmental change and population history in the eastern Adriatic and western Balkans during the Late Pleistocene and Early Holocene. *Quaternary International 465*, 177-191. DOI: 10.1016/j.quaint.2016.12.035

Pinhasi, R. Thomas, M. Hofreiter, M. Currat, M. and Burger, J. 2012. The genetic history of Europeans. *Trends in Genetics*, 496–505.

Plants for a Future. Available at: www.pfaf.org. Accessed 12th February 2015.

Porčić, M. 2012. *De facto* refuse or structured deposition? The house inventories of Late Neolithic Vinča culture. Starinar 62: 19-43. DOI:0.2298/STA1262019P.

Porčić, M. and Nikolić, M. 2016. The Approximate Bayesian Computation approach to reconstructing population dynamics and size from settlement data: demography of the Mesolithic-Neolithic transition at Lepenski Vir. *Archaeological and Anthropological Sciences 8*/1, 169–186.

Price, T.D. (ed.). 2000. *Europe's first farmers*, Cambridge: Cambridge University Press.

Primavera, M. and Fiorentino, G. 2011. Archaeobotany as an in-site/off-site tool for paleoenvironmental research at Pulo diMolfetta (Puglia, south-eastern Italy). In: I. Turbanti-Memmi (ed.), *Proceedings on the 37th international symposium on archaeometry. 12-16 May 2008, Sienna*, Berlin, Heidelberg: Springer, 421–426.

Purugganan, M. and Fuller, D.Q. 2011. Archaeological data reveal slow rates of evolution during plant domestication. *Evolution 65*/1, 171–183.

R Core Team (2016). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/. Accessed 20th January 2017.

Raczky, P. 2012. Körös culture research history. In: A. Anders and Z. Siklósi (eds.), *The Körös culture in Eastern Hungary*, Oxford: Archaeopress. BAR international series 2334, 9–37.

Raczky, P. Sümegi, P. Bartosiewicz, L. Gál, E. *et al*. 2010. Ecological barrier versus mental marginal zone? Problems of the northernmost Körös Culture settlements in the Great Hungarian Plain. In: D. Gronenborn and J. Petrasch (eds.), *The spread of the Neolithic to central Europe: international symposium, Mainz 24-26 June 2005 spread of the Neolithic to central Europe*, Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 147–174.

Radović, M. 2015. Bioanthropological report. In: M. Vander Linden and I. Pandžić (eds.), *The Neolithic site of Kočićevo in the lower Vrbas Valley (Republika Srpska, Bosnia and Herzegovina): report of the 2009-2014 field seasons*, Banja Luka: Univeristy of Banja Luka, 121–133.

Redžić, S. J. 2006. Wild edible plants and their traditional use in the human nutrition in Bosnia-Herzegovina. *Ecology of Food and Nutrition*, 189–232.

Reed, J. Kryštufek, B. and Eastwood, W. 2004. The physical geography of the Balkans and nomenclature of place names. In: H. I. Griffiths, B. Kryštufek, and J. M. Reed (eds.), *Balkan Biodiversity. Pattern and process in the European hotspot*, Dordrecht, Boston, London: Kluwer Academic publishers, 9–22.

Reed, K. 2006. *Early Farming in Dalmatia: Preliminary Archaeobotanical Report on the Middle Neolithic site of Danil*o. MSc Dissertation, Institute of Archaeology, University College London

Reed, K. 2012. *Farmers in Transition. The archaeobotanical analysis of the Carpathian Basin from the Late Neolithic to the Late Bronze Age (5000-900 BC).* Ph.D. Thesis, University of Leicester.

Reed, K. 2015. From the field to the hearth: plant remains from Neolithic Croatia (*ca*. 6000–4000 cal BC). *Vegetation History and Archaeobotany*, 601–619.

Reed, K. 2016. Archaeobotany in Croatia: an overview. *VAMZ 49*/3.s, 7–28.

Reed, K. and Colledge, S. 2016. Plant economies in the Neolithic eastern Adriatic: archaeobotanical results from Danilo and Pokrovnik. *Journal of Dalmatian archaeology and history 109*/1, 9–23.

Reed, K. and Podrug, E. 2016. Reconstructing late Neolithic plant economies at the Eastern Adriatic site of Velištak (5th millennium cal BC). *Documenta Praehistorica XLIII*, 399–412.

Reimer, P. Bard, E. Bayliss, A. Beck, J. *et al*. 2013. IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. *Radiocarbon 55*/4, 1869–1887.

Reingruber, A. 2011. Early Neolithic settlement patterns and exchange networks in the Aegean. *Documenta Praehistorica*, 291–305.

Renfrew, J. 1974. Report on the carbonised cereal grains and seeds from Obre I, Kakanj and Obre II. *Wissenschaftliche mitteilungen des Bosnisch-Herzegowinischen landesmuseums IV*, 47–53.

Renfrew, J. 1976. Carbonised seeds from Anza. In: M. Gimbutas (ed.), *Neolithic Macedonia as reflected by excavationsat Anza. Southeast Yugoslavia. Volume 1*, Los Angeles, California: The Institute of Archaeology, University of California, 300–312.

Renfrew, J. 1979. The first farmers in South East Europe. *Archaeo-Physika 8*, 243–265.

Reynolds, P. 1981. Deadstock and livestock. In: R. Mercer (ed.), *Farming Practice in British Prehistory*, Edinburgh: Edinburgh University Press, 97–122.

Reynolds, P. 1999. Crop yields of the prehistoric cereal types emmer and spelt. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 267–274.

Richerson, P. and Boyd, R. 2005. *Not by genes alone: how culture transformed human evolution*, Chicago and London: University of Chicago.

Riehl, S. 2008. Climate and agriculture in the ancient Near East: A synthesis of the archaeobotanical and stable carbon isotope evidence. In: *Vegetation History and Archaeobotany*.

Robb, J. 2013. Material culture, landscapes of action, and emergent causation. *Current Anthropology 54*, 657-683.

Robb, J. and Miracle, P. 2007. Beyond “migration” versus “acculturation”: new models for the spread of agriculture. In: *Going over: the Mesolithic-Neolithic transition in north-west Europe*, 99–115.

Roberts, N. Eastwood, W. Kuzucuolu, C. Fiorentino, G. and Caracuta, V. 2011. Climatic, vegetation and cultural change in the eastern Mediterranean during the mid-Holocene environmental transition. *The Holocene 21*/1, 147–162.

Robertson, A. Karamata, S. and Šarić, K. 2009. Overview of ophiolites and related units in the Late Palaeozoic-Early Cenozoic magmatic and tectonic development of Tethys in the northern part of the Balkan region. *Lithos 108*, 1–36.

Rösch, M. 1998. The history of crops and crop weeds in south-western Germany from the Neolithic period to modern times, as shown by archaeobotanical evidence. *Vegetation History and Archaeobotany 7*, 109–125.

Rösch, M. Ehrmann, O. Herrmann, L. Schulz, E. *et al*. 2002. An experimental approach to Neolithic shifting cultivation. *Vegetation History and Archaeobotany 11*, 143–154.

Rossignol-Strick, M. 1999. The Holocene climatic optimum and pollen records of sapropel 1 in the eastern Mediterranean, 9000-6000 BP. *Quaternary Science Reviews 18*, 515–530.

Rothamstead Research. 2017. Available at: http://rothamsted.ac.uk/long-term-experiments-national-capability/classical-experiments. Accessed 12th March 2016.

Rottoli, M. 2006. Alcuni aspetti dell’agricoltura neolitica in Italia settentrionale. *Atti della Societa dei Naturalisti e Matematici di Modena 137*, 243–254.

Rottoli, M. and Castiglioni, E. 2009. Prehistory of plant growing and collecting in northern Italy, based on seed remains from the early Neolithic to the Chalcolithic (c. 5600–2100 cal B.C.). *Vegetation History and Archaeobotany 18*, 91–103.

Rottoli, M. and Pessina, A. 2007. Neolithic agriculture in Italy: an update of archaeobotanical data with particular emphasis on northern settlements. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic plants in Southwest Asia and Europe,* Walnut Creek, CA: Left Coast Press, 141–153.

Rowell, T. A. 1986. Sedge (*Cladium mariscus*) in Cambridgeshire: its use and protection since the seventeenth century. *Agricultural History Review*, 140–148.

Rowley-Conwy, P. Gourichon, L. Helmer, D. and Vigne, J-D. 2013. Early domestic animals in Italy, Istria, the Tyrrhenian Islands, and southern France. In: S. Colledge, J. Conolly, K. Dobney, K. Manning, and S. Shennan (eds.), *The origins and spread of domestic animals in southwest Asia and Europe,* Walnut Creek, CA: Left Coast Press, 161–194.

Royo-Esnal, A. Torra, J. Conesa, J. and Recasens, J. 2010. Characterisation of emergence of autumn and spring cohorts of *Galium* spp. in winter cereals. *Weed Research 50*, 572–585.

Rožić, L. O. 2003. Archeological Research at Brezovljani in 2003. *Journal of the Historical Society of Križevci 5*/1, 75–79.

Ruas, M-P. 2016. Lieux de cueillettes, lieux de cultures: les fruits à la croisée des chemins. In: M.-P. Ruas (ed.), *Des fruits d'ici et d'ailleurs. Regards sur l'histoire de quelques fruits consommés en Europe*, Montreuil: Omniscience, 287–322.

Rudner, Z. and Sümegi, P. 2001. Recurring Taiga forest-steppe habitats in the Carpathian Basin in the Upper Weichselian. *Quaternary International 76–77*, 177–189.

Salavert, A. 2010. Le pavot (Papaver somniferum) à la fin du 6e millénaire av. J.-C. en Europe occidentale. *Anthropobotanica 3*/1, 3–16.

Salavert, A. 2011. Plant economy of the first farmers of central Belgium (Linearbandkeramik, 5200-5000 b.c.). *Vegetation History and Archaeobotany 20*/5, 321–332.

Sans, F. X. and Masalles, R. M. 1995. Phenological patterns in an arable land weed community related to disturbance. *Weed Research 35*/5, 321–332.

Saxena, M. 1981. Agronomy of lentils. In: C. Webb and G. Hawtin (eds.), *Lentils,* Slough: Commonwealth Agricultural Bureaux, 111–130.

Schaal, C. Unpublished. *New carpological analyses from Neolithic sites of North-eastern France, including records of "new glume wheat,"* Paper presented at the 17th Conference of the International Work Group for Palaeoethnobotany (2016), Paris, France. Abstract available at: https://iwgp2016paris.sciencesconf.org.

Schiffer, M.B. 1972. Archaeological Context and Systemic Context. *American Antiquity,* 156–165.

Schiffer, M.B. 1976. *Behavioral archaeology,* New York: Academic press.

Schiffer, M.B. 1983. Toward the identification of formation processes. *American Antiquity 48*/4, 675–706.

Schiffer, M.B. 1987. *Formation Processes of the Archaeological Record*, Albuquerque: University of New Mexico Press.

Schmidt, R. Müller, J. Drescher-Schneider, R. Krisai, R. *et al*. 2000. Changes in lake level and trophy at Lake Vrana, a large karstic lake on the Island of Cres (Croatia), with respect to palaeoclimate and anthropogenic impacts during the last approx. 16,000 years. *Journal of Limnology 59*/2, 113–130.

Schröter, C. 1895. Über die pflanzenreste der Neolithischen Landseidlung von Butmir. In: *Die neolithische station von Butmir bei Sarajevo in Bosnien.* Ausgrabungen im Jahre 1983, edited by the Museum of Bosnia and Herzegovina. Wien: Adolf Holzhausen, 37–46.

Scott, A.C. and Damblon, F. 2010. Charcoal: taphonomy and significance in geology, botany and archaeology. *Palaeogeography, Palaeoclimatology, Palaeoecology 291*/1–2, 1–10.

Selleger, C. 2014. Use of wild food plant resources in the Dogon coutry, Mali. In: A. Chevalier, E. Marinova, and L. Peña-Chocarro (eds.), *Plants and people. Choices and diversity through time*, Oxford and Philadelphia: Oxbow Books, 236–241.

Shahack-Gross, R. 2011. Herbivorous livestock dung: Formation, taphonomy, methods for identification, and archaeological significance. *Journal of Archaeological Science*, 205–218.

Shennan, S. 2008. Evolution in Archaeology. *Annual Review of Anthropology 37*/1, 75–91.

Shennan, S. Downey, S. Timpson, A. Edinborough, K. *et al*. 2013. Regional population collapse followed initial agriculture booms in mid-Holocene Europe. *Nature communications 4*, 2486.

Sherratt, A. 1980. Water, soil and seasonality in early cereal cultivation. *World Archaeology 11*/3, 313–330.

Sigaut, F. 1988. A method for identifying grain storage techniques and its application for European agricultural history. *Tools and Tillage 6*/1, 3–32.

Sigaut, F. 1989. Storage and threshing in pre-industrial Europe, additional notes. *Tools and Tillage 6*/2, 119–124.

Sigaut, F. 1999. Yields, sowing and fertility. Analytical significance of yields. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 275–280.

Šilc, U. Vrbničanin, S. Božić, D. Čarni, A. and Stevanović, Z. D. 2012. Alien plant species and factors of invasiveness of anthropogenic vegetation in the Northwestern Balkans - a phytosociological approach. *Central European Journal of Biology 7*/4, 720–730.

Silim, S. Saxena, M. and Erskine, W. 1991. Effects of sowing date on the growth and yield of lentil in a rainfed Mediterranean environment. *Experimental Agriculture 27*, 145–154.

Smith, A. 2014. The use of multivariate statistics within archaeobotany. In: J.Marston, J.D'Alpoim-Guedes and C.Warinner (eds.). *Method and theory in paleoethnobotany*. Boulder: University Press of Colorado, 181-204.

Sommer, U. and Astaloş, C. 2015. The village and the house in the early Neolithic. Research into activity areas and rubbish disposal at the late Criş-settlement of Tăşnad (Satu Mare county, Romania). In: C. Virag (ed.), *Neolithic cultural phenomena in the Upper Tisza Basin*, Satu Mare: Muzeului Sătmărean, 75–95.

Spasić, M. and Živanović, S. 2015. Foodways architecture: storing, processing and dining structures at the Late Neolithic Vinča culture site at Stubline. *Documenta Praehistorica XLII*, 219–230.

Spataro, M. 2002. *The first farming communities of the Adriatic: pottery production and circulation in the Early and Middle Neolithic*, Tieste: Società per la preistoria e protostoria della regione Friuli-Venezia Giulia. Edizioni Svevo Trieste.

Spataro, M. 2009. The first specialised potters of the Adriatic region: the makers of Neolithic figulina ware. In: S. Forenbaher (ed.), *A connecting sea: maritime interaction in Adriatic prehistory*, Oxford: Archaeopress. BAR international series 2037, 59–72.

Spataro, M. 2010. The neolithisation of the Central Balkans: leapfrogging diffusion and cultural transmission. In: D. Gronenborn and J. Petrasch (eds.), *The spread of the Neolithic to central Europe: international symposium, Mainz 24-26 June 2005 spread of the Neolithic to central Europe*, Mainz: Verlag des Römisch-Germanischen Zentralmuseums, 95–106.

Spataro, M. 2014. Continuity and change in pottery manufacture between the early and middle Neolithic of Romania. *Archaeological and Anthropological Sciences* 6/2, 175–197.

Stamnes, A. A. 2016. Effect of temperature change on Iron Age cereal production and settlement patterns in Mid-Norway. In: I. Iversen and H. Petersson (eds.), *The agrarian life of the North 2000 BC-AD 1000. Studies in settlement and farming in Norway*, Kristiansand: Portal, 27–39.

Starnini, E. Ghisotti, F. Girod, A. and Nisbet, R. 2000. Nuovi dati sul neolitico antico della Pianura Padana centrale dal sito di Isorella (Brescia). In: A. Pessina and G. Muscio (eds.), *La neolitizzazione tra oriente e occidente. Atti del Convegno di Studi. Udine, 23–24 aprile 1999*, Udine: Museo Friulano di Storia Naturale, 231–256.

Steiner, B. Antolín, F. Vach, W. and Jacomet, S. 2017. Subsampling of large-volume samples in waterlogged sediments. A time-saving strategy or a source of error? *Review of Palaeobotany and Palynology 245*, 10–27.

Stevanović, M. 1997. The age of clay: the social dynamics of house destruction. *Journal of Anthropological Archaeology 16*, 334–395.

Stevanović, V. Tan, K. and Iatrou, G. 2003. Distribution of the endemic Balkan flora on serpentine I. - Obligate serpentine endemics. *Plant Systematics and Evolution 242*/1–4, 149–170.

Stevens, C. 2003. An investigation of agricultural consumption and production models for prehistoric and Roman Britain. *Environmental Archaeology* /1, 61–76.

Stevens, C. 2014. Intersite variation within archaeobotanical charred assemblages. A case study exploring the social organization of agricultural husbandry in Iron Age and Roman Britain. In: J. M. Marston, J. d'Alpoim Guedes, and C. Warinner (eds.), *Method and theory in paleoethnobotany*, Boulder: University of Colorado Press, 235–254.

Stevens, C.J. 1996. *Iron Age and Roman Agriculture in the Upper Thames Valley: Archaeobotanical and Social Perspectives.* Ph.D. Thesis, Department of Archaeology and anthropology, University of Cambridge.

Stevens, C.J. Murphy, C. Roberts, R. Lucas, L. *et al*. 2016. Between China and South Asia : A Middle Asian corridor of crop dispersal and agricultural innovation in the Bronze Age. *The Holocene 26*/10, 1541–1555.

Styring, A. K. Manning, H. Fraser, R. A. Wallace, C. *et al.* 2013. The effect of charring and burial on the biochemical composition of cereal grains: investigating the integrity of archaeological plant material. *Journal of Archaeological Science 40*, 4767–4779. DOI:10.1016/j.jas.2013.03.024.

Styring, A.K. Ater, M. Hmimsa, Y. Fraser, R. *et al*. 2016. Disentangling the effect of farming practice from aridity on crop stable isotope values: A present-day model from Morocco and its application to early farming sites in the eastern Mediterranean. *The Anthropocene Review 3*/1, 2–22.

Styring, A.K. Charles, M. P. Fantone, F. Hald, M. *et al*. 2017a. Isotope Evidence for Agricultural Extensification Reveals how the World’s First Cities were Fed. *Nature Plants 17076*/June, 1–11.

Styring, A.K. Rösch, M. Stephan, E. Stika, H-P. *et al*. 2017b. Centralisation and long-term change in farming regimes: comparing agricultural practices in Neolithic and Iron Age south-west Germany. *Proceedings of the Prehistoric Society*, 1–25.

Sümegi, P. 2004. Environmental changes under the neolithisation process in central Europe: before and after. *Antaeus 27*, 117–127.

Sümegi, P. 2007. Palaeogeographical background of the Mesolithic and Early Neolithic settlement in the Carpathian Basin. In: J. Kozłowski and M. Nowak (eds.), *Mesolithic/Neolithic interactions in the Balkans and in the Middle Danube Basin*, Oxford: Archaeopress. BAR international series 1726, 47–52.

Sümegi, P. and Kertész, R. 1998. Palaeogeographic characteristic of the Carpathian Basin - an ecological trap during the early Neolithic? *Jászkunság 44*, 144–157.

Sümegi, P. and Molnár, S. 2007. The Kiri-Tó meander: sediments and the question of floods. In: A. Whittle (ed.), *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös culture site of Ecsegfalva, county Békés. Volume I*, Budapest: Archaeological Institute of the Hungarian Academy of Sciences, 47–66.

Sümegi, P. Kertész, R. and Hertelendi, E. 2002. Environmental change and human adaptation in the Carpathian Basin at the Late Glacial/Postglacial transition. In: E. Jerem and K. Biró (eds.), *Archaeometry 98: proceedings of the 31st Symposium Budapest, April 26 - May 3 1998*, Oxford: Archaeopress. BAR international series 1043, 171–177.

Sümegi, P. Gulyás, S. Persaits, G. Náfrádi, K. and Törőcsik, T. 2013. Palaeoenvironmental studies in the Danube-Tisza interfluve: possible contact between the Körös sites in the Tisza and the Danube valleys. In: E. Bánffy (ed.), *The Early Neolithic in the Danube-Tisza interfluve,* Oxford: Archaeopress. BAR international series 2584, 23–29.

Summerfield, R. 1981. Adaptation to environments. In: C. Webb and G. Hawtin (eds.), *Lentils*, Slough: Commonwealth Agricultural Bureaux, 91–110.

Swarbrick, J. and Raymond, J. 1970. The identification of the seeds of the British Papaveraceae. *Annals of Botany 34*, 1115–22.

Tanno, K. and Willcox, G. 2006. The origins of cultivation of *Cicer arietinum* L. and *Vicia faba* L.: Early finds from Tell el-Kerkh, north-west Syria, late 10th millennium B.P. *Vegetation History and Archaeobotany 15*/3, 197–204.

Tardío, J. Pardo-De-Santayana, M. and Morales, R. 2006. Ethnobotanical review of wild edible plants in Spain. *Botanical Journal of the Linnean Society*, 27–71.

Teetor, P. 2011. *R Cookbook*, Beijing, Cambridge, Farnham, Köln, Sebastopol, Tokyo: O'Reilly.

Tela Botanica. Available at: http://www.tela-botanica.org. Accessed during August and September 2016.

Ter Braak, C. J. F. 1988. *Canoco: a FORTRAN program for canonical community, version 2.1/Microcomputer power*, Ithaca, New York.

Tereso, P. Bettencourt, A. Ramil-Rego, P. Teira-Brión, A. *et al*. 2016. Agriculture in NW Iberia during the Bronze Age: A review of archaeobotanical data. *Journal of Archaeological Science 10*, 44–58.

The Plant List. 2013. Available at: www.theplantlist.org. Accessed Autumns of 2015 and 2016.

Thissen, L. 2000a. A Chronological framework for the Neolithisation of the Southern Balkans. In: S. Hiller and V. Nikolov (eds.), *Karanovo III: Beiträge zum Neolithikum in Südosteuropa*, Wien: Ferdinand Berger & Söhne, 193–200.

Thissen, L. 2000b. Thessaly, Franchthi and Western Turkey: clues to the Neolithisation of Greece? *Documenta Praehistorica XXVII*, 141–154.

Tolar, T. Jacomet, S. Velušček, A. and Čufar, K. 2011. Plant economy at a late Neolithic dwelling site in Slovenia at the time of the Alpine Iceman. *Vegetation History and Archaeobotany 20*, 207–222.

Tringham, R. 1971. *Hunters, fishers and farmers of Eastern Europe 6000-3000 BC*, London: Hutchinson and Co LTD.

Tringham, R. 2000a. Southeastern Europe in the transition to agriculture in Europe: bridge, buffer or mosaic. In: T. D. Price (ed.), *Europe's first farmers*, Cambridge, New York, Melbourn, Madrid, Cape Town, Singapore, São Paolo: Cambridge University Press, 19–56.

Tringham, R. 2000b. The continuous house: a view from the deep past. In: R. A. Joyce and S. D. Gillespie (eds.), *Beyond Kinship: social and material reproduction in house societies*, Philadelphia: University of Pennsylvania Press, 115–134.

Tringham, R. 2005. Weaving house life and death into places: a blueprint for a hypermedia narrative. In: D. Bailey, A. Whittle., and V. Cummings (eds.), *(Un)settling the Neolithic*, Oxford: Oxbow Books, 98–111.

Tringham, R. Brukner, B. Kaiser, T. Borojević, K. *et al*. 1992. Excavations at Opovo, 1985–1987: Socioeconomic Change in the Balkan Neolithic. *Journal of Field Archaeology 19*/3, 351–386.

Tripković, B. 2003. A dialogue between the household and community: a case study of Banjica. In: L. Nikolova (ed.), *Early Symbolic Systems for Communication in Southeast Europe*, Oxford: Archaeopress. BAR international series 1139, 447–458.

Tripković, B. 2011. Containers and grains: food storage and symbolism in the Central Balkans (Vinča period). *Documenta Praehistorica 38*, 159–172.

Valamoti, S.M. 2004. *Plants and people in Late Neolithic and Early Bronze Age northern Greece: an archaeobotanical investigation*. Oxford: Archaeopress, BAR International series 1258.

Valamoti, S.M. 2005. Grain versus chaff: identifying a contrast between grain-rich and chaff-rich sites in the Neolithic of northern Greece. *Vegetation History and Archaeobotany 14*: 259-267. DOI:10.1007/s00334-005-0073-z.

Valamoti, S.M. 2007a. Detecting seasonal movement from animal dung: an investigation in Neolithic northern Greece. *Antiquity 81*/314, 1053–1064.

Valamoti, S.M. 2007b. Traditional foods and culinary novelties in Neolithic and Bronze Age Northern Greece: an overview of the archaeobotanical evidence. In: C. Mee and J. Renard (eds.), *Cooking up the past*, Oxford: Oxbow books, 89–108.

Valamoti, S.M. 2011. Flax in Neolithic and Bronze Age Greece: Archaeobotanical evidence. *Vegetation History and Archaeobotany 20*/6, 549–560.

Valamoti, S.M. 2013. Towards a distinction of digested and undigested glume bases in the archaeobotanical record from Neolithic northern Greece: a prliminary experimental investigation. *Journal of Environmental Archaeology 18*/1, 31–42.

Valamoti, S.M. 2016. Millet, the late comer: on the tracks of Panicum miliaceum in prehistoric Greece. *Archaeological and Anthropological Sciences 8*, 51–63.

Valamoti, S.M. and Charles, M. 2005. Distinguishing food from fodder through the study of charred plant remains: an experimental approach to dung-derived chaff. *Vegetation History and Archaeobotany 14*/4, 528–533.

Valamoti, S.M. and Jones, G. 2003. Plant diversity and storage at Mandalo, Macedonia, Greece: archaeobotanical evidence from the Final Neolithic and Early Bronze Age. *Annual of the British School at Athens 98*, 1–35.

Valamoti, S.M. and Kotsakis, K. 2007. Transitions to agriculture in the Aegean: the archaeobotanical evidence. In: S. Colledge and J. Conolly (eds.), *The origins and spread of domestic plants in Southwest Asia and Europe*, Walnut Creek, CA: Left Coast Press, 75–91.

Valde-Nowak, P. 2010. The Mesolithic in the northernmost periphery of the Carpathian Basin. In: J. Kozłowski and P. Racsky (eds.), *Neolithization of the Carpathian Basin: nothernmost distribution of the Starčevo/Körös culture*, Kraków: Polska Akademia Umiejętności; Budapest : Institute of Archaeological Sciences of the Eötvös Loránd University, 7–22.

van Andel, T.H. and Runnels, C. N. 1995. The earliest farmers in Europe. *Antiquity 69*/264, 481–500.

Van Assche, J. and Vandelook, F. 2006. Germination ecology of eleven species of Geraniaceae and Malvaceae, with special reference to the effects of drying seeds. *Seed Science Research 16*/283–290.

van der Maarel, E. 1975. The Braun-Blanquet approach in perspective. *Vegetatio 30*/3, 213–219.

van der Veen, M. 1992. *Crop husbandry regimes. An archaeobotanical study of farming in northern England 1000 BC - AD 500*, Sheffield, Shefield archaeological Monographs 3: J.R. Collis Publications.

van der Veen, M. 1999. The economic value of chaff and straw in arid and temperate zones. *Vegetation History and Archaeobotany 8*, 211–224.

van der Veen, M. 2007. Formation processes of desiccated and carbonized plant remains - the identification of routine practice. *Journal of Archaeological Science 34*/6, 968–990.

Van Der Veen, M. and Jones, G. 2006. A re-analysis of agricultural production and consumption: Implications for understanding the British Iron Age. *Vegetation History and Archaeobotany 15*/3, 217–228.

van der Veen, M. and Palmer, C. 1997. Environmental factors and the yield potential of ancient wheat crops. *Journal of Archaeological Science 24*, 163–182.

van Zeist, W. 1975. Preliminary report on the botany of Gomolava. *Journal of Archaeological Science 2*, 315–352.

van Zeist, W. 2001. Plant husbandry and vegetation at tell Gomolava, Vojvodina, Yugoslavia. *Palaeohistoria 43/44*, 87–116.

van Zeist, W. A. 1999. Evidence for agricultural change in the Balikh basin, northern Syria. In: C. Gosden and J. Hather (eds.), *The prehistory of food. Appetites for change*, London: Routledge, 350–373.

van Zeist, W. and Bakker-Heeres, J.1975. Evidence for linseed cultivation before 6000 bc. *Journal of Archaeological Science 2*/3, 215–219.

Vander Linden, M. 2011. In constant motion? Recent advances in mathematical modelling and radiocarbon chronology of the neolithisation of Europe. In: A. Hadjikoumis, E. Robinson, and S. Viner (eds.), *The Dynamics of neolithisation in Europe*, Oxford and Oakville: Oxbow books, 25–45.

Vander Linden, M. Pandžić, I. Gaastra, J. Jovanović, B. and de Vareilles, A. Unpublished. *Report of the March 2015 field season in Kosjerovo (Republika Srpska, Bosnia&Herzegovina)*, Unpublished preliminary excavation report.

Vander Linden, M. Gaastra, J. de Vareilles, A. and Silva, F. Submitted. By sail and and by land: comparing the inland and maritime streams of neolithisation across the western Balkans. In: J. Rowland, G. J. Tassie, and G. Lucarini (eds.), *The neolithisation of the Mediterranean basin: the transition to food-producing economies in North Africa, Southern Europe and the Levant*, Berlin: Topoi.

Vander Linden, M. Orton, D. Pandžić, I. Đurđević, M. *et al*. 2013. EUROFARM: comparison and modelling of early farming and associated technologies in Europe. *Antiquity +, 336*.

Vander Linden, M. Pandžić, I. and Orton, D. 2014a. New radiocarbon dates for the Neolithic period in Bosnia & Herzegovina. *Godišnjak Centra za balkanološka ispitivanja 43*, 7–34.

Vander Linden, M. Marriner, G. Orton, D. de Vareilles, A. *et al*. 2014b. Preliminary report on the excavations in Seocka pećina, Montenegro (September 2013). In: D. Mihailović (ed.), *Palaeolithic and Mesolithic research in the central Balkans*, Belgrade: Serbian Archaeological Society, 153–158.

Vander Linden, M. Marriner, G. and Pandžić, I. 2015. Discussion. In: I. Pandžić and M. Vander Linden (eds.), *The Neolithic site of Kočićevo in the lower Vrbas Valley (Republika Srpska, Bosnia and Herzegovina): report of the 2009-2014 field seasons*, Banja Luka: University of Banja Luka.

VanDerwarker, A. 2010. Simple measures for integrating plant and animal remains. In: A. M. VanDerwarker and T. M. Peres (eds.), *Integrating zooarchaeology and paleoethnobotany. A consideration of issues, methods and cases*, New York, Dordrecht, Heidelberg, London: Springer, 65–74.

Veal, L. 2015. *Defining Neolithic human settlement and occupationin an alluvial landscape context: a geoarchaeological investigation at Kosjerovo, lower Vrbas Valley, northern Bosnia and Herzegovina.* B.Sc. Dissertation, Institute of Archaeology, University College London.

Voytek, B. 2011. In the shadow of the grand narrative: revisiting the early Holocene of the northern Adriatic. *Journal of World Prehistory 24*, 189–199.

Walker, M. Berkelhammer, M. Björck, S. Cwynar, L. *et al*. 2012. Formal subdivision of the Holocene Series/Epoch: a Discussion Paper by a Working Group of INTIMATE (Integration of ice-core, marine and terrestrial records) and the Subcommission on Quaternary Stratigraphy (International Commission on Stratigraphy). *Journal of Quaternary Science 27*/7, 649–659.

Wallace, M. and Charles, M. 2013. What goes in does not always come out: The impact of the ruminant digestive system of sheep on plant material, and its importance for the interpre tation of dung-derived archaeobotanical assemblages. *Environmental Archaeology 18*/1, 18–30.

Wallace, M. Jones, G. Charles, M. Fraser, R. *et al*. 2013. Stable carbon isotope analysis as a direct means of inferring crop water status and water management practices. *World Archaeology 45*/3, 388–409. DOI:10.1080/00438243.2013.821671.

Wang, J. Luo, M. Chen, Z. You, F. *et al*. 2013. *Aegilops tauschii* single nucleotide polymorphisms shed light on the origins of wheat D-genome genetic diversity and pinpoint the geographic origin of hexaploid wheat. *New Phytologist 198*/3, 925–937.

Wärner, C. Welk, E. Durka, W. Wittig, B. and Diekmann, M. 2011. Biological Flora of Central Europe: *Euphorbia palustris* L. *Perspectives in Plant Ecology, Evolution and Systematics 13,* 55–69.

Weller, J. and Ortega, R. 2015. Genetic control of flowering time in legumes. *Frontiers in plant science 6*/April, 207.

Weninger, B. Alram-Stern, E. Bauer, E. Clare, L. *et al*. 2006. Climate forcing due to the 8200 cal yr BP event observed at Early Neolithic sites in the eastern Mediterranean. *Quaternary Research 66*, 401–420.

Wesolowski, V., Mendonça de Souza, F. Reinhard, K. and Ceccantini, G. 2010. Evaluating microfossil content of dental calculus from Brazilian sambaquis. *Journal of Archaeological Science 37*/6, 1326–1338.

Westhoff, V. and van der Maarel, E. 1978. The Braun-Blanquet approach. In: R. . Whittaker (ed.), *Classification of plant communities*, The Hague: Junk Publishers, 287–399.

White, C. and Shelton, C. P. 2014. Recovering macrobotanical remains: current methods and techniques. In: J. M. Marston, J. d'Alpoim Guedes, and C. Warinner (eds.), *Method and theory in paleoethnobotany*, Boulder: University of Colorado Press, 95–114.

Whittle, A. 1996. *Europe in the Neolithic: the creation of new worlds*, Cambridge: Cambridge University Press.

Whittle, A. 1997. Moving on and moving around: Neolithic settlement mobility. In: Topping, P. (ed), Neolithic landscapes. Oxford: Oxbow books, 15-22.

Whittle, A. (ed.) 2007. Going over: people and their times. In: *Going over: the Mesolithic-Neolithic transition in north-western Europe*, 617–628.

Whittle, A. Bartosiewicz, L. Borić, D. Pettitt, P. and Richards, M. 2002. In the beginning: new radiocarbon dates for the early Neolithic in northern Serbia and south-east Hungary. *Antaeus 25*, 63–117.

Whittle, A. Bayliss, A. Barclay, A. Gaydarska, B. *et al*. 2016. A Vinča potscape: formal chronological models for the use and development of Vinča ceramics in south-east Europe. *Documenta Praehistorica XLIII*, 1–60.

Wickham, H. 2009. *ggplot2: Elegant graphics for data analysis*, New York: Springer-Verlag.

Wilkinson, K. and Stevens, C. 2008. *Environmental archaeology: approaches, techniques and applications*, Revised ed. Stroud: Tempus.

Willcox, G. 1999. Archaeobotanical significance of growing Near Eastern progenitors of domestic plants at Jalès, France. In: P. Anderson (ed.), *Prehistory of agriculture. New experimental and ethnographic approaches*, Los Angeles, California: University of California Press, Monograph 40, 103–117.

Willcox, G. 2005. The distribution, natural habitats and availability of wild cereals in relation to their domestication in the Near East: Multiple events, multiple centres. In: *Vegetation History and Archaeobotany*, 534–541.

Willcox, G. 2016. Les fruits au Poche-Orient avant la domestication des fruitiers. In: M.-P. Ruas (ed.), *Des fruits d'ici et d'ailleurs. Regards sur l'histoire de quelques fruits consommés en Europe*, Montreuil: Omniscience, 41–54.

Willcox, G. Fornite, S. and Herveux, L. 2008. Early Holocene cultivation before domestication in northern Syria. *Vegetation History and Archaeobotany 17*/3, 313–325.

Williams, D. 1973. Flotation at Siraf. *Antiquity 47*, 288–292.

Willis, K. 1994. The vegetational history of the Balkans. *Quaternary Science Reviews 13*/8, 769–788.

Willis, K. 2007. Pollen analysis in the Kiri-tó and local environment. In: A. Whittle (ed.), *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös culture site of Ecsegfalva, county Békés. Volume I*, Budapest: Institute of Archaeology, Hungarian Academy of Sciences, 83–98.

Wilson, D.G. 1984. The carbonisation of weed seeds and their representation in macrofossil assemblages. In: W. Van Zeist and W. Casparie (eds.), *Plants and ancient man*, Rotterdam: A.A. Balkema, 201–206.

Wilson, P. and King, M. 2003. *Arable plants - a field guide*, Old Basing: WILDguides.

WorldClim – World Climate Data. 2016. Available at: http://www.worldclim.org. Accessed 5th June 2015.

Wright, P. 2003. Preservation or destruction of plant remains by carbonization? *Journal of Archaeological Science 30*/5, 577–583.

Wu, H. Guiot, J. Brewer, S. and Guo, Z. 2007. Climatic changes in Eurasia and Africa at the Last Glacial Maximum and the mid-Holocene: Reconstruc- tion from pollen data using inverse vegetation modeling. *Climate Dynamics 29*, 211–299.

Yanko-Hombach, V. Gilbert, A. and Dolukhanov, P. 2007. Controversy over the great flood hypotheses in the Black Sea in light of geological, paleontological, and archaeological evidence. *Quaternary International 167–168*, 91–113.

Zanchetta, G. Bini, M. Cremaschi, M. Magni, M. and Sadori, L. 2013. The transition from natural to anthropogenic-dominated environmental change in Italy and the surrounding regions since the Neolithic: An introduction. *Quaternary International 303*, 1–9.

Zapata, L. Peña-Chocarro, L. Pérez-Jordá, G. and Stika, H. 2004. Early neolithic agriculture in the iberian peninsula. *Journal of World Prehistory*, 283–325.

Zecchin, M. Gordini, E. and Ramella, R. 2015. Recognition of a drowned delta in the northern Adriatic Sea, Italy: Stratigraphic characteristics and its significance in the frame of the early Holocene sea-level rise. *The Holocene*, 1–12.

Zeder, M. 2017. Out of the Fertile Crescent: the dispersal of domestic livestock through Europe and Africa. In: M. Petraglia, N. Boivin, and R. Crassard (eds.), *Human Dispersal and Species Movement: from Prehistory to the Present*, Cambridge: Cambridge University Press, 261–303.

Zhao, Z. 2011. New archaeobotanic data for the study of the origins of agriculture in China. *Current Anthropology 52*/S4, S295-306.

Zilhão, J. 1993. The spread of agro-pastoral economies across Mediterranean Europe: a view from the far west. *Journal of Mediterranean Archaeology*, 5–63.

Zilhão, J. 2001. Radiocarbon evidence for maritime pioneer colonization at the origins of farming in west Mediterranean Europe. *Proceedings of the National Academy of Sciences of the United States of America 98*/24, 14180–14185.

Zilhão, J. 2003. The Neolithic transition in Portugal and the role of demic diffusion in the spread of agriculture across West Mediterranean. In: A. Ammerman and P. Biagi (eds.), *The Widening Harvest. The Neolithic Transition in Europe: Looking Back, Looking Forward*, Boston: Colloquia and Conference Papers, 6. The Archaeological Institute of America, 207–223.

Zohary, D. Hopf, M. and Weiss, E. 2012. *Domestication of crops in the Old World*, Oxford: Oxford University Press, 4th Edition.

Zvelebil, M. 2001. The agricultural transition and the origins of Neolithic society in Europe. *Documenta Praehistorica 28*, 1–26.

Zvelebil, M. and Lillie, M. 2000. Transition to agriculture in eastern Europe. In: T. D. Price (ed.), *Europe's first farmers*, Cambridge, New York, Melbourn, Madrid, Cape Town, Singapore, São Paolo: Cambridge University Press, 57–92.

Zvelebil, M. and Rowley-Conwy, P. 1986. Foragers and Farmers in Atlantic Europe. In: Zvelebil, M. (ed.). Hunters in Transition. Cambridge: Cambridge University Press, 67-93.

Zvelebil, M. Lukes, A. and Pettitt, P. 2010. The emergence of the LBK Culture: search for the ancestors. In: D. Gronenborn and J. Petrasch (eds.), *The spread of the Neolithic to central Europe.* International symposium, Mainz 24-26 June 2005: Spread of the Neolithic to central Europe, Mainz: Verlag des Römisch-Germanischen Zentralmuseums: 301-325.

Deeply Set Roots: an Archaeobotanical Perspective on the Origins of Crop Husbandry in the Western Balkans

APPENDICES

Anne de Labroue de Vareilles Sommières

Thesis submitted in fulfilment of the Degree of Doctor of Philosophy
Institute of Archaeology, University College London
September 2017

Contents

APPENDIX I

Tables, figures and additional information for Chapter 7

This appendix contains additional information on the sites analysed in Chapter 7, and tabulated results from the sorted flots. The criteria used in the identification of plant macro-remains are listed in the final table (Table 1.17). All tables adopt the following key: - 1 or 2 items; - - 2 to 10 items; + 11 to 50 items; ++ 51 to 100 items; +++ >100 items; cf.= compares favourably; all items are charred unless otherwise stated; M = mineralised; S = silicified; P = present; LF = light fraction; HF = heavy fraction. Charcoal is measured to the nearest half millimetre.

1.1 Tăşnad Sere (Chapter 7.1; Astaloş *et al*. 2013; Sommer & Astaloş 2015: 83-91)

The site was discovered during a large-scale drainage programme in 1970. Excavations became more urgent in 2001 with the expansion of the Tăşnad spa, positioned on a nearby natural spring. After an initial rescue intervention in 2001-02, Mr. C. Virag has been directing ongoing excavations since 2004. Dr. U. Sommer (IoA) began excavating in the summer of 2012 and, as part of a larger excavation project, she opened an 8x10m trench to uncover the Criş village. The excavation trench was divided into one metre transects, running eight metres South to North and labelled with a letter. The first transect 'A' was later extended westwards to include transect 'ZZ'. Transects were subdivided into 1x1m^2 and labelled with numbers (e.g. A1, A2, …, A8). Tables 1.1 to 1.3 below list the plant macro-remains and other artefacts retrieved from the sorted samples.

1.2 At (Chapter 7.2; Chu *et al*. 2016; Pantović Unpublished-a)

The site was first discovered by Vršac museum curators F. Milleker and R. Rašajski during 19th and 20th century sand mining activities (Mihailović 1992). In 1984 a large Neolithic pit was discovered during Ms. I. Radovanović's small-scale excavations. Two radiocarbon dates were later obtained, confirming both Starčevo (5500/5400 cal. BC) and late Vinča (4400 cal. BC) presence (Whittle *et al*. 2002: 69-70). Four additional dates, taken during more recent excavations (see Chapter 7.1), date the Starčevo layer to 5842-5668 cal. BC, and overlying deposits to the final Vinča phase (4896-4373 cal. BC). Ten 10L bulk soil samples were taken from the Starčevo layer, and results from the analysis of the flots are presented in Tables 1.4 to 1.5 below.

Tasnad Sere – year	**2014**	**2014**	**2014**	**2014**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2013**	**2014**	**2015**	**2014**	**2014**	**2014**	**2015**	**2015**	**2014**	**2014**	**2015**	**2015**	**2014**	**2014**	**2014**	**2014**	**2015**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2015**
Square/Spit	A1/1	A1/2	A1/3	A1/6	A1/7	A1/8	A2/6	A2/6	A2/9	A3/2	A3/3	A3/6	A3/8	A4/7	A4/8	A5/7	A5/7	A5/9	A6/2	A6/4	A6/8	A6/9	A7/3	A7/4	A7/5	A7/6	A7/9	A8/2	A8/3	A8/4	A8/5	A8/6	A8/7	A8/9
Context	4	4	5		5		5	5	5		4/5	5	5	5	5	5	5		5		5	5	5	5	5	5	5	5	5	5		5	5	5
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Charcoal >4mm	+	- -	-	-	-	-	-	-		-	- -	-				-	-								-									
2-4mm	+	+	- -	- -	- -	-	- -		- -	+	-	- -				-	-		- -	-	-	-	- -	-	-				-		-	-	-	
<2mm	+++	+++	++	++	++	+++	+	+++	+++	+++	++	+++	+++	+++	+	++	++	- -	++	+	++	- -	+++	++	+	-	- -	- -	+++	++	+	+		- -
volume (ml)	8	1	0.5	1	1	0.5	0.5	0.5	0.5	1	0.5	1	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5
Cereals																																		
T.dicoccum grain												1																						
T.monococcum/dicoccum														1																				
Triticum sp. grain					1									1																	1			
Cerealia fragments				2		3	6	11	1		1	8		6		3					1		3	4	1				5		11	4		
Total grains*	**0**	**0**	**0**	**1**	**1**	**1**	**2**	**3**	**1**	**0**	**1**	**3**	**0**	**4**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**1**	**1**	**0**	**0**	**0**	**3**	**0**	**4**	**1**	**0**	**0**
Preservation index – mean				0	1	0	0	0	0		0	0.2		0.3		0					0		0	0	0				0		0.1	0		
mode				0	1	0	0	0	0		0	0		0		0					0		0	0	0				0		0	0		
Fragmentation index				N/A	0	N/A	N/A	N/A	N/A		N/A	8		3		N/A					N/A		N/A	N/A	N/A				N/A		11	N/A		
T.dicoccum glume base																															2			
T.mono./dicoccum gl. base												1																						
Triticum sp. glume base					2			2	2		1		1	4	1	2	2				1		1	5	6				5		6	7		
Total glume bases	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**2**	**2**	**0**	**1**	**1**	**1**	**4**	**1**	**2**	**2**	**0**	**0**	**0**	**1**	**0**	**1**	**5**	**6**	**0**	**0**	**0**	**5**	**0**	**8**	**7**	**0**	**0**
Glume base:grain ratio	**/**	**/**	**/**	**0**	**2**	**0**	**0**	**0.667**	**2**	**/**	**1**	**0.333**	**N/A**	**1**	**N/A**	**2**	**N/A**	**/**	**/**	**/**	**1**	**/**	**0.5**	**5**	**6**	**/**	**/**	**/**	**1.667**	**/**	**2**	**7**	**/**	**/**
Fruits and nuts																																		
Physalis alkakengi																	1 cf.						1											
Indeterminate nut shell frag.												1																	1					
Total	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Wild/Weed seeds																																		
Stellaria sp.						1																												
Small wild Poaceae, <2mm																																1		
Total seeds	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Non-cereal P.I. - mean						1						0											2						0			2		
Grain:seed ratio	/	/	/	**N/A**	**N/A**	1	**N/A**	**N/A**	**N/A**	/	**N/A**	**N/A**	/	**N/A**	**/**	**N/A**	/	/	/	/	/	/	**N/A**	**N/A**	**N/A**	/	/	/	**N/A**	/	**N/A**	1	/	/
Seed density	**0**	**0**	**0**	**0.1**	**0.1**	**0.2**	**0.2**	**0.3**	**0.1**	**0**	**0.1**	**0.4**	**0**	**0.4**	**0**	**0.1**	**0.1**	**0**	**0**	**0**	**0.1**	**0**	**0.3**	**0.1**	**0.1**	**0**	**0**	**0**	**0.4**	**0**	**0.4**	**0.2**	**0**	**0**
№ items/litre (excl. charcoal)	**0**	**0**	**0**	**0.1**	**0.3**	**0.2**	**0.2**	**0.5**	**0.3**	**0**	**0.2**	**0.5**	**0.1**	**0.8**	**0.1**	**0.3**	**0.3**	**0**	**0**	**0**	**0.2**	**0**	**0.4**	**0.6**	**0.7**	**0**	**0**	**0**	**0.9**	**0**	**1.2**	**0.9**	**0**	**0**
Other finds																																		
Pumice stone?											1																							
modern rootlets						P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P		P	P	P		P	P	P	P
Modern seeds						P	P		P	P	P	P		P		P			P	P		P	P	P	P			P	P	P	P		P	P
Modern cereal straw						P	P	P		P	P	P	P	P				P	P	P	P		P		P	P	P	P	P	P	P	P	P	P

Table 1.1: Plant macro-remains from Tăşnad Sere, Square A

Tasnad Sere – year	**2014**	**2013**	**2014**	**2015**	**2012**	**2014**	**2014**	**2015**	**2014**	**2014**	**2015**	**2012**	**2014**	**2015**	**2014**	**2014**	**2014**	**2015**	**2015**	**2014**	**2015**	**2014**	**2014**
Square/Spit		D1	D1/7	D1/8	D2/3	D2/6	D2/7	D2/8	D3/6	D3/7	D3/8	D4/3	D4/4	D4/8	D5/4	D5/6	D5/7	D5/8	D5/9	D6/7	D7/9	D8/4	D8/8
Context	5	5	5		4/5	5	5	5	5	5		5	5		5	5	5		5	5		5	5
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Charcoal >4mm		- -	-			-	-		-	-		-	- -		-								
2-4mm	-	- -	-	-	- -	- -	- -	-	- -	- -			- -		-		- -					- -	-
<2mm	+	++	++	+	- -	++	+	+	+++	++	+	+	+	-	+	+	+	+	+	+	- -	+	++
volume (ml)	1	1	0.5	0.5	0.5	1	0.5	1	1	0.5	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cereals																							
cf. *Hordeum vulgare*						1																	
Cerealia fragments	1												6		1	3	1						
Total grains*	1	0	0	0	0	1	0	0	0	0	0	0	2	0	1	1	1	0	0	0	0	0	0
Preservation index – mean	0					2							0		0	0	0						
Fragmentation index	N/A					0							N/A		N/A	N/A	N/A						
T.dicoccum glume base				1																			
T.mono./dicoccum gl. base																1							
Triticum sp. glume base	2			1						3			1			1						2	
Total glume bases	2	0	0	1	0	0	0	0	0	3	0	0	1	0	0	2	0	0	0	0	0	2	0
Glume base:grain ratio	2	/	/	N/A	/	0	/	/	/	N/A	/	/	0.5	/	0	2	0	/	/	/	/	N/A	/
Wild/Weed seeds																							
Indeterminate seed									1		1							1					
Non-cereal P.I. - mean									0		0							0					
Grain:seed ratio	N/A	/	/	/	/	N/A	/	/	0	/	0	/	N/A	/	N/A	N/A	N/A	0	/	/	/	/	/
Seed density	**0.1**	**0**	**0**	**0**	**0**	**0.1**	**0**	**0**	**0.1**	**0**	**0.1**	**0**	**0.2**	**0**	**0.1**	**0.1**	**0.1**	**0.1**	**0**	**0**	**0**	**0**	**0**
№ items/litre (ex. charcoal)	**0.3**	**0**	**0**	**0.1**	**0**	**0.1**	**0**	**0**	**0.1**	**0.3**	**0.1**	**0**	**0.3**	**0**	**0.1**	**0.3**	**0.1**	**0.1**	**0**	**0**	**0**	**0.2**	**0**
Other finds																							
modern rootlets	P	P	P	P	P	P		P		P	P	P	P	P		P		P	P		P	P	P
Modern seeds	P	P	P	P				P		P	P	P	P	P	P	P			P	P			P
Modern cereal straw	P		P	P			P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P

Table 1.2: Plant macro-remains from Tăşnad Sere, Square D

Tasnad Sere – year	**2014**	**2014**	**2015**	**2014**	**2014**	**2016**	**2016**	**2016**	**2013**	**2013**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2013**	**2015**	**2015**	**2016**	**2015**	**2012**	**2015**	**2015**	**2015**	**2016**	**2016**	**2016**	**2015**	**2015**	**2015**	**2012**	**2012**
Square/Spit	A1/4	A1/5	A1/9	A2/7	A3/7	A3/10	A3/10	A3/11	A4/4	A5/5	A5/6	A6/3	A6/4	A6/4	A6/6	A7/3	A8/1	B1/7	B1/7	B1/9	B1/10	B2/8	B3/2	B3/7	B3/8	B3/9	B3/11	B3/12	B3/13	B4/7	B4/8	B4/9	B5/?	B5/2
Context	5	5	5	5	5	5	5, F.4	5	5	5	5	5	5	F.9	F.?	5	5	5	5	?	5	?	?	?	?	5	5	5	5	?	5	5	?	4/ 5
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CharcoaL	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P
Cereals																																		
H. vulgare subsp. v*ulgare*																																		
T.dicoccum																																		
T.monococcum/dicoccum																																		
T. cf. *dicoccum*										1																								
Triticum sp. grain																																		
Cerealia fragments										3	1		4																					
Total grains*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fruits and nuts																																		
Indeterminate nut shell frag.											6																		1					
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Wild/Weed seeds																																		
Amaranthaceae															1																			
Brassicaceae			2																							2				1	1			
cf. *Capsella bursa-pastoris*																																		
Caryophyllaceae																		2						4	3	1								
Chenopodiaceae		1	1											1				5		2		1		2	2	1								
Cyperaceae																		4						1	2									
Fabaceae																																		
Linaceae										1																								
Poaceae, wild <2mm																															1			
Polygonaceae																									2									
cf. *Trifolium* sp.					1																													
Vitaceae																																		
Indet. seed (frag.)					1		1				5 (4)														2	3								
Total seeds	**0**	**1**	**3**	**0**	**2**	**0**	**1**	**0**	**0**	**1**	**9**	**0**	**0**	**1**	**1**	**0**	**0**	**11**	**0**	**2**	**0**	**1**	**0**	**7**	**11**	**7**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**
Grain:seed ratio	**/**	**0**	**0**	**/**	**0**	**/**	**0**	**/**	**/**	**2**	**0.1**	**/**	**N/A**	**0**	**0**	**/**	**/**	**0**	**/**	**0**	**/**	**0**	**/**	**0**	**0**	**0**	**/**	**/**	**/**	**0**	**0**	**/**	**/**	**/**
Grain/Seed density																																		
№ items/litre (ex. charcoal)																																		
Other finds																																		
Indet. vascular tissue			P						P	P	P		P			P		P											1					
Charred bone		P									P																							
Pottery/daub					P				P					P						P				P										
Obsidian			P																															
Flint debitage																																		
Intrusive modern vegetation	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Table 1.3: Plant macro-remains from Tăşnad Sere. Flots sorted by Ms. A. Leon (Institute of Archaeology, UCL)

Table 1.3 continued

Tasnad Sere – year	**2013**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2015**	**2012**	**2015**	**2015**	**2015**	**2013**	**2013**	**2015**	**2015**	**2013**	**2015**	**2015**	**2013**	**2015**	**2015**	**2013**	**2013**	**2015**	**2012**	**2013**	**2015**	**2015**	**2015**	**2013**	**2015**	**2015**	**2013**	**2013**	**2015**
Square/Spit	B5/6	B5/8	B6/7	B6/8	B7/6	B7/7	B7/8	B7/9	B8/?	B8/7	B8/8	B8/9	C1/6	C1/7	C1/8	C1/9	C2/7	C2/8	C2/9	C3/6	C3/8	C3/9	C4/6	C4/7	C4/8	C5/2	C5/7	C5/8	C5/9	C6/6	C6/7	C6/8	C6/9	C7/5	C7/6	C7/8
Context	5	?	?	5	5	5	5	5	4	5	5	?	5	5	5	5	5	?	5	5	5	?	5	5	5	4/ 5	5	?	?	5	?	5	?	5	5	?
Sample volume (L)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	20	10	10	10	10
CharcoaL			P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Cereals																																				
H. vulgare subsp. v*ulgare*																																				
T.dicoccum																																				
T.monococcum/dicoccum																																				
T. cf. *dicoccum*																																				
Triticum sp. grain																																				
Cerealia fragments																															1					
Total grains*	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Fruits and nuts																																				
Indet. nut shell frag.																				1														1		
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Wild/Weed seeds																																				
Amaranthaceae					1																1															
Brassicaceae			1										16	1							3											4				1
cf. *Capsella bursa-pastoris*																									1											
Caryophyllaceae													>70	1						1														1		
Chenopodiaceae		1		2	1		2						>40	2		3				3	2	1						1						4		
Cyperaceae		1																																		
Fabaceae														1																						
Linaceae																																				
Poaceae, wild <2mm																				1																
Polygonaceae		3											>26							1													1	1		
cf. *Trifolium* sp.																																				
Vitaceae																																				
Indet. seed (frag.)		1			1				1			1	1						4		2	2												1		1
Total seeds	**0**	**6**	**1**	**2**	**3**	**0**	**2**	**0**	**1**	**0**	**0**	**1**	**>153**	**5**	**0**	**3**	**0**	**0**	**4**	**6**	**8**	**3**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**1**	**7**	**0**	**2**
Grain:seed ratio	**/**	**0**	**0**	**0**	**0**	**/**	**0**	**/**	**0**	**/**	**/**	**0**	**0**	**0**	**/**	**0**	**/**	**/**	**0**	**0**	**0**	**0**	**/**	**/**	**0**	**/**	**/**	**0**	**/**	**/**	**N/A**	**0**	**0**	**0**	**/**	**0**
Grain/Seed density																																				
№ items/litre (ex. charcoal)																																				
Other finds																																				
Indet. vascular tissue				P	P											P	P		P	P	P	P	P	P			P				P			P		P
Charred bone					P																														P	
Pottery/daub												P	P	P																						
Obsidian													P							P	P															
Flint debitage																																				
Intrusive modern vegetation		P	P	P	P	P	P		P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Table 1.3 continued

Tasnad Sere – year	**2012**	**2013**	**2013**	**2015**	**2015**	**2013**	**2013**	**2015**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2015**	**2012**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2014**	**2012**	**2014**	**2014**	**2012**	**2014**	**2012**	**2014**	**2012**	**2012**	**2012**	**2012**	**2016**	**2016**	**2016**
Square/Spit	C8/3	C8/6	C8/7	C8/8	C8/9	D1/9	D2/6	D2/8	D4/6	D5/5	D6/4	D6/5	D6/6	D7/5	D7/6	D8/9	E1/?	E1/7	E2/7	E3/6	E3/7	E4/5	E4/6	E4/7	E5/3	E5/4	E5/5	E6/2	E6/5	E7/2	E8/6	F6/3	G3/6	H5/6	H7/6	ZZ1/3	ZZ2/2	ZZ2/3
Context	?	5	5	?	5	?	5	5	5	5	5	5	5	?	5	?	4/ 5	5	5	5	5	5	?	5	4/ 5	5	5	4/ 5	5	?	5	5	?	4/ 5	4 /5	5	4/ 5	4/ 5
Sample volume (L)	10	10	10	10	6	10	10	10	10	10	10	10	10	10	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CharcoaL	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Cereals																																						
H. vulgare subsp. v*ulgare*																																						
T.dicoccum																																						
T.monococcum/dicoccum																																						
T. cf. *dicoccum*																																						
Triticum sp. grain																																						
Cerealia fragments							1																															
Total grains*	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fruits and nuts																																						
Indet. nut shell frag.													1			1																						
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Wild/Weed seeds																																						
Amaranthaceae																																						
Brassicaceae																																						
cf. *Capsella bursa-pastoris*																																						
Caryophyllaceae		1																1																				
Chenopodiaceae					3													1			1										1							
Cyperaceae																																						
Fabaceae																																						
Linaceae																																						
Poaceae, wild <2mm		1																																				
Polygonaceae		1																																				
cf. *Trifolium* sp.																																						
Vitaceae																																						
Indet. seed (frag.)			1						1				4		1																							
Total seeds	**0**	**3**	**1**	**0**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**0**	**1**	**0**	**0**	**2**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Grain:seed ratio	**/**	**0**	**0**	**/**	**0**	**/**	**N/A**	**/**	**0**	**/**	**/**	**/**	**0**	**/**	**0**	**/**	**/**	**0**	**/**	**/**	**0**	**/**	**/**	**/**	**/**	**/**	**/**	**/**	**/**	**/**	**0**	**/**	**/**	**/**	**/**	**/**	**/**	**/**
Grain/Seed density																																						
№ items/litre (ex. charcoal)																																						
Other finds																																						
Indet. vascular tissue			P				P			P			P		P	P		P			P		P	P			P					P						
Charred bone			P						P																	P												
Pottery/daub										P									P				P	P		P	P		P		P	P	P					
Obsidian															P	P										P			P									
Flint debitage		P																																				
Intrusive modern vegetation	P	P	P	P	P	P	P	P		P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P

Sample N°	Original N°	Volume (L)	Feature	Context	Exc. Layer	Description
1	1	10	3	J103	11	
2	2	10	2a	J105	11	Oven
3	4	10	2a	J105	11	Oven
4	5	10	2a	J106	11	Oven
5	6	10	2b	J106	11	soil from the group of vessels, pit dwelling
6	8	10	2b	J106	13	
7	9	10	6	J102-103	12	Semi-circular zone of dark brown sediment in the middle of the feature
8	10	10	6	J102-103		from the bottom of the feature
9	11	10	2b		16 (base)	
10	12	10	2b			bottom of the feature

Table 1.4: Contexts sampled at AtII

Sample	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**	
	LF	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**
Feature	3		2a		2a		2a		2b		2b		6		6		2b		2b	
Sample volume (L)	10		10		10		10		10		10		10		10		10		10	
Charcoal >4mm		- -	-	+		+		- -	-	+		- -	- -	- -		- -	-	- -		- -
2-4mm	+	+	+	++	- -	++	-	+	+	+	- -	- -	+	+	- -	- -	- -	+	- -	- -
<2mm	+++	+	+++	+++	+++	+++	++	+++	+++	+++	++	+	+++	++	++	++	+++	+++	++	++
volume (ml)	1.5	1	2	4	1	4	0.5	2	2	2.5	0.5	1	1.5	1.5	0.5	1	0.5	3.5	0.5	2
Cereals																				
Hordeum vulgare ssp. *vulgare*			1				2	2	6	1									6	
cf. *H. vulgare* ssp. *vulgare*	1			1	1				1										3	
Triticum monococcum L. 1-grain																	2			
T. monococcum/dicoccum	2		2						1											
T. cf. *timopheevi* Zhuk.						1														
T. dicoccum/timopheevi									2					1						
Indet. glume wheat					1		2		1	2	1	1			2		3			
Triticum spp.						1		1								1				
Indeterminate cereal grain	6	3	6	3	4	1		5	11	1		1	2	1			5		3	1
Indet. cereal grain fragments	16	3	45	18	27	5	27	15	153	7	12		19	1	11		41	31	31	8
WGE (1 = 0.0133g)	3		4		4		7		10		2		2		1		8		7	
Total grain	**15**		**17**		**23**		**19**		**36**		**5**		**6**		**4**		**18**		**20**	
Preservation index – mean	0.3		0.4		0.3		0.6		0.8		0.6		0.3		0.8		0.7		0.8	
mode	0		0		0		0		0		1		0		1		0, 1		0	
Fragmentation index	1.6		4.8		1.7		3.5		6.2		4		6		3.7		7.2		3	
T. monococcum glume base	2																	1		
T. monococcum spikelet fork	2									1			1							
T. mono./dicoccum gl. base			1						1											
T. mono./dicoccum sp. fork		1							1		2									
Indet. glume wheat gl. base	2				1				1				5		1					
Indet. glume wheat sp. fork	1								1				1							
Total glume bases	**10**		**1**		**1**		**0**		**8**		**4**		**9**		**1**		**1**		**0**	
Glume base : grain ratio	**0.7**		**0.07**		**0.05**		**0**		**0.3**		**0.8**		**1.5**		**0.25**		**0.06**		**0**	
Panicum cf. *miliaceum* L.			1																	
Fruits and nuts																				
Physalis alkakengi L.					1								1		1					
Prunus sp. whole equivalent						1														
Sambucus ebulus L.					1		1						1							
Indet. fruit stone fragments*	1							1						7						1
Total (* counted as 1)	**1**		**0**		**3**		**2**		**0**		**0**		**3**		**1**		**0**		**1**	
Wild / Weed seeds																				
Odontites/Euphrasia sp.									1											
Setaria verticillata/viridis spp.									1											
Veronica hederifolia L.																			1	
Large wild grass seeds (>4mm)			1						1								1			
Wild grass frags, whole equiv.							1													
Indeterminate seed	1												1						1	
Total	**1**		**1**		**0**		**1**		**3**		**0**		**1**		**0**		**1**		**2**	
Grain:seed ratio	15		17		N/A		9.5		13		N/A		6		N/A		18		10	
Gl. base : seed ratio	7		1		N/A		0		2.7		N/A		9		N/A		1		0	
Non-cereal P.I. – mean	0		1		1.3		1		0.7		/		1.3		2		0		1.3	
mode	0		1		1		2,1,0		1		/		2		2		0		1	
Grain/Seed density (excl. chaff)	**1.7**		**1.9**		**2.6**		**2.2**		**3.9**		**0.5**		**1**		**0.5**		**1.9**		**2.3**	
Indet. food/parenchyma frag.	7						1													
№ items / litre (excl. charcoal)	**3.1**		**2**		**2.7**		**2.3**		**4.7**		**0.9**		**1.9**		**0.6**		**2**		**2.3**	
Other finds																				
Broken fish scale					1								1						4	
Intrusive modern seeds	P		P		P		P		P		P		P		P		P		P	
Intrusive rootlets	P		P		P		P		P		P		P		P		P		P	

Table 1.5: Plant macro-remains from AtII

1.3 Potporanj – Kremenjak (Chapter 7.3; Pantović unpublished-b)

The Middle/Late Neolithic site of Potporanj was first recognised in 1882 by Mr. F. Milleker, then curator of the Vršac museum, who collected tens of thousands of artefacts from both Potporanj and At. The first excavations began in 1899, during which a vast collection of extraordinary artefacts firmly endorsed Potporanj as an important Vinča settlement (Milleker 1938, cited in Pantović unpublished). The site, for instance, holds the largest assemblage of obsidian within the Vinča territory. In 1957 Mr. O. Brukner, then curator of the Vršac museum, conducted rescue excavations in advance of the Danube-Tisza-Danube (DTD) canal, which was constructed along an ancient river bed on the eastern edge of Potporanj (Brukner 1960, cited in Pantović unpublished). The canal cut through the site, destroying at least 20ha of archaeological deposits. The exposed section and five additional trenches revealed burnt rectangular houses that suggested that this part of the settlement had been abandoned after a destructive conflagration (Brukner 1960, cited in Pantović unpublished). In 2011 Ms. I. Pantović resumed excavations under the auspices of the City Museum of Vršac. Eleven 10L bulk soil samples were taken in 2014, and processed for plant macro-remains. Results from the analysis of the flots are presented in Table 1.6.

Sample	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**		**11**	
	LF	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**
Layer/Square or Ditch	13/D		14/Ditch 2		14/Ditch 2		15/E		16/D		16/B		16/F		17/A		17/D		17/D		17/B	
Sample volume (L)	10		10		10		10		10		10		10		10		10		10		10	
Charcoal >4mm	- -	- -	-	+	- -	+		+	- -	+	-	+	- -	+	-	- -	- -	- -	- -	+		- -
2-4mm	+	+	+	+	+	+	+	++	+	++	+	++	+	+	- -	+	- -	++	+	++	-	+
<2mm	++	+	+++	++	+++	- -	+++	++	+++	++	+++	++	+++	++	++	++	++	++	++	++	++	++
volume (ml)	2	4	5	4	1	1	2	15	3	8	4	11	4	4	1	4	1	10	1	10	0	1
Cereals																						
Triticum monococcum L. 1-grain				1	3		5	5	14	9	2		2	1		1	4	3	6	4	6	3
T. monococcum (1 or 2-grained)						1		1	2	5	1			1			5	1	2	3	1	
Triticum dicoccum Schübl.			1				8		29	2			6		3		6	1	2	2		1
T. monococcum/dicoccum			4		2		11	5	23	5	3		6		6		2	1	8	4	4	
T. cf. *timopheevi* Zhuk.			1												1					1	1	
Indeterminate glume wheat	3			6			7	3	18	24	6		2	3	3	3	15	1	7	1	2	2
Indeterminate wheat			1						26	11	3	1	7	2	2		2		4		3	
Indeterminate cereal	3			1			6	4	36	4	4			1	1				3	1		
Indet. cereal grain fragments	3		14				14	4	536	29	83		123	2	84		132	10	121	11	10	7
WGE (1 = 0.0133g)	1		4				4		57		9		15		8		18		13		4	
Total grain	**7**		**19**		**6**		**59**		**265**		**29**		**46**		**28**		**66**		**57**		**27**	
Preservation index – mean	0.4		1.1		2.2		1.3		1		0.7		1		1.1		1.1		1.3		1.5	
mode	0		1		2		2		1		0		1		0		1		1		1	
Fragmentation index	0.5		0.9		0		0.3		2.7		4.2		4		10.5		3		3		0.7	
T. monococcum gl. base			3	3	2			1	5	3	9	1	6			3	6	3	11	16	1	2
T. monococcum sp. fork		2	3	5	6		1	3	15	5	5	1	12	3	3	1	14	10	26	170	1	1
T. dicoccum gl. base																				5		
T. dicoccum sp. fork										2										4		
T.dicoccum/timopheevi gl. base																				16		
T.dicoccum/timopheevi sp. fork																1		3	1	18		
Triticum sp. gl. base	2	1	9	6	6		5	2	6	1	13		17	2	4	1	53	36	102	110	5	2
Triticum sp. sp. fork			3	2				3	10		1		3	4	3	4	6	36	13	115		
T. aestivum/durum rachis																			1			
Total glume bases	**7**		**48**		**20**		**22**		**79**		**37**		**69**		**22**		**212**		**954**		**14**	
Glume base : grain ratio	**1**		**2.5**		**3.3**		**0.4**		**0.3**		**1.3**		**1.5**		**0.8**		**3.2**		**16.7**		**0.5**	
Silicified cereal awn fragments																			+++			
Glume wheat rachis internode																			+			

Table 1.6: Plant macro-remains from Potporanj (continued below)

Sample	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**		**11**	
Lentil, fruits and nuts																						
Lens culinaris Medik.	1			1	1		5,1cf.	14	1cf.	5			1	4	1	1				3		2
Cornus mas L. whole equivalent							5				3		2				3		2		2	
Corylus avellana L. shell frags.								10				4		1				3				2
cf. *Fragaria vesca* L.											1											
Physalis alkakengi L.							7		4		8		2				4		6		2	
Prunus cf. *spinosa*, whole equiv.																				3		
Prunus sp., whole equiv.										1				1				1				
Sambucus ebulus L.									2	1	6				1		3		1		2	
Indet. fruit stone fragments*														5		1		6		2		
Mericarp/ fruit flesh fragments*															2							
Total (*counted as 1)	**1**		**1**		**1**		**42**		**14**		**22**		**12**		**5**		**15**		**16**		**10**	
Wild/Weed seeds																						
Ajuga /Teucrium spp. Big	1														1		1		2		2	
Anthemis arvensis L. SHF			1 cf.				1															
Bromus sp. BFH							19		38	3	2		3						4		2	
Carex sp. Large lenticular, BFH											3						1					
Carex sp. Small trilete, SFH											1											
Chenopodium album L. SFH			1		2						54		5		4				17		8	
Chenopodium hybridum L. BFH											1											
F. convolvulus (L.) Á Löve BFH	1		1,2M		1		2		4		30		1		1		1,1M		2		1 cf.	
Galium aparine L. BFH								1														
Lamiaceae, type 1 Small															1							
Lamiaceae, type 2 Small																					1	
Lapsana communis L. BFH							1				1											
Linum catharticum L. SHH																	1,1cf.					
Polygonum sp. BFH											5		1									
Polygonum/Rumex sp. BFH									2	1	5						1					
Prunella vulgaris L. SFH																			1		1 cf.	
Setaria verticillata/viridis SFH											7				1							
Trifolium spp. SFH											8						6		1			
Trifolium/Medicago sp. BFH																			1			
Large wild grass (>4mm) BFH	1		1		3			1	3	1	1		2		1			1	1	2	2	
Medium grass (2-4mm) SFH			1				1		1													
Small wild grass (<2mm) SFH	1		1								1										1	
Wild grass seed fragments					+		+		+		- -		- -		-		- -	-				
Domesticated/wild grass, SFH	2						1	2	3		1	1										
2-4mm cotyledon, whole equiv.										2												
Indeterminate seed	1				3		3		1	2	8		2				3		1			

Table 1.6 continued

Sample	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**		**11**	
Total seeds	**6**		**8**		**9**		**32**		**61**		**129**		**14**		**9**		**17**		**32**		**18**	
Total seeds (Fathen excl.)	7		7		7		32		61		75		9		5		17		15		10	
Grain:seed ratio	**1**		**2.4**		**0.7**		**1.8**		**4.3**		**0.2**		**3.3**		**3.1**		**3.9**		**1.8**		**1.5**	
Gl. base:seed ratio	**1**		**6**		**2.2**		**0.7**		**1.3**		**0.3**		**4.9**		**2.4**		**12.5**		**29.8**		**0.8**	
Non-cereal P.I. – mean	1		1.3		1.1		1.9		2.2		1.9		1.6		1.6		1.5		1.9		1.9	
mode	1		1		1		2		3		2		2		1, 2		1, 2		2		2	
Grain/Seed density (ex. chaff)	**1.5**		**2.8**		**1.6**		**13.3**		**34**		**18**		**7.2**		**4.2**		**9.8**		**10.5**		**5.5**	
Indet. charred bud																			1			
charred wild grass awn							1															
Indet. Fruit base/ pedestal													2									
Indet. food/parenchyma frag.			2		1		9															2
№ items / litre (excl. charcoal)	**2.2**		**7.8**		**3.7**		**16.5**		**41.9**		**21.7**		**14.3**		**6.4**		**31**		**106.1**		**7.1**	
Other finds																						
Charred fish bone							1															
Charred rodent faeces							1															
Obsidian chip, 4mm long												1										
Reed/straw impressions																						- -
Intrusive modern seeds	P				P		P		P		P		P		P		P		P		P	
Intrusive modern straw	P		P		P						P		P				P		P		P	

Key: SFH = small, free, heavy; BFH = big, free, heavy (Chapter 5.1.3.2)

1.4 EUROFARM excavations (Chapter 7.4)

The three sites mentioned but not discussed in Chapter 7 are described below. Bulk soil samples were processed using a Siraf-type flotation tank (Williams 1973). A 300µm mesh was used to collect the flots from the Laminski sites, and a 250µm mesh was used to collect those from Kosjerovo. Heavy residues were retained in a 1mm mesh. Between samples the water level in the tank was dropped and a net used to collect any residues on the surface. The tank was also completely emptied and cleaned between sites to avoid contamination. Both flots and heavy residues were left to dry away from direct sunlight. Results from the analysis of the flots are presented in Tables 1.7 to 1.10 located after the site descriptions.

1.4.1 Laminski Jaružani (Pandžić & Vander Linden 2015: 149-50)

The site lies on the northern bank of a meander of the Matura, a tributary of the Sava river. In 2012 a 2x2m test pit was excavated by Prof. C. French and Mr. T. Rajkovača, but no clear indication of an occupation was recovered. In March 2014 two fields either side of the Matura were surveyed and two 2x1m test pits (TP3, TP4), set at a 25m interval on a roughly E-W axis, were excavated in the field North of the Matura where augering boreholes had revealed the presence of a buried soil. The test pits were excavated in artificial spits and two bulk soil samples of the buried soil were taken from each pit, equating to 144 litres of soil. The pottery finds from within the *c*.10cm thick buried soil suggest a Late Neolithic date.

1.4.2 Laminski Jaružani Njiva (Pandžić & Vander Linden 2015: 151-52)

This site was discovered about 1km East-South-East of *Laminski Jaružani*, and on the same meander of the Matura. It lies on a gravel terrace bordered on its northern edge by a paleochannel located at the bottom of TP9. Initially, two 2x1m test pits were opened (TP7, TP8), 25m apart following the E-W axis of the slope. After the discovery of a horizon rich in archaeological finds, and taking into account the buried soil located via the auger transects, a further 2x1m test pits were opened (TP9, TP10). TP10 was positioned in between and equidistant to test pits 7 and 8, whilst TP9 was placed 20m North-East of TP7. Two bulk soil samples were taken from the buried soil, one from TP7, the other from TP9, equating to a total of 56 litres of soil[1]. The pottery and lithic finds suggest a Late Neolithic date.

1.4.3 Kosjerovo (Pandžić & Vander Linden 2015: 152-57; Vander Linden *et al*. unpublished)

The Middle/Late Neolithic site was found on a very low ridge in an otherwise flat landscape of cultivated fields, about 1km West of the modern course of the Vrbas river. It lies *c*.9km to the

---

[1] The night before the excavations I slipped off an unlit staircase, tearing the ligaments in my left foot, and was therefore unable to be on site to direct sampling procedures.

North-East of the modern town of Laktaši and *c*.200m East of a barrow, possibly dating to the Bronze Age. Much like Kočićevo, the site lay on a gravel ridge with a well developed soil in a hydrologically active landscape (Marriner *et al.* 2015). Boreholes undertaken in 2012 by Prof. C. French and Mr. T. Rajokovača revealed the presence of a buried soil and when the fields were surveyed in March 2014 a high density of prehistoric ceramics and flints were noted within the plough soil. Two test pits were therefore opened: TP13 a 4x1m on a roughly aligned North-South axis, and TP14 a 2x2m *c*.20m East of TP13. In TP14 however, a short profile was exposed of a well developed modern soil upon degrading sand. Plant macro-remains from samples 10 and 13 taken from TP14 may therefore be modern. Two bulk soil samples were taken from the upper level (sample 9) and lower level (sample 11) of the buried soil in TP13. A third bulk soil sample (sample 12) was taken from what appeared to be ditch-like feature beneath the buried soil. A total of 77 litres of soil was floated in March 2014.

In March 2015 three larger trenches were opened. Trench 3000, 4x2m, was opened immediately to the North of TP13. Unfortunately archaeological layers had been extensively disrupted by a modern feature containing Medieval pottery and drainage pipe fragments. Samples were therefore not retrieved. Trench 4000, 5x4m, was positioned 15m further North. It was subdivided into 1x1m squares using letters M to Q (from East to West), and numbers 1 to 4 (from North to South). "After removal of the plough horizon as a single unit, excavations proceeded by arbitrary 20cm spits, unless specific archaeological layers were observed and then excavated as such" (Vander Linden *et al.* unpublished). The buried soil was uncovered about 30cm beneath the plough soil and radiocarbon dated to the Middle/Late Neolithic from animal bones (4561-4444 cal. BC, 4686-4488 cal. BC, 4856-4719 cal. BC and 5231-5052 cal. BC but without any stratigraphic coherence). Initially I took 20 litres of soil from every other square (samples 1-6). However, after it had become clear that the sticky silt was slow and difficult to float, and that discreet archaeological features were unlikely, the sampling strategy was adapted. Fifteen litres of soil were then taken from every excavated spit (not all squares were excavated to the same depth) to explore potential concentration differences within the buried soil (samples 7-25). The latter strategy was also adopted in Trench 5000, 5x2m, opened a metre South of Trench 4000 after layers rich in material culture had been uncovered. Trench 5000 was subdivided into 1x1m squares using letters M to Q (from East to West), and numbers 6 and 7 (from North to South), and the same excavation procedure followed. A total of 400 litres of soil were floated from trenches 4000 and 5000. Samples were also taken for the physical, chemical and micromorphological analyses of the buried soil (Marriner *et al.* 2015; Veal 2015). These indicate that the soil developed under stable climatic conditions with only minor alluvial flooding. The Neolithic occupation is clearly visible in the enriched concentration of trace elements within the soil, which, once abandoned and covered, appears to have suffered few physical post-depositional disruptions (Marriner *et al*. 2015; Veal 2015). However, the higher fragmentation rate of ceramic finds in the upper levels does indicate some post-depositional disturbance, namely by more recent ploughing (Vander Linden *et al*. Unpublished).

Table 1.7: Sites and contexts sampled during the EUROFARM excavations

Site	Year	Tr.	Sq.	Fture	Date (cal. BC)	Sample	Vol. (L)	Context	Description
Kočićevo	2012		A15		Neo/BA	1	3	1074	mottled yellow sand – riverbank
	2012		A14		BA?	2	10.5	1070	wattle (?) fragment
	2012		Z14		Neo/BA	3	8	1130	20-40cm below plough soil, mixed by ancient plough ('overbank')
	2012		A15		Neo/BA	4	1.5	1131	40-80cm below plough soil, 'overbank' horizon
	2012		B15		Mid-Late Neo	**5**	3	1132	buried soil, 80-120cm below plough soil
	2012		A12		Mid-Late Neo	**6**	5	1132	buried soil, 80-120cm below plough soil
	2012		A13		Mid-Late Neo	**7**	1.5	1132	buried soil, 80-120cm below plough soil
	2013				Neo/BA	8	1.5	1153	0-20cm below plough soil, 'overbank' horizon
	2013				Mid-Late Neo	**9**	6	1157	soil adjacent to human bones found *c*.40cm below the plough soil
	2013				Mid-Late Neo	**10**	3	1166	'overbank' horizon, 50-60cm below the plough soil
	2013			9	Mid-Late Neo	**11**	8	1193	southern upper fill of F.9
	2013			8	Mid-Late Neo	**12**	9	1194	southern fill of F.8
	2013			13	Mid-Late Neo	**13**	9	1195	southern fill of F.13
	2013			11	5000-4827	**14**	7	1196	NE upper fill of F.11
	2013			2	unsure	**15**	9	1197	southern fill of F.2
	2013			12	Mid-Late Neo	**16**	7	1198	NE fill of F.12
	2013			7	Mid-Late Neo	**17**	4	1199	SW fill of F.7
	2013			6	Mid-Late Neo	**18**	3	1200	SW fill of F.6
	2013			14	Mid-Late Neo	**19**	7	1203	fill of F.14
	2013			15	Mid-Late Neo	**20**	2	1206	southern fill of F.15
	2013			16	Mid-Late Neo	**21**	7	1209	fill of F.16
Laminski Jarużani	2014	3			Late Neo?	1	41	1205	Buried soil
	2014	4			Late Neo?	2	39	1303/4	Buried soil
	2014	4			Late Neo?	3	36	1305	Buried soil
	2014	3			Late Neo?	4	28	1207	Buried soil
L.Jaružani Njiva	2014	7			Late Neo?	6&7	20	1602/3	Buried soil
	2014	9			Late Neo?	8	36	1809/10	Buried soil
Kosjerovo	2014	13			Neo/BA	9	22	2202/3	Buried soil, 30-50cm below plough soil
	2014	13			1400-1250	11	12	2203	Buried soil, 40-50cm below plough soil
	2014	13			Late Neo	**12**	12	2206	shallow feature detected below the buried soil
	2014	14			modern?	10	24	2303	40-60cm deep, degraded parent material
	2014	14			modern?	13	7	2303	discreet daub (?) and surrounding burnt soil within 2303
	2015	4000	N2		Mid-Late Neo	**1**	20	4007	Buried soil, dark grey silt
	2015	4000	P2		Mid-Late Neo	**2**	20	4017	Buried soil, light beige grey sandy silt
	2015	4000	M2		Mid-Late Neo	**3**	20	4019	Buried soil, light beige grey sandy silt
	2015	4000	N2		Mid-Late Neo	**4**	20	4020	Buried soil, light beige grey sandy silt
	2015	4000	Q3-4		Mid-Late Neo	**6**	20	4024	Buried soil, light beige grey sandy silt
	2015	5000	N6-7		Mid-Late Neo	**5**	15	5003	Buried soil, dark grey silt
	2015	5000	O6		Mid-Late Neo	**7**	15	5004	Buried soil, dark grey silt
	2015	5000	O7		Mid-Late Neo	**8**	15	5005	Buried soil, dark grey silt
	2015	4000	P3		Mid-Late Neo	**9**	15	4025	Buried soil, light beige grey sandy silt
	2015	4000	P4		Mid-Late Neo	**10**	15	4025	Buried soil, light beige grey sandy silt
	2015	5000	P6		Mid-Late Neo	**11**	15	5006	Buried soil, dark grey silt
	2015	5000	P7		Mid-Late Neo	**12**	15	5007	Buried soil, dark grey silt
	2015	4000	O3		Mid-Late Neo	**13**	15	4026	Buried soil, light beige grey sandy silt
	2015	4000	O4		Mid-Late Neo	**14**	15	4026	Buried soil, light beige grey sandy silt
	2015	5000	Q7		Mid-Late Neo	**15**	15	5008	Buried soil, dark grey silt
	2015	5000	Q6		Mid-Late Neo	**16**	15	5009	Buried soil, dark grey silt
	2015	4000	M3		Mid-Late Neo	**17**	15	4027	Buried soil, dark grey silt
	2015	4000	N4		Mid-Late Neo	**18**	15	4027	Buried soil, dark grey silt
	2015	5000	6+M7		Mid-Late Neo	**19**	15	5011	Buried soil, light beige grey sandy silt
	2015	4000	M3		Mid-Late Neo	**20**	15	4028	Buried soil, dark grey silt
	2015	4000	M4		Mid-Late Neo	**21**	15	4028	Buried soil, dark grey silt
	2015	5000	N6		Mid-Late Neo	**22**	15	5012	Buried soil, light beige grey sandy silt
	2015	5000	O7		Mid-Late Neo	**23**	15	5013	Buried soil, light beige grey sandy silt
	2015	5000	P6		Mid-Late Neo	**24**	15	5014	Buried soil, light beige grey sandy silt
	2015	5000	Q7		Mid-Late Neo	**25**	15	5015	Buried soil, light beige grey sandy silt

Site	**Laminci-Jaružani** (L.Neo?)				**Donje Dubrave** (BA?)	**L. Jaružani Njiva** (L.Neo?)		**Kosjerovo** (only sample 12 is included in Chapter 8)				
Sample	**1**	**2**	**3**	**4**	**5**	**6&7**	**8**	**9**	**10**	**11**	**12**	**13**
Sample volume (L)	41	39	36	28	12	20	36	22	24	12	12	7
Charcoal ≥4mm				-	-					-	-	+
2-4mm	-		-	-	-		-	-		++	+	++
<2mm	+++	++	++	++	+++	++	++	++	++	++	+++	+++
Volume – millilitres	0	0.5	0.5	0.5	2	0	0.5	0.5	0	0.5	2ml.	3ml.
Cereals												
Triticum monococcum L.				1							4	
Triticum sp.									1			
Triticum/Hordeum sp.											3	
Indeterminate cereal grain		1								4		
Indet. cereal grain fragments										18	27	26
WGE (estimated by eye)										12	18	15
Total grains	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**16**	**25**	**15**
mean/L	/	0.03	/	0.04	/	/	/	/	0.04	1.3	2.1	2.1
T. monococcum sp. fork										6	4	
T. monococcum gl. base										18		
T. mono./dicoccum sp. fork										8	9	1
T. mono./dicoccum gl. base											19	
Triticum sp. glume base		1					1					1
Total glume bases	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**46**	**45**	**3**
mean/L	/	0.03	/	/	/	/	0.03	/	/	3.8	3.8	0.4
Gl.base:grain ratio	**/**	**1**	**/**	**0**	**/**	**/**	**/**	**/**	**0**	**2.9**	**1.8**	**0.2**
Panicum miliaceum L.					1							
Pulses and oil seeds												
Fabaceae, large (frags.)										7.5 (78)		
Linum cf. *usitatissimum* L.	1		1	1								
Fruits and nuts												
Cornus mas L. (frags.)	1 (14)											
Corylus sp.							1					
Sambucus sp.								1				
Indet. Mesocarp fragment												1
Total fruits and nuts	**2**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**1**
mean/L	0.05	/	/	/	/	/	0.03	0.05	/	/	/	0.1
Wild/Weed seeds												
Alchemilla sp.			1									
Brassicaceae, 1mm wide												1
Chenopodium album L.	3	1	1				1					
F. convolvulus (L.) Á. Löve				1								
Papaver somniferum L.										4		
Polygonaceae								1				
Rubiaceae									1			
Rumex sp.									1			
Trifolium/Medicago sp.									1			
Indeterminate seed	1		1				1		1	1		
Total wild/weed seeds	**4**	**1**	**3**	**1**	**0**	**0**	**2**	**1**	**4**	**5**	**0**	**1**
Indet. Parenchyma			1									
№ items/litre (ex. charcoal)	**0.17**	**0.08**	**0.11**	**0.11**	**0.08**	**0**	**0.11**	**0.09**	**0.21**	**12.67**	**5.83**	**2.86**
Other finds												
Modern vegetation	P	P	P	P	P	P	P	P	P	P	P	P
Fish bone (scales)										- (-)	(-)	
Charred bone fragments				-						-		+

Table 1.8: Plant macro-remains from sites sampled during EUROFARM excavations in 2014

Sample	**1**	**2**	**3**	**4**	**6**	**9**	**10**	**13**	**14**	**17**	**18**	**20**	**21**	**5**	**7**	**8**	**11**	**12**	**15**	**16**	**19**	**22**	**23**	**24**	**25**
Square	N2	P2	M2	N2	N6-7	P3	P4	O3-4	O3-4	N3	N4	M3	M4	Q3-4	O6	O7	P6	P7	Q7	Q6	M6+7	N6	O7	P6	Q7
Context	4007	4017	4019	4020	4024	4025	4025	4026	4026	4027	4027	4028	4028	5003	5004	5005	5006	5007	5008	5009	5011	5012	5013	5014	5015
Sample volume (L)	20	20	20	20	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Charcoal >4mm	-	-		-								-									-				-
2-4mm	- -	-	- -	+				-	-			-	-		-			-			-	-	-	- -	- -
<2mm	+	+	+	+	- -	-	-	+	+	- -	+	+	- -	- -	- -		- -	+	+	- -	+	-	- -	+	+
volume (ml)	1	1	1	2	0	0	0	0.5	0.5	0	0.5	0.5	0	0	0	0	0	0.5	0	0	1	0	0	0.5	1
Cereals																									
H. vulgare ssp. *vulgare*													2												
Triticum dicoccum Schübl.											1														
T.mono./dicoccum				1								1													
Triticum sp.														1											
Indet. cereal grain frag.													5								1				2
Panicum miliaceum		1																							
Total grains	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**7**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**2**
T.dicoccum sp. Fork																									1
Fruits/nuts																									
Corylus avellana			1					1																	
Sambucus ebulus											1	1	1		1				1						
Wild/Weed seeds																									
Chenopodium album				1																					
Crucianella sp.		1																							
Mentha sp.																								1	
Panicum/Setaria sp.														1											
Trifolium/Medicago sp.												1													
Verbena officinalis			1																						
Medium Poaceae, 2-4mm				2																					
Small Poaceae, <2mm	1																								
Total wild/weed seeds	**1**	**1**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**
№ items/litre (ex. charcoal)	**0.05**	**0.10**	**0.10**	**0.20**	**0**	**0**	**0**	**0.07**	**0**	**0**	**0.13**	**0.20**	**0.53**	**0.13**	**0.07**	**0**	**0**	**0**	**0.07**	**0**	**0.07**	**0**	**0**	**0.07**	**0.20**
Indet. Parenchyma frags.	- -	-	-					-	- -		-		-		-						-	-	-	- -	- -
Modern vegetation	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Table 1.9: Plant macro-remains from Kosjerovo (2015 excavations)

Table 1.10: Plant macro-remains from Kočićevo (continued below)

Excavation season	**2012**						
Sample	1	2	3	4	**5**	**6**	**7**
Sample volume (L)	3	10.5	8	1.5	3	5	1.5
Context	1074	1070	1130	1131	1132	1132	1132
Sq./Fture/cm from plough soil	A15	A14	Z14	A15	B15	A12	A13
Charcoal volume (ml)	0.5	2	5	0.5	0	1	0
Cereals							
H. vulgare ssp. *vulgare*							
Triticum aestivum/durum							
Triticum monococcum L.		1					
T. dicoccum Schübl.		4				6	
T. monococcum/dicoccum							
T. cf. *spelta/dicoccum*		2					
Triticum sp.		1				3	
Triticum/Hordeum sp.	1						
Unidentifiable cereal grains							
Indet. cereal grain fragments		7		1	1	25	
WGE (1 = 0.01825)		1		1	1	3	
Total grains	**1**	**9**	**0**	**1**	**1**	**12**	**0**
Preservation index – mean	1	1.3	/	0	0	1.4	/
mode	1	1	/	0	0	1	/
Fragmentation index	0	0.9	/	N/A	N/A	2.8	/
T. monococcum gl. base							
T. dicoccum gl. base						1	
T. mono./dicoccum gl. base						8	
Triticum sp. glume base		2		5		102	5
Total glume bases	**0**	**2**	**0**	**5**	**0**	**111**	**5**
Glume base:grain ratio	**0**	**0.2**	**/**	**5**	**0**	**9.3**	**/**
Other possible cereals							
Panicum miliaceum L.			3				
Setaria cf. *italica* (L.) Beauv.						1	
Pulses, fruits and nuts							
Pisum sativum L.						1	
Indet. large Fabaceae							
Cornus cf. *mas* L. frag.						1	
Indet. Mesocarp fragment							
Total	**0**	**0**	**0**	**0**	**0**	**2**	**0**
Wild/Weed seeds							
Apiaceae					1		
Bromus sp.							
Chenopodium sp.			1				
Cyperaceae							
Persicaria maculosa Gray.							
Phleum sp.		1					
Polygonaceae							
Rumex sp.							
Thalictrum sp.							
Urtica sp.			1				
Medium wild grass (2-4mm)	1		1				
Indet. Grass seed fragment							
Indeterminate seed		1					
Total wild/weed seeds	**1**	**2**	**3**	**0**	**1**	**0**	**0**
Non-cereal P.I. - mean	1	1	0.7	/	0	/	/
mode	1	2, 0	1	/	0	/	/
Grain:seed ratio	**1**	**4.5**	**0**	**/**	**1**	**/**	**/**
Grain/Seed density	**0.67**	**1.05**	**0.75**	**0.67**	**0.67**	**3**	**0**
Indet. food/parenchyma frag.		48	6	8	6	30	6
№ items / litre (ex. charcoal)	**0.67**	**5.81**	**1.50**	**9.33**	**2.67**	**31.20**	**7.33**

Table 1.10 continued

Excavation season	**2013**													
Sample	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Sample volume (L)	1.5	6	3	8	9	9	7	9	7	4	3	7	2	7
Context	1153	1157	1166	1193	1194	1195	1196	1197	1198	1199	1200	1203	1206	1209
Sq./Fture/cm from plough soil	0-20	20-40	A1-2	F.9	F.8	F.13	F.11	F.2	F.12	F.7	F.6	F.14	F.15	F.16
Charcoal volume (ml)	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0.5	0.5	1	0.5	0
Cereals														
H. vulgare ssp. *vulgare*				1 cf.	1									
Triticum aestivum/durum						1								
Triticum monococcum L.														
T. dicoccum Schübl.	1		1			5		1	1	1				
T. monococcum/dicoccum			1			6				2				
T. cf. *spelta/dicoccum*														
Triticum sp.	2	1	1			2								
Triticum/Hordeum sp.	1								1				2	
Unidentifiable cereal grains						7		1						
Indet. cereal grain fragments	19		4	1	3	14		2	8	8	1	4	4	
WGE (1 = 0.01825)	3		1	1	1	3		1	1	1	1	1	1	
Total grains	**7**	**1**	**4**	**2**	**2**	**24**	**0**	**3**	**3**	**4**	**1**	**1**	**3**	**0**
Preservation index – mean	0.7	1	1	1	1	1.3	/	0.5	1	1	0	0	0.7	/
mode	1	1	1	1, 0	2, 0	1	/	0	1, 2	1	0	0	1	/
Fragmentation index	4.8	0	1.3	0.5	3	0.7	/	1	4	2.7	/	/	2	/
T. monococcum gl. base		2												
T. dicoccum gl. base														
T. mono./dicoccum gl. base											4			
Triticum sp. glume base			2			3		1	3		2		1	
Total glume bases	**0**	**2**	**2**	**0**	**0**	**3**	**0**	**1**	**3**	**0**	**6**	**0**	**1**	**0**
Glume base:grain ratio	**0**	**/**	**0.67**	**0**	**0**	**0.1**	**/**	**0.3**	**1**	**0**	**6**	**0**	**0.3**	**/**
Other possible cereals														
Panicum miliaceum L.														
Setaria cf. *italica* (L.) Beauv.														
Pulses, fruits and nuts														
Pisum sativum L.														
Indet. large Fabaceae									1					
Cornus cf. *mas* L. frag.														
Indet. Mesocarp fragment					1									
Total	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
Wild/Weed seeds														
Apiaceae														
Bromus sp.														1
Chenopodium sp.														
Cyperaceae				1										
Persicaria maculosa Gray.						1								
Phleum sp.														
Polygonaceae					1						1			
Rumex sp.			1						1			1		
Thalictrum sp.			1											
Urtica sp.														
Medium wild grass (2-4mm)			1											
Indet. Grass seed fragment					1									
Indeterminate seed				1					4		1			
Total wild/weed seeds	**0**	**0**	**3**	**2**	**2**	**1**	**0**	**0**	**5**	**0**	**2**	**1**	**0**	**1**
Non-cereal P.I. - mean	/	/	1.3	0.5	0.5	2	/	/	0.2	/	0.5	1	/	2
mode	/	/	1	1, 0	1, 0	2	/	/	0	/	1, 0	1	/	2
Grain:seed ratio	**/**	**/**	**1.3**	**1**	**1**	**24**	**/**	**/**	**0.6**	**/**	**0.5**	**1**	**/**	**0**
Grain/Seed density	**4.67**	**0.17**	**2.33**	**0.5**	**0.56**	**2.78**	**0**	**0.33**	**1.29**	**1**	**1**	**0.29**	**1.5**	**0.14**
Indet. food/parenchyma frag.			12											
№ items / litre (ex. charcoal)	**4.67**	**0.50**	**7**	**0.50**	**0.56**	**3.11**	**0**	**0.44**	**1.71**	**1**	**3**	**0.29**	**2**	**0.14**

1.5 Gradac, Bapska (Chapter 7.6; Burić 2009; 2011; Burić & Težak-Gregl 2009)

The site was first mentioned in the archives of the National Museum in Zagreb in the late 1870s, when a local school teacher and antiquarian, Mr. M. Epner, reported finding numerous Neolithic surface artefacts. With the museum's support Mr. Epner went on to direct excavations during which at least two areas of the site were explored. After Mr. Epner had retired the site continued to generate interest as one of the larger Neolithic settlements in Croatia and was repeatedly excavated between 1911 and the late 1950s by prominent archaeologists of the time: Mr. M. Vohlaski (better known for discovering the tell site of Gomolova, Serbia), Mr. R.R. Schmidt (Director of the Institute of Prehistory, University of Tübingen, between 1921-30 and known for his work on Vučedol, Croatia), Mr. V. Milojčić (chair of the University of Heidelberg between 1958-78 and author of the influential synthetic work *Chronologie der Jüngeren SteinzeitMittel- und Südosteuropas* (1949)), and Mr. S. Dimitrijević (Chair of Prehistoric Archaeology, University of Zagreb, in the 1970s and author of *The Sopot-Lengyel culture* (1968) in which finds from Gradac figure prominently). Both Milojčić and Dimitrijević attributed their deepest excavation layers to the Sopot culture, on top of which were Late Vinča horizons (Vinča C and D). A single radiocarbon date was obtained from Dimitrijević's excavations: 4881-4488 cal. BC.

> “V. Milojčić (1949) and S. Dimitrijević (1968) have written the most about the site, but both only wrote preliminary reports on a select portion of the materials. As ill fate would have it, this preliminary level cannot be improved by re-examining the old finds, as this area was beset by the whirlwind of war in the Balkans, during which most of the artefacts discovered during Dimitrijević’s research were lost or destroyed” (Burić & Težak-Gregl 2009: 85).

1.6 Hermanov Vinograd (Los Unpublished)

The site was first recognised in the late 19th century by the then director of the Museum of Vjekoslav, who surveyed an area of *c.*800m^2. In the 1970s the site was partially destroyed during the construction of the D2 southern bypass of Osijek and the Osijek-Vinkovci rail line, which runs almost perpendicular to the bypass. Small-scale excavations began in 1998, under the direction of Ms. J. Šimić from the Museum of Vojvodina, to record and protect the site from the nearby construction of a sewage plant. Further work took place in 2007, confirming the settlement's importance as one of the larger Sopot tell sites within north-eastern Croatia.

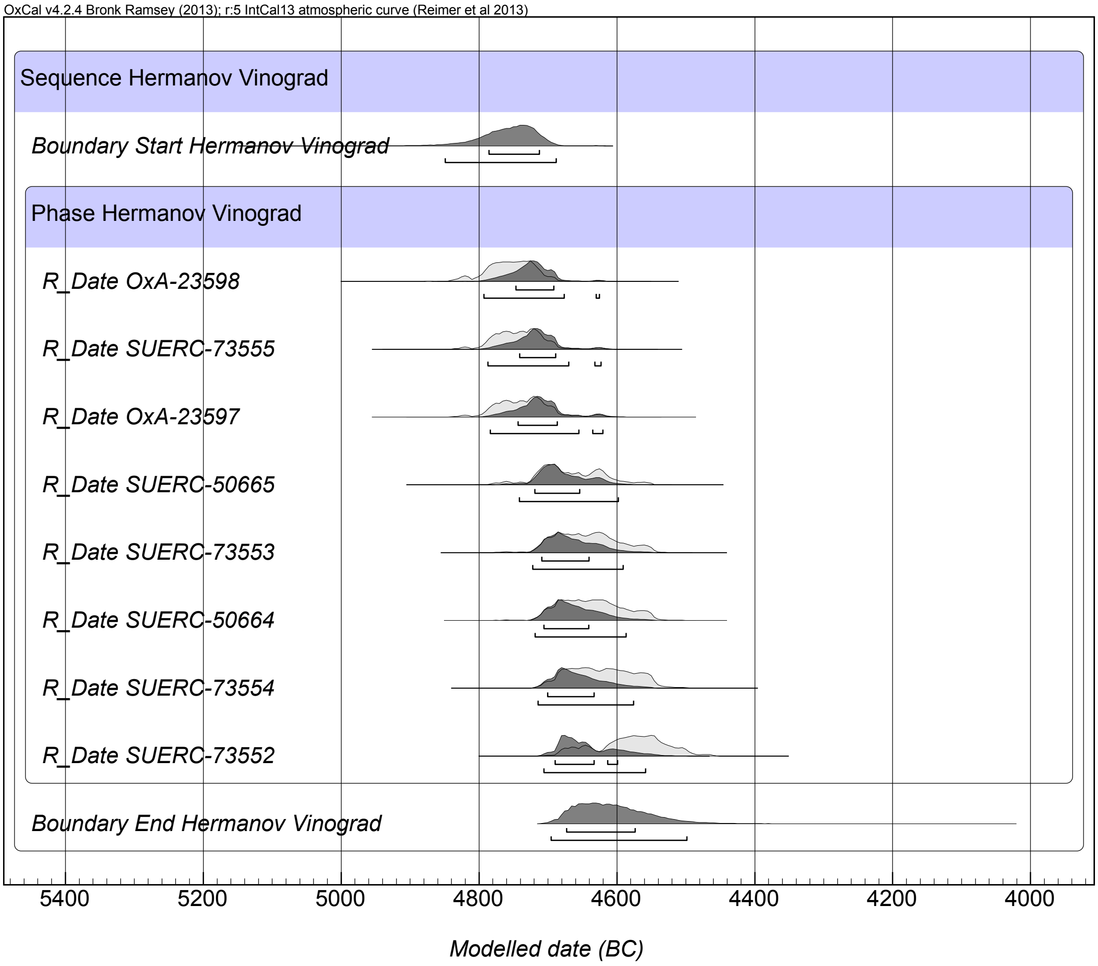


Figure 1: Approximate temporal spans for the occupation of Hermanov Vinograd

Table 1.11: Contexts sampled at Hermanov Vinograd I

Original sample	New sample	Volume (L)	Context	E/W side	Stratigrahic phase	Structure	Description
986	**1**	2	1277	E	7		Pit fill
992	**2**	5	1274	E	6		Canal
1043	**3**	4	1387	W	6		Trampled surface of burnt sandy clay
138	**4**	4	1387	W	6		Trampled surface of burnt sandy clay
1045	**5**	4	1385	W	6		Moat
999	**6**	8	1243	W	6		Post-hole
858	**8**	1	874	E	5		Trampled surface
252	**7**	4	1252	W	5a		Trampled grey surface
827	**9**	10	981	W	5	Grave 1	Fill
1011	**10**	9	1240	W	5	Grave 1	Fill
690	**11**	5	346	W	5	10	Foundation cut
540	**12**	5	441	E	4		Hearth/fire
34	**13**	7	83/87	E	3		Trampled surface
165	**14**	8	186	E	3		Layer of ash in oven.
397	**15**	12	267	E	3		Pit fill
393	**16**	12	265	E	3		Pit fill
451	**17**	10	284	E	3	5	Hearth/fire
412	**18**	10	282	E	3	5	Yellowish/brown layer
400	**19**	7.5	44=188	E	3	5	Layer of burnt clay
190	**20**	2	188=44	E	3	5	Layer of burnt clay
192	**21**	4	192	E	3	5	Pit fill
463	**22**	10	195=299	E	3	8, large pit	Baked clay feature
520	**23**	8	299=195	E	3	8, large pit	Baked clay feature
607	**24**	7	298	E	3	8, large pit	Black and yellow layer, base of Struc.8
821	**25**	6	345	W	3		Trampled surface
794	**26**	4	712	W	3		Layer of burnt clay / Fire
803	**27**	8	702	W	3		Campfire/pit – ash deposit
1012	**28**	8	1149	W	3		Pit fill
957	**29**	8	1109	W	3		Pit fill
669	**30**	8	327	W	3		Pit fill
787	**31**	6	729, F.730	W	3		Pit fill
785	**32**	8	704, F.730	W	3		Pit fill
950	**33**	17	1218	W	3	Grave 2	Fill
954	**34**	15	1221	W	3	Grave 2	Fill
579	**35**	7	430	W	3	6, phase II	Foundation cut
772	**36**	4	648	W	3	6, phase II	Foundation cut
781	**37**	2	699	W	3	6, phase II	Central yellow deposit
713	**38**	8	422	W	3	6, phase II	Dark layer in northern part
697	**39**	3	342	W	3	9, ditch/fence	Defensive structure with Struc. 6
667	**40**	10	342	W	3	9, ditch/fence	Defensive structure with Struc. 6
489	**41**	6	387	W	3	7, phase III	Foundation cut
471	**42**	8	376	W	3	7, phase III	Foundation cut
469	**43**	7	378	W	3	7, phase III	Foundation cut
493	**44**	6	386	W	3	7, phase III	Greyish layer
589	**45**	10	591	W	3	7, phase II	Foundation cut
812	**46**	10	744	W	3	7, phase II	Post-hole
266	**47**	7	238	W	3	7, phase II	Post-hole
726	**48**	8	585	W	3	7, phase II	Yellowish/brown layer

Table 1.11 continued

Original sample	New sample	Volume (L)	Context	E/W side	Stratigrahic phase	Structure	Description
935	**49**	2	1124	W	3	10	
876	**50**	2	713	W	3	11	
810	**51**	5	726	W	3	11	
808	**52**	2	718	W	3	11	
575	**53**	2	410	W	3	12	Foundation cut
728	**54**	8	597	W	3	12	Foundation cut
718	**55**	2	599	W	3	12	Foundation cut
564	**56**	10	412	W	3	12	Foundation cut
286	**57**	16	103	E	2		Trampled surface
389	**58**	8	103	E	2		Trampled surface
387	**59**	10	103	E	2		Trampled surface
663	**60**	5	541, F.183	E	2		Ash layer in oven
139	**61**	10	179, F.183	E	2		Baked clay floor of oven
1006	**62**	4	140	W	2		Humogley layer
434	**63**	5	359	W	2	6, phase III	Collapsed layer
497	**64**	6	363	W	2	6, phase III	Sandy layer below Ctxt.359
495	**65**	8	363	W	2	6, phase III	Sandy layer below Ctxt.359
777	**66**	1	723	W	2	6, phase III	
322	**67**	6	142	W	2	7, phase IV	Floor surface
320	**68**	8	142	W	2	7, phase IV	Floor surface
107	**69**	6	157	W	2	7, phase IV	Foundation cut
352	**70**	6	307	W	2	7, phase IV	Foundation cut
566	**71**	2	436	W	2	7, phase IV	Foundation cut
223	**72**	6	150, F.151	W	2	7, phase IV	Foundation cut
707	**73**	5	594, F.151	W	2	7, phase IV	Foundation cut
715	**74**	1	583	W	2	7, phase IV	Foundation cut
219	**75**	3	159, F.160	W	2	7, phase IV	Foundation cut
705	**76**	7	593, F.160	W	2	7, phase IV	Foundation cut
225	**77**	8	164	W	2	7, phase IV	Foundation cut
105	**78**	2	152	W	2	7, phase IV	Foundation cut
243	**79**	6	213	W	2	7, phase IV	Post-hole
268	**80**	2	242	W	2	7, phase IV	Post-hole
221	**81**	2	166	W	2	7, phase IV	Post-hole
231	**82**	2	205	W	2	7, phase IV	Post-hole
354	**83**	8	308	W	2	7, phase IV	Post-hole
250	**84**	3	219	W	2	7, phase IV	Post-hole
360	**85**	4	314	W	2	7, phase IV	Post-hole
298	**86**	4	246	W	2	7, phase IV	Post-hole
294	**87**	6	244	W	2	7, phase IV	Post-hole
227	**88**	8	162	W	2	7, phase IV	Post-hole
264	**89**	4	229	W	2	7, phase IV	Post-hole
356	**90**	1	312	W	2	7, phase IV	Post-hole
363	**91**	6	316	W	2	7, phase IV	Post-hole
262	**92**	3	223	W	2	7, phase IV	Post-hole
358	**93**	10	310	W	2	7, phase IV	Post-hole
229	**94**	8	168	W	2	7, phase IV	Post-hole
432/430	**95**	13	250	W	2	7, phase IV	Layer of burnt clay
32	**96**	4	80	E	1		Pit/Hearth?

Table 1.12: Taxa identified to species and their ecological and biological characteristics (H.V.I). Continued below

'weed' taxa from H.V. I Phase 6 (5 samples)	Ubiq.	Total	Seed size and shape	Habitat	Plant height	Ph	Texture	Fertility	Moisture	Life span	Seed bank	Repro.	Germination	Sets seed	Flower. C.	Add. Refs.
Aphanes/Alchemilla spp.	20%	1	S													
Apium graveolens	20%	1	SFH	g, wt	high	n	h	/	damp, wet	bi		seed	a		2	
Atriplex spp.	20%	1	SFH	a, d, g, p	high	al	m	f	moist, damp	an		seed	s	Autumn	2	2, 3
Carex cf. *sylvatica*	20%	1	BFH	wd, wt	med/high	n, al	h	/	damp	per	?3/4	v/s			1	2
Carex spp.	20%	2	SFH													
Chenopodium album	20%	3	SFH	a, d	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2	1, 2, 3
Chenopodium sp.	20%	1	SFH		med/high	n, al	m, h	f	moist, damp	an	?3/4	seed	s	Autumn	2	
Echinocloa crus-galli	20%	1	SFH	a, d	high	al	m, h	f	moist, damp	an	4	seed	a/s	Aug-Oct	3	
Euphorbia peplus	20%	1	SFH	a, d	small	n, al	m, l	f	dry, moist	an	4?	seed	s	Aug-Oct	3	2, 3
Fallopia convolvulus	20%	1	BFH	a, d	high, T	n	m	/	moist, damp	an	4?	seed	s	Jul-Nov	2	1, 2, 3, 4
Persicaria lapathifolia	20%	2	BFH	a, d	med/high	n, wa	m, l	f	moist	an	?3/4	seed	s	Aug-Oct	2	2, 3
Plantago lanceolata	20%	1	SHH	a, d, g, p	high	al	m	/	dry, moist	per	3	v+s	s+a	Jun-Sept	3	1, 2, 3
Poa spp.	20%	2	SFH													
Polygonum aviculare	20%	4	BFH	a, d	high	n	l	f	dry, moist	an	4	seed	s	Jul-Nov	3	1, 2, 3
Polygonum spp.	20%	2	S													
Rumex acetosella	20%	1	SFH	a, d, g, p	low/med	wa	l	-f	dry, moist	per	4	v/s	s	Jun-Sept	3	1, 2, 3
Rumex sp.	20%	1	SFH													
Large Poaceae (wild)	20%	1	BFH													

Key: Habitat defines present-day areas where species are usually found: a= arable, d= disturbed, g= grassland, p= pasture, wd= woodland, wt= wetland (floodplain, marches, semi-aquatic). Plant height is the maximum height reached in suitable growing conditions: low=<30cm, medium=30-60cm, high>60cm, T= twining. pH: al= alkaline, n= neutral, wa= weakly acid. Fertility: f= requires fertile soils, -f= thrives in poorer soils, if= indicator of nutrient-poor soils, /= grows in intermediate fertility. Life cycle: an= annual, bi= biennial, per= perennial. Seed bank (Grime *et al*. 1989): 1= transient seed bank, seeds will germinate before the next generation of seeds are produced; 2= seeds can overwinter and germinate in the spring; 3= mostly transient but some will survive in the seed bank; 4= persistent, seeds will remain in the soil for several seasons, even years, before germinating. Reproduction = by seed or vegetatively (v), s/v = mostly by seed, v/s = mostly vegetatively, v+s= both vegetatively and by seed. Germination season: a= autumn, s= spring, a/s= mostly autumn, s/a= mostly spring, a+s= either autumn or spring. Flowering onset and duration (Bogaard *et al*. 2001: Table 3, Chapter 6.3): 1= short flowering, early to intermediate onset; 2= late flowering, short to intermediate duration; 3= long flowering, early to intermediate onset; 4= medium flowering duration, intermediate onset. When information differed between sources the greatest value or range was used. Blank cells represent absent, unknown and/or indeterminate characteristics. Bojňanský & Fargašová 2007 and http://www.tela-botanica.org were consulted for all species. Additional references: **1**- Stevens 1996: Tables 4.3-4.34; **2**- Grime *et al*. 1989; **3**- Hanf 1983; **4**-Wilson & King 2003; **5**- Wärner *et al*. 2011; **6**- Royo-Esnal *et al*. 2010; **7**- Hunt *et al*. 2009; **8**- Murrumbidgee 2008; **9**- Van Assche & Vandelook 2006; **10**- Cudney *et al*. 2007; **11**- http://www.cabi.org/isc/datasheet/8058; **12**- http://www.cabi.org/isc/datasheet/20367; **13**- Brennan 2009: 15-17.

'weed' taxa from H.V. I Phase 3 (44 samples)	Ubiq.	Total	Seed size and shape	Habitat	Plant height	Ph	Texture	Fertility	Moisture	Life span	Seed bank	Repro.	Germination	Sets seed	Flower. C.	Add. Refs.
Asteraceae	2.7%	1	B													
Atriplex spp.	2.7%	1	SFH	a, d, g, p	high	al	m	f	moist, damp	an		seed	s	Autumn	2	2, 3
Carex cf. *muricata*	2.7%	1	SFH	g	med/high	n, wa	m, h	/	moist	per	?3/4	v		Jun-Aug	1	
Carex cf. *sylvatica*	2.7%	1	BFH	wd, wt	med/high	n, al	h	/	damp	per	?3/4	v/s			1	2
Chenopodium album	55%	200	SFH	a, d	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2	1, 2, 3
Chenopodium sp.	36%	162	SFH		med/high	n, al	m, h	f	moist, damp	an	?3/4	seed	s	Autumn	2	
Echinocloa crus-galli	2.7%	76	SFH	a, d	high	al	m, h	f	moist, damp	an	4	seed	a/s	Aug-Oct	3	
Fallopia convolvulus	4.5%	2	BFH	a, d	high, T	n	m	/	moist, damp	an	4?	seed	s	Jul-Nov	2	1, 2, 3, 4
Galeopsis/Stachys sp.	2.7%	1	BFH													
Hyoscyamus niger	4.5%	2	SFH	d	med/high	wa	l	f	moist	an/bi	3?				4	1, 3
Lolium sp.	2.7%	1	BFH	a, d, g, p	med/high	n, al			moist	an/per			?a/s		3	
Lolium/Festuca spp.	14%	9	BFH													
Montia cf. *fontana* ssp. *Chondrosperma*	2.7%	1	SHH	a, d	small, scrambler	n, wa	m, h	/	damp, wet	an/per		s/v			1	3
P.somniferum/dubium	2.7%	1	SHH	a	med	n	m	/	moist	an	4	seed	s/a	Jun-Sept	3	1, 2, 3
Papaver somniferum	2.7%	1	SHH	a, d	med	n, al	m	/	moist	an	4	seed	s/a	Jun-Sept	3	
Physalis/Solanum sp.	4.5%	2	SHH	a, d, g, wd		n, al	h	f	moist, damp	an/per						
Poa spp.	2.7%	4	SFH													
Polygonum aviculare	2.7%	2	BFH	a, d	high	n	l	f	dry, moist	an	4	seed	s	Jul-Nov	3	1, 2, 3
Polygonum sp.	2.7%	1	S													
Rumex sp.	2.7%	1	SFH													
Large Poaceae (wild)	14%	18	BFH													
Small Poaceae (wild)	4.5%	2	SFH													

'weed' taxa from H.V. I Phase 2 (39 samples)	Ubiq.	Total	Seed size and shape	Habitat	Plant height	Ph	Texture	Fertility	Moisture	Life span	Seed bank	Repro.	Germination	Sets seed	Flower. C.	Add. Refs.
cf. *Agrostemma githago*	2.5%	1	BFH	a	high	n	m	f	damp	an/bi	1	seed	a/s	Aug-Oct	2	1, 3, 4
Artemisia sp.	5.1%	3	SFL													
Atriplex sp.	2.5%	1	SFH	a, d, g, p	high	al	m	f	moist, damp	an		seed	s	Autumn	2	2, 3
Brassicaceae	2.5%	1	SFH													
Carex cf. *nigra*	2.5%	1	BFH	wt, p	med/high	/	h	-f	damp, wet	per	?3/4	v	s	Aug-Oct	1	1, 2
Chenopodium album	56%	253	SFH	a, d	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2	1, 2, 3
Chenopodium sp.	38%	143	SFH		med/high	n, al	m, h	f	moist, damp	an	?3/4	seed	s	Autumn	2	
Echinocloa crus-galli	15%	24	SFH	a, d	high	al	m, h	f	moist, damp	an	4	seed	a/s	Aug-Oct	3	
Lolium/Festuca sp.	2.5%	1	BFH													
Physalis/Solanum sp.	2.5%	1	SHH	a, d, g, wd		n, al	h	f	moist, damp	an/per						
Polygonum aviculare	2.5%	1	BFH	a, d	high	n	l	f	dry, moist	an	4	seed	s	Jul-Nov	3	1, 2, 3
Potentilla spp.	2.5%	1	S		low/med					per						
R. bulbosus/acris/repens	5.1%	2	BFH			n, al	m, h			per		v/s		Jun-Aug	4	1, 2, 3
Rumex sp.	2.5%	1	SFH													
Large Poaceae (wild)	13%	6	BFH													

Table 1.13: Plant macro-remains from Hermanov Vinograd I

New sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Original sample number	986	992	1043	138	1045	999	252	858	827	1011	690	540	34	165	397	393	451	412	400	190	192	463	520	607	821	794	803	1012	957	669	787	785	950	954
Context	1277	1274	1387		1385	1243	1252	874	981	1240	346	441	83/87	186	267	265	284	282	44/188		192	195/299		298	345	712	702	1149	1109	327	729	704	1218	1221
Feature*			?																?			?									730			
East or West excavation area	E	E	W	W	W	W	W	E	W	W	W	E	E	E	E	E	E	E	E	E	E	E	E	E	W	W	W	W	W	W	W	W	W	W
Stratigraphic phase	7	6					5a	5				4	3				3					3			3									
Structure											10						5					8, large pit												
Description	Pit	Canal	Trampled s.		Moat	P-hle	Trampled s.		Grave 1		F.cut	Fire	Trp.S	Oven	Pit	Pit	Fire	Layers/surfaces			Pit	Baked clay		Layer	Trp.S	Fire?	Pit	Pit	Pit	Pit	Pit	Pit	Grave 2	
Sample volume (L)	2	5	4	4	4	8	4	1	10	9	5	5	7	8	12	12	10	10	7.5	2	4	10	8	7	6	4	8	8	8	8	6	8	17	15
Charcoal >4mm	- -	+	-				-		-		-	-	-	-	-	-		- -			- -	- -	-	- -	-	- -	+	+	-	-	-	- -	+	+
2-4mm	+	+++				-				-	-	-	-	-	-	-		-		- -	- -	+	- -	+	-	- -	+	- -	-	- -	-	+	+	++
<2mm	+++	+++	+	+	- -	++	+	- -	+	+	+	++	++	+	+	+	- -	+++	++	+	+++	+++	+++	+++	+	++	+++	+	++	++	+	+++	+++	+++
volume (ml)	3.5	84	0	0	0	0.5	0	0	0	0	0.5	0.5	0.5	0	0	0	0	0.5	0	0	1.5	1	1	3	0.5	1	8	3.5	1	1	0.5	2	8	12
Cereals																																		
H. vulgare ssp. *vulgare*		6																																
Hordeum vulgare sl.		4									1					1																		
Triticum monococcum L. 1-grain																								2										
T. monococcum L.																																		
T. monococcum/dicoccum		4				3																												
Triticum dicoccum Schübl.		1				2								1	1						1				1									
T. cf. *timopheevi* Zhuk.																																		
T.dicoccum/'new' type	1					1				1														1										1
T. aestivum/durum, oval shape		7																																
Triticum sp. grain		1				2										2					1		2	8										
Indeterminate cereal		8					1			2		1	2			3							1	9			2						1	
Indet. cereal grain fragments														4				1	1				31	80	3				3					25
WGE (1 = 0.0133g)														1				1	1				2	9	1				1					2
Total grain	**1**	**31**	**0**	**0**	**0**	**8**	**1**	**0**	**0**	**3**	**1**	**1**	**2**	**2**	**1**	**6**	**0**	**1**	**1**	**0**	**2**	**0**	**5**	**29**	**2**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**1**	**3**
Preservation index mean	1	1.1	/	/	/	1.5	0	/	/	0.7	2	0	0	1	2	0.7	/	0	0	/	1.5	/	0.4	0.6	1	/	0	/	0	/	/	/	0	0.7
mode	1	2	/	/	/	2, 1	0	/	/	0	2	0	0	2, 0	2	0	/	0	0	/	2, 1	/	0	0	2, 0	/	0	/	0	/	/	/	0	0
Fragmentation index	0	0	/	/	/	0	0	/	/	0	0	0	0	4	0	0	/	N/A	N/A	/	0	/	10.3	4	3	/	0	/	N/A	/	/	/	0	25
T. monococcum glume base																		1			4		5	31			5						2	
T. monococcum spikelet fork			1				2			1		1						2			10	1	41	88			17		2			2	8	4
T. mono/dicoccum gl. base												1											1	17			5						3	1
T. mono/dicoccum sp. fork		1										2									4		9	20					1				2	1
T. dicoccum glumes base													1					1	1				2	34										1
T. dicoccum spikelet fork																					1	1	2	5										1
T. cf. *timopheevi* glume base																																		
T. cf. *timopheevi* spikelet fork																								9										
T.dicoccum/'new' type gl. base																					2													
T.dicoccum/'new' type sp. fork																					3													
Triticum sp. glume base		1								1		1						4	1		33	3	54	311	1		30			1	1		8	10
Triticum sp. spikelet fork												1	1					3			10		35	54			7						8	3
Total glume bases	**0**	**3**	**2**	**0**	**0**	**0**	**4**	**0**	**0**	**3**	**0**	**10**	**3**	**0**	**0**	**0**	**0**	**16**	**2**	**0**	**95**	**7**	**236**	**745**	**1**	**0**	**88**	**0**	**6**	**1**	**1**	**4**	**49**	**30**
Glume base:grain ratio	**0**	**0.1**	**N/A**	**/**	**/**	**0**	**4**	**/**	**/**	**1**	**0**	**10**	**1.5**	**0**	**0**	**0**	**/**	**16**	**2**	**/**	**47.5**	**N/A**	**47.2**	**25.7**	**0.5**	**/**	**44**	**/**	**6**	**N/A**	**N/A**	**N/A**	**49**	**10**
Triticum sp. rachis internodes																					1		1	4			1							
Large Poaceae culm frags.																								- -										
Large Poaceae culm nodes frg.																								+										
Pulses																																		
Lens culinaris																		1																2
Vicia faba		1																																
Indet. Large legume		2																1					2	1										2
Total pulses	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**
Fruits and nuts																																		
Cornus mas fruit																							1 fr	1			1, 2fr							
C.mas whole equivalent																							1	1			2							
Corylus avellana shell fr		1																			1						3					1		
Crataegus monogyna																																		
Fragaria vesca																								1										
Physalis alkakengi		1																						1			2						cf.1M	7 M
Sambucus sp.																																		
Sambucus ebulus																						1												
Sambucus nigra/racemosa																																		
Total fruits and nuts	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**3**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**1**	**1**	**7**

Table 1.13 continued

New sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Wild/Weed seeds																																		
cf. *Agrostemma githago*																																		
Aphanes/Alchemilla spp.		1																																
Apium graveolens		1 M																																
Artemisia sp.																																		
Asteraceae																																		
Atriplex sp.						1																												1
Avena sp.																																		
Brassicaceae																																		
Carex sp.		2																						1										
Carex cf. *muricata*																								1										
Carex cf. *nigra*																																		
Carex cf. *sylvatica*		1																																
Cerastium spp.																																		
Chenopodium sp.		1																	1 M			2	2	10			4, 3M				2		1	
Chenopodium album		3														2			1		2	2	1	10			21						2	4
Echinocloa crus-galli		1 cf.																																
Euphorbia peplus		1																																
Fallopia convolvulus		2																					1											
Galeopsis/Stachys sp.																					1 M													
Galium aparine											1																							
Hyoscyamus niger																							1											
Lolium sp.																																		
Lolium/Festuca spp.																						1	4	1										
Medicago sp.																																		
Montia cf. *fontana* ssp. *Chondrosperma*																																		
Papaver somniferum											1																							
P. somniferum/dubium																																		
Persicaria lapathifolia		1, 1M																																
Phleum sp.																																		
Physalis/Solanum sp.	1 M																																	
Plantago lanceolata		1																																
Poa sp.		2																						4										
Polygonum sp.		1, 1M																						1										
Polygonum aviculare		2, 2M																						2										
Potentilla sp.																																		
R. bulbosus/acris/repens																																		
Rumex sp.						1																												
Rumex acetosella		1																																
Large Poaceae WGE (wild/dom.)						2																1		7										1
Large Poaceae WGE (wild, >4mm)																							2	6										3
Small Poaceae (wild, <2mm)																							1	1										
Indeterminate seed		5, 8M																			1			4			1,1M							1
Total wild seed	**1**	**38**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**2**	**0**	**4**	**6**	**12**	**48**	**0**	**0**	**30**	**0**	**0**	**0**	**2**	**0**	**3**	**10**
Total wild seed (Fa-then excl.)	1	35	0	0	0	4	0	0	0	0	2	0	0	0	0	0	0	0	1	0	2	4	11	38	0	0	9	0	0	0	2	0	1	6
Grain:seed ratio	**1**	**0.8**	**/**	**/**	**/**	**2**	**N/A**	**/**	**/**	**N/A**	**0.5**	**N/A**	**N/A**	**N/A**	**N/A**	**3**	**/**	**N/A**	**0.5**	**/**	**0.5**	**0**	**0.4**	**0.6**	**N/A**	**/**	**0.1**	**/**	**N/A**	**/**	**0**	**/**	**0.3**	**0.3**
Gl. base:seed ratio	**0**	**0.1**	**N/A**	**/**	**/**	**0**	**N/A**	**/**	**/**	**N/A**	**0**	**N/A**	**N/A**	**/**	**/**	**0**	**/**	**N/A**	**1**	**/**	**23.8**	**1.2**	**19.7**	**15.5**	**N/A**	**/**	**2.9**	**/**	**N/A**	**N/A**	**0.5**	**N/A**	**16.3**	**3**
Non-cereal P.I. mean	1	1.4	/	/	/	0.5	/	/	/	/	1.5	/	/	/	/	1	/	0.5	1.5	/	1.3	1.6	1.5	1.5	/	/	1.6	/	/	/	1	/	1.3	1.7
mode	1	0, 2	/	/	/	1, 0	/	/	/	/	1, 2	/	/	/	/	1	/	1	2, 1	/	2	2	1, 2	2	/	/	1	/	/	/	1	/	1	2
Large monocot culm node																																		
Food/Parenchyma																																		1
Grain/Seed density	**1.0**	**14.8**	**0**	**0**	**0**	**1.5**	**0.3**	**0**	**0**	**0.3**	**0.6**	**0.2**	**0.3**	**0.3**	**0.1**	**0.7**	**0**	**0.3**	**0.4**	**0**	**1.8**	**0.7**	**2.5**	**11.6**	**0.3**	**0**	**4.6**	**0**	**0.1**	**0**	**0.3**	**0.1**	**0.3**	**1.6**
№ items / litre (excl. charcoal)	**1.0**	**15.4**	**0.5**	**0**	**0**	**1.5**	**1.3**	**0**	**0**	**0.7**	**0.6**	**2.2**	**0.7**	**0.3**	**0.1**	**0.7**	**0**	**1.9**	**0.7**	**0**	**25.8**	**1.4**	**32.1**	**119**	**0.5**	**0**	**15.8**	**0**	**0.9**	**0.1**	**0.5**	**0.6**	**3.2**	**3.7**
Other finds																																		
bone fragments		+																-			-													- -
burnt bone fragments	- -	+																									-							
bones		+																	-				-											-
burnt stone																											+							
fish scales	-	++																			-													-
egg shell		+																																
Mineralised monocot leaf fr.																								1 cf.										
intrusive roots			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
intrusive seeds		P		P	P	P	P		P	P	P	P	P	P	P	P	P		P	P	P	P	P		P	P	P	P	P	P	P	P	P	P

New sample number	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**
Original sample number	579	772	781	713	697	667	489	471	469	493	589	812	266	726	935	876	810	808	575	728	718	564	286	389	387	663	139	1006	434	497	495	777
Context	430	648	699	422	342	342	387	376	378	386	591	744	238	585	1124	713	726	718	410	597	599	412	103	103	103	541	179	140	359	363	363	723
Feature*																										183						
East or West excavation area	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	E	E	E	E	E	W	W	W	W	W
Stratigraphic phase	3				3		3				3				3	3			3				2					2	2			
Structure/'Objekta'	6, phase II				9, by strc.6		7, phase III				7, phase II				10	11			12										6, phase III			
Description	Found. Cut		Layers/surf.		Ditch/fence		Foundation cuts			layer	F.cut	P-holes		Layer					Foundation cuts				Trpled surfaces			Oven		Layer	Layer	Layer below		
Sample volume (L)	7	4	2	8	3	10	6	8	7	6	10	10	7	8	2	2	5	2	2	8	2	10	16	8	10	5	10	4	5	6	8	1
Charcoal >4mm		-	-	- -			-	+	- -	+	-	+	- -	-		-	- -	- -	- -	- -		- -	- -	-		-						-
2-4mm	-	-	-	+	-		+	+	+	+	- -	+	-	-	-	+	- -	- -	- -	+		+	- -	-						-	-	-
<2mm	+	+	+++	+++	+	- -	+++	+++	+++	+++	++	+++	++	++	- -	+++	++	+++	+++	++	+	+++	+++	+	- -	+	- -	- -		+	+	+
volume (ml)	0	0	1	2	0	0	2	13	5	11.5	1	11	1	0.5	0	2	1	2	2	2.5	0	3	2	0	0	0	0	0	0	0	0	0
Cereals																																
H. vulgare ssp. *vulgare*																																
Hordeum vulgare sl.																																
Triticum monococcum L. 1-grain							2				2																					
T. monococcum L.																2																
T. monococcum/dicoccum		2	1				3			9	1																					
Triticum dicoccum Schübl.										2				1																		
T. cf. *timopheevi* Zhuk.																																
T.dicoccum/'new' type														1																		
T. aestivum/durum, oval shape																																
Triticum sp. grain						2	10				2								1													
Indeterminate cereal		2	8			1	1	2					1						1			2								1		
Indet. cereal grain fragments				18				5	2					11							1	13										
WGE (1 = 0.0133g)				14				1	1					1							1	8										
Total grain	**0**	**4**	**9**	**14**	**0**	**3**	**16**	**3**	**1**	**11**	**5**	**0**	**1**	**3**	**0**	**2**	**0**	**0**	**2**	**0**	**1**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Preservation index mean	/	0.8	0.1	0	/	0.7	1.1	0	0	1.5	1.2	/	0	1	/	1.5	/	/	0.5	/	0	0	/	/	/	/	/	/	/	0	/	/
mode	/	0	0	0	/	1	1	0	0	2	1	/	0	1	/	2, 1	/	/	0, 1	/	0	0	/	/	/	/	/	/	/	0	/	/
Fragmentation index	/	0	0	N/A	/	0	0	2.5	N/A	0	0	/	0	5.5	/	0	/	/	0	/	0	7.5	/	/	/	/	/	/	/	0	/	/
T. monococcum glume base		1					13		1	3				1		3			2													1
T. monococcum spikelet fork		4	3	2			56	5	1	12	3	1		1		7		2	4	1	1	10						1		1		
T. mono/dicoc glume base		1					19	2	1	1							1	1	5			6										1
T. mono/dicoc spikelet fork			1	1			3			4							1					2										
T. dicoccum glumes base				2				8		3		1	1									1										
T. dicoccum spikelet fork		1		2			1	3		1		1							2		1	5	2									
T. cf. *timopheevi* glume base							1																									
T. cf. *timopheevi* spikelet fork							1																									
T.dicoccum/'new' type gl. base				1					1																							
T.dicoccum/'new' type sp. fork							2	4	2									1														
Triticum sp. glume base		13	5	13			129	21	9	26	11	6	2	3		3		3	10	1		11						1	1			
Triticum sp. spikelet fork		5	3	3			24	7		7		2	2	1		2	1	1	13			2										1
Total glume bases	**0**	**35**	**19**	**32**	**0**	**0**	**336**	**69**	**18**	**81**	**17**	**15**	**7**	**8**	**0**	**24**	**5**	**12**	**55**	**3**	**4**	**56**	**4**	**0**	**0**	**0**	**0**	**3**	**1**	**1**	**0**	**4**
Glume base:grain ratio	**/**	**8.8**	**2.1**	**2.3**	**/**	**0**	**21**	**23**	**18**	**7.4**	**3.4**	**N/A**	**7**	**2.7**	**/**	**12**	**N/A**	**N/A**	**27.5**	**N/A**	**4**	**5.6**	**N/A**	**/**	**/**	**/**	**/**	**N/A**	**N/A**	**1**	**/**	**N/A**
Triticum sp. rachis internodes							2	1		2									2													
Large Poaceae culm frags.																																
Large Poaceae culm nodes frg.																																
Pulses																																
Lens culinaris				1																												
Vicia faba																																
Indet. Large legume										2																						
Total pulses	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fruits and nuts																																
Cornus mas fruit								1 fr									1 fr															
C.mas whole equivalent								1									1															
Corylus avellana shell fr								2	2																							
Crataegus monogyna							1																									
Fragaria vesca																																
Physalis alkakengi	33																															
Sambucus sp.									1 M																							
Sambucus ebulus																																
Sambucus nigra/racemosa																																
Total fruits and nuts	**33**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

New sample number	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**
Wild/Weed seeds																																
cf. *Agrostemma githago*																																
Aphanes/Alchemilla spp.																																
Apium graveolens																																
Artemisia sp.																																
Asteraceae							1																									
Atriplex sp.																																
Avena sp.																																
Brassicaceae																																
Carex sp.																																
Carex cf. *muricata*																																
Carex cf. *nigra*																																
Carex cf. *sylvatica*																																
Cerastium spp.																																
Chenopodium sp.	1						17	5, 4M	2	101	2		1	3						1			1									
Chenopodium album	1	3	3		1	2	46	3	2	86	2	3	1		1					1		1								1	1	
Echinocloa crus-galli							76**																1									
Euphorbia peplus																																
Fallopia convolvulus										1																						
Galeopsis/Stachys sp.																																
Galium aparine																																
Hyoscyamus niger								1																								
Lolium sp.							1																									
Lolium/Festuca spp.							1				1											1										
Medicago sp.																																
Montia cf. *fontana* ssp. *Chondrosperma*													1																			
Papaver somniferum			1 M																													
P. somniferum/dubium								1 M																								
Persicaria lapathifolia																																
Phleum sp.																																
Physalis/Solanum sp.								1 M													1											
Plantago lanceolata																																
Poa sp.																																
Polygonum sp.																																
Polygonum aviculare																																
Potentilla sp.																																
R. bulbosus/acris/repens																							1		1							
Rumex sp.							1																									
Rumex acetosella																																
Large Poaceae WGE (wild/dom.)			2				2			2	4					1			1		1	4		1								2
Large Poaceae WGE (wild, >4mm)							3			2												2								1 M		
Small Poaceae (wild, <2mm)																																
Indeterminate seed			1				1			1	1		1									1 M										2
Total wild seed	**2**	**3**	**7**	**0**	**1**	**2**	**149**	**15**	**4**	**193**	**10**	**3**	**4**	**3**	**1**	**1**	**0**	**0**	**1**	**2**	**2**	**9**	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**4**
Total wild seed (Fa-then excl.)	1	0	4	0	0	0	103	12	2	107	8	0	3	3	0	1	0	0	1	1	2	8	3	1	1	0	0	0	0	1	0	4
Grain:seed ratio	**0**	**1.3**	**1.3**	**N/A**	**0.0**	**1.5**	**0.1**	**0.2**	**0.3**	**0.1**	**0.5**	**0.0**	**0.3**	**1.0**	**0.0**	**2.0**	**/**	**/**	**2.0**	**0.0**	**0.5**	**1.1**	**0.0**	**0.0**	**0.0**	**/**	**/**	**/**	**/**	**0.5**	**0**	**0**
Glume b.:seed ratio	**0**	**11.7**	**2.7**	**N/A**	**0.0**	**0.0**	**2.3**	**4.6**	**4.5**	**0.4**	**1.7**	**5.0**	**1.8**	**2.7**	**0.0**	**24.0**	**/**	**/**	**55**	**1.5**	**2**	**6.2**	**1.3**	**0**	**0**	**/**	**/**	**N/A**	**N/A**	**0.5**	**0**	**1**
Non-cereal P.I. - mean	1.5	1.7	1.1	2	2	3	1.7	1.3	1.4	1.6	0.9	1.7	1	1	2	0	1	/	0	1	0.5	0.9	1.7	0	2	/	/	/	/	1.5	2	0
mode	2	2	1	2	2	3	2	1	1	1	2, 1	2	1	1	2	0	1	/	0	1	0	0	2	0	2	/	/	/	/	2, 1	2	0
Large monocot culm node																																
Food/Parenchyma												5 V	4									6										
Grain/Seed density	**5.0**	**1.8**	**8.0**	**1.9**	**0.3**	**0.5**	**27.7**	**2.5**	**1.0**	**34.3**	**1.5**	**0.3**	**0.7**	**0.8**	**0.5**	**1.5**	**0.2**	**0**	**1.5**	**0.3**	**1.5**	**1.9**	**0.2**	**0.1**	**0.1**	**0**	**0**	**0**	**0**	**0.5**	**0.1**	**4.0**
№ items / litre (excl. charcoal)	**5.0**	**10.5**	**17.5**	**5.9**	**0.3**	**0.5**	**84.0**	**11.3**	**3.6**	**48.2**	**3.2**	**2.3**	**2.3**	**1.8**	**0.5**	**13.5**	**1.2**	**6.0**	**30.0**	**0.6**	**3.5**	**8.1**	**0.4**	**0.1**	**0.1**	**0**	**0**	**0.8**	**0.2**	**0.7**	**0.1**	**8.0**
Other finds																																
bone fragments			-	-				- -					-						+	-		-							-			
burnt bone fragments									-			-																				
bones				- -	-							-				-						-										
burnt stone																																
fish scales								-														- -										
egg shell																																
Mineralised monocot leaf fr.																																
intrusive roots	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P		P	P	P	P	P	P	P	P	P	P	P	P	P
intrusive seeds	P	P		P	P	P	P	P	P	P	P	P	P	P	P		P		P	P	P	P	P	P	P	P	P	P	P	P	P	P

New sample number	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**
Original sample number	322	320	107	352	566	223	707	715	219	705	225	105	243	268	221	231	354	250	360	298	294	227	264	356	363	262	358	229	430/2	32
Context	142	142	157	307	436	150	594	583	159	593	164	152	213	242	166	205	308	219	314	246	244	162	229	312	316	223	310	168	250	80
Feature*						151			160																					
East or West excavation area	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	E
Stratigraphic phase	2																													1
Structure/'Objekta'	7, phase IV																													
Description	Floor		Ten Foundation cuts										Sixteen Post-holes																Layer	Pit?
Sample volume (L)	6	8	6	6	2	6	5	1	3	7	8	2	6	2	2	2	8	3	4	4	6	8	4	1	6	3	10	8	13	4
Charcoal >4mm	-		-	-	-	-		-	-	- -	-	-	-	-	-	+	-	-	-	- -	- -	+	- -	-	- -	-	-	-	- -	+
2-4mm	- -	-	-	- -	- -	-	-	- -	-	+	- -	-	-	-	- -	+	- -	- -	- -	- -	+	+	- -	-	- -	-	- -	- -	+	+
<2mm		++	+++	+++	+++	+	+++	+++	++	+++	++	++	++	+	- -	+++	+++	+++	+++	++	+++	+++	++	- -	+++	+	+++	+++	+++	+++
volume (ml)	1	0	0.5	1.5	0.5	0	0	0.5	0	1	0.5	0	0	0	0	4.5	3	1	1	1	3	2.5	1.5	0	1	0	0.5	1	7.5	5
Cereals																														
H. vulgare ssp. *vulgare*																														
Hordeum vulgare sl.																									1					
Triticum monococcum L. 1-grain		1		1																										
T. monococcum L.	1			1																		4								
T. monococcum/dicoccum		1		4		1										2													2	
Triticum dicoccum Schübl.																1					1									
T. cf. *timopheevi* Zhuk.								1																						
T.dicoccum/'new' type																														
T. aestivum/durum, oval shape																														
Triticum sp. grain							1	1		2						2						1					4			4
Indeterminate cereal						1				1							3		2		6	5			2			2	3	2
Indet. cereal grain fragments			1						1											3			2							
WGE (1 = 0.0133g)			1						1											1			1							
Total grain	**1**	**2**	**1**	**6**	**0**	**2**	**1**	**2**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**5**	**3**	**0**	**2**	**1**	**7**	**10**	**1**	**0**	**3**	**0**	**4**	**2**	**5**	**6**
Preservation index mean	2	2	0	1.3	/	0.7	1	0.5	0	0.7	/	/	/	/	/	1.4	0	/	0	0	0.3	0.7	0	/	0.7	/	1	0	0.6	0.7
mode	2	2	0	1	/	0, 2	1	3, 1	0	1	/	/	/	/	/	1	0	/	0	0	0	0	0	/	0	/	1	0	0	1
Fragmentation index	0	0	N/A	0	/	0	0	0	N/A	0	/	/	/	/	/	0	0	/	0	N/A	0	0	N/A	/	0	/	0	0	0	0
T. monococcum glume base				4												2		4	1											
T. monococcum spikelet fork				19	2											4		4	3	1		3	4		6				12	
T. mono/dicoc glume base				14	1							3				1			1		1							1	1	
T. mono/dicoc spikelet fork	1			12	1					2																		1	1	
T. dicoccum glumes base		1		1	2			1		1							1			1		1			6				2	1
T. dicoccum spikelet fork				6	1					1		1				3	2				1	1							3	1
T. cf. *timopheevi* glume base				1																										
T. cf. *timopheevi* spikelet fork				1																										
T.dicoccum/'new' type gl. base																				1	1									
T.dicoccum/'new' type sp. fork				1	2																								4	
Triticum sp. glume base				58	5			1	1	2	4	1			1	21	3	6	2	3	1	14	3		27		3		27	2
Triticum sp. spikelet fork				43	2		1		1							3	1	1	1		1	5			14		2	2	2	1
Total glume bases	**2**	**1**	**0**	**242**	**24**	**0**	**2**	**2**	**3**	**9**	**4**	**6**	**0**	**0**	**1**	**44**	**10**	**20**	**12**	**7**	**7**	**33**	**11**	**0**	**73**	**0**	**7**	**7**	**74**	**7**
Glume base:grain ratio	**2**	**0.5**	**0**	**40.3**	**N/A**	**0**	**2**	**1**	**3**	**3**	**N/A**	**N/A**	**/**	**/**	**N/A**	**8.8**	**3.3**	**N/A**	**6**	**7**	**1**	**3.3**	**11**	**/**	**24.3**	**/**	**1.8**	**3.5**	**14.8**	**1.2**
Triticum sp. rachis internodes																														
Large Poaceae culm frags.																														
Large Poaceae culm nodes frg.																														
Pulses																														
Lens culinaris			1																											
Vicia faba																														
Indet. Large legume																1					1									
Total pulses	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fruits and nuts																														
Cornus mas fruit				4 fr	3 fr										1 fr															4 fr
C.mas whole equivalent				1	1										1															1
Corylus avellana shell fr																														1
Crataegus monogyna																														
Fragaria vesca																														
Physalis alkakengi																														9
Sambucus sp.																														
Sambucus ebulus																							1							
Sambucus nigra/racemosa																1						1								
Total fruits and nuts	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**11**

New sample number	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**
Wild/Weed seeds																														
cf. *Agrostemma githago*																											1			
Aphanes/Alchemilla spp.																														
Apium graveolens																														
Artemisia sp.			1										2																	
Asteraceae																														
Atriplex sp.																					1									
Avena sp.																														1
Brassicaceae													1																	
Carex sp.																														
Carex cf. *muricata*																														
Carex cf. *nigra*																													1	
Carex cf. *sylvatica*																														
Cerastium spp.																														1
Chenopodium sp.	1	1						1			1					7	5	1	4	1	1	9	5		29		9		68	11
Chenopodium album		1		41,4cf.		2	4		1	1	1	3	3			3	6		8	1		14	7		61	3	26	1	60	2
Echinocloa crus-galli				2							1											2			12				6	
Euphorbia peplus																														
Fallopia convolvulus																														1
Galeopsis/Stachys sp.																														
Galium aparine																														
Hyoscyamus niger																														
Lolium sp.																														
Lolium/Festuca spp.									1																					
Medicago sp.																														1
Montia cf. *fontana* ssp. *Chondrosperma*																														
Papaver somniferum																														
P. somniferum/dubium																														
Persicaria lapathifolia																														
Phleum sp.																														1
Physalis/Solanum sp.																							1							
Plantago lanceolata																														
Poa sp.																														
Polygonum sp.																														
Polygonum aviculare										1 cf.																				
Potentilla sp.									1 M																					
R. bulbosus/acris/repens																														
Rumex sp.				1																										
Rumex acetosella																														
Large Poaceae WGE (wild/dom.)					1			1		1		1				1			1			1			1				1	1
Large Poaceae WGE (wild, >4mm)				1								1										1					2			1
Small Poaceae (wild, <2mm)																														
Indeterminate seed								1		1	1 M							1				2			1				2	
Total wild seed	**1**	**2**	**1**	**49**	**1**	**2**	**4**	**3**	**3**	**4**	**4**	**5**	**6**	**0**	**0**	**11**	**11**	**2**	**13**	**2**	**2**	**29**	**13**	**0**	**104**	**3**	**38**	**1**	**138**	**20**
Total wild seed (Fa-then excl.)	1	1	1	4	1	0	0	3	2	3	3	2	3	0	0	8	5	2	5	1	2	15	6	0	43	0	12	0	78	18
Grain:seed ratio	**1**	**1**	**1**	**0.1**	**0**	**1**	**0.3**	**0.7**	**0.3**	**0.8**	**0**	**0**	**0**	**/**	**/**	**0.5**	**0.3**	**0**	**0.2**	**0.5**	**3.5**	**0.3**	**0.1**	**/**	**0**	**/**	**0.1**	**N/A**	**0.0**	**0.3**
Glume b.:seed ratio	**2**	**0.5**	**0**	**4.9**	**24**	**0**	**0.5**	**0.7**	**1**	**2.25**	**1**	**1.2**	**0**	**/**	**N/A**	**4.0**	**0.9**	**10**	**0.9**	**3.5**	**3.5**	**1.1**	**0.8**	**/**	**0.7**	**/**	**0.2**	**7.0**	**0.5**	**0.4**
Non-cereal P.I. - mean	1	1	2	1.6	0.5	2	2.5	0.3	1.7	0.8	1.3	1.8	1.7	/	1	1.2	1.4	0.5	1.5	1	1.4	1.5	1.6	/	1.9	2.3	1.7	2	1.6	1.6
mode	1	1	2	2	1, 0	2	2, 3	0	2	0	2	2	2	/	1	1	1	1, 0	2	1	1	1	1	/	1	2	1	2	1	1
Large monocot culm node																						1								
Food/Parenchyma			8	22															6			75 V				13	2		8 V	
Grain/Seed density	**0.3**	**0.5**	**0.5**	**9.3**	**1.0**	**0.7**	**1.0**	**5.0**	**1.3**	**1.0**	**0.5**	**2.5**	**1.0**	**0**	**0.5**	**9.0**	**1.8**	**0.7**	**3.8**	**0.8**	**1.7**	**5.0**	**3.8**	**0**	**17.8**	**1.0**	**4.2**	**0.4**	**11.0**	**9.3**
№ items / litre (excl. charcoal)	**0.7**	**0.6**	**1.8**	**53.3**	**13.0**	**0.7**	**1.4**	**7.0**	**2.3**	**2.3**	**1.0**	**5.5**	**1.0**	**0**	**1.0**	**31.0**	**3.0**	**7.3**	**8.3**	**2.5**	**2.8**	**18.6**	**6.5**	**0**	**30.0**	**5.3**	**5.1**	**1.3**	**17.3**	**11.0**
Other finds																														
bone fragments													-		-					-							-			
burnt bone fragments																		-											-	
bones				-		- -													-			-			- -				- -	
burnt stone																														
fish scales																														
egg shell																														
Mineralised monocot leaf fr.																														
intrusive roots	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
intrusive seeds	P	P	P	P		P	P		P	P	P	P	P	P		P	P	P	P	P	P	P	P		P	P	P	P	P	P

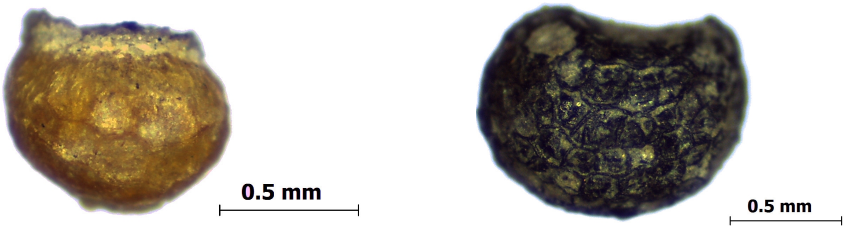


Figure 2: Mineralised (left) and charred opium poppy seeds from H.V.I, (from samples 37 and 11 respectively)

Table 1.14: Contexts sampled at Hermanov Vinograd II

Original sample	New sample	Volume (L)	Context	Stratigrahic phase	Structure	Description
372	**1**	4	415, F.416	4		Pit fill
540	**2**	8	420, F.416	4		Pit basal fill
321	**3**	5	390, F.391	4		Pit fill
211	**4**	8	390, F.391	4		Pit fill
544	**5**	10	828, F.391	4		Pit fill, above [830]
592	**6**	6	830, F.391	4		Pit basal fill
419	**7**	3	422	4		White border around 422
398	**8**	8	423	4		Pit fill
340	**9**	6	308	4	7, phase I	Baked clay floor
538	**10**	6	806	4	7, phase I	Fire/Hearth
295	**11**	8	347	4	6, phase I	Floor
273	**12**	1	297	3		Trampled surface
213	**13**	6	302	3		Post-hole
259	**14**	6	332	3	4, phase I	Floor
270	**15**	8	323	3	6, phase II	Baked clay floor
290	**16**	10	345	3		Pit fill, by Struc.6
396	**17**	8	475	3	7, phase II	Floor
275	**18**	10	175	2		Trampled surface
253	**19**	6	236	2		Pit fill
150	**20**	8	177	2		Pit fill
128	**21**	8	242	2	Grave 1	Fill
159	**22**	3	204	2	Grave 2	Fill
245	**23**	2	324	2	2	
170	**24**	8	171	2	4, phase II	Floor
229	**25**	8	276	2	6, phase III	Destruction layer
404	**26**	3	477	2	7, phase III	Floor
16	**27**	4	14	1	1	Baked clay floor
161	**28**	8	173	1	4, phase III	Hearth
450	**29**	6	488		8, phase a	Pit fill
421	**30**	8	486		8, phase a	Floor
425	**31**	3	482		8, phase a+1	Floor, above [486]
589	**32**	6	704		7, phase a	Floor
534	**33**	8	703		7, phase a+1	Floor, above [704]

Phase 'a' represents an unspecific phase. Phase 'a' and 'a+1' in Structures 7 and 8 are not necessarily contemporary

Table 1.15: Taxa identified to species and their ecological and biological characteristics (H.V.II). See Table 1.12 above for the key.

'weed' taxa from H.V.II Phase 4 (11 samples)	Ubiq.	Total	Seed size and shape	Habitat	Plant height	Ph	Texture	Fertility	Moisture	Life span	Seed bank	Repro.	Germination	Sets seed	Flower. C.	Add. Refs.
Chenopodium album	45%	13	SFH	a, d	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2	1, 2, 3
Chenopodium sp.	18%	4	SFH		med/high	n, al	m, h	f	moist, damp	an	?3/4	seed	s	Autumn	2	
Galium aparine	9.1%	1	BFH	all but wt	high, T	n		f	damp	an		seed	a+s	Jun-Sept	3	1, 2, 3, 12
Lychnis flos-cuculi	9.1%	1	SHH	g	med/high	n	h	/	damp, wet	per	4	v/s			1	1, 2
Medicago sp.	9.1%	1	S													
Phleum sp.	9.1%	1	SFH	a, d, g, p	med/high	n, al	m	/	dry, moist	per		v/s			4	
Physalis/Solanum sp.	36%	4	SHH	a, d, g, wd		n, al	h	f	moist, damp	an/per						
Plantago lanceolata	9.1%	1	SHH	a, d, g, p	high	al	m	/	dry, moist	per	3	v+s	s+a	Jun-Sept	3	1, 2, 3
Poa sp.	9.1%	1	SFH													
Polygonum sp.	18%	2	S													
Rumex sp.	9.1%	1	SFH													
Small Poaceae (wild)	9.1%	1	SFH													
Verbena officinalis	9.1%	1	SFH	d, p	med/high	al	m	f	dry	bi/per		v/?s		Aug-Oct	2	1, 3
Large Poaceae (wild)	9.1%	1	BFH													

'weed' taxa from H.V.II Phase 2 (9 samples)	Ubiq.	Total	Seed size and shape	Habitat	Plant height	Ph	Texture	Fertility	Moisture	Life span	Seed bank	Repro.	Germination	Sets seed	Flower. C.	Add. Refs.
Aphanes/Alchemilla sp.	11%	2	S													
Brassica/Sinapis sp.	22%	2	BFH													
Chenopodium album	22%	3	SFH	a, d	high	n	m, h	f	moist	an	4	seed	s	Aug-Oct	2	1, 2, 3
Chenopodium sp.	33%	4	SFH		med/high	n, al	m, h	f	moist, damp	an	?3/4	seed	s	Autumn	2	
Echinocloa crus-galli	11%	4	SFH	a, d	high	al	m, h	f	moist, damp	an	4	seed	a/s	Aug-Oct	3	
Hyoscyamus niger	33%	5	SFH	d	med/high	wa	l	f	moist	an/bi	3?				4	1, 3
Medicago sp.	11%	2	S													
P.somniferum/dubium	11%	1	SHH	a	med	n	m	/	moist	an	4	seed	s/a	Jun-Sept	3	1, 2, 3
Physalis/Solanum sp.	33%	4	SHH	a, d, g, wd		n, al	h	f	moist, damp	an/per						
Plantago lanceolata	11%	1	SHH	a, d, g, p	high	al	m	/	dry, moist	per	3	v+s	s+a	Jun-Sept	3	1, 2, 3
Polygonum sp.	11%	2	S													
Potentilla/Fragaria sp.	11%	1	S		low/med					per						
Small Poaceae (wild)	22%	2	SFH													
Trifolium/Medicago sp.	11%	1	SFH													
cf. *Urtica dioica*	11%	1	SFH	d	high	wa	l, m	f	damp	per	4	v/s	s/a	Aug-Oct	4	1, 2, 3

Table 1.16: Plant macro-remains from Hermanov Vinograd II (continued below)

New sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Original sample number	372	540	321	211	544	592	419	398	340	538	295	273	213	259	270	290	396	275	253	150	128	159	245	170	229	404	16	161	450	421	425	589	534
Context	415	420	390	390	828	830	422	423	308	806	347	297	302	332	323	345	475	175	236	177	242	204	324	171	276	477	14	173	488	486	482	704	703
Feature *	416		391				?																										
Stratigraphic phase	4								4		4	3		3	3	3	3	2			2	2	2	2	2	2	1	1	?	?	?	?	?
Structure									7, phase I		6 (I)			4 (I)	6 (II)		7 (II)				Grv 1	Grv 2	2	4 (II)	6 (III)	7 (III)	1	4 (III)	8 (a)	8 (a)	8(a+1)	7 (a)	7(a+1)
Description	Pit		Pit				Pit		Floor	Harth	Floor	Trp.S	P-hle	Floor	Floor	Pit	Floor	Trp.S	Pit	Pit	fill	fill		Floor	Layer	Floor	Floor	Harth	Pit	Floor	Floor	Floor	Floor
Sample volume (L)	4	8	5	8	10	6	3	8	6	6	8	1	6	6	8	10	8	10	6	8	8	3	2	8	8	3	4	8	6	8	3	6	8
Charcoal >4mm	++	+	+	- -		+	-	++	- -	+	- -	- -	+++	-	-	- -	-	- -	- -	-	-	- -	-	- -	- -	-	- -	- -	- -	+++	+		
2-4mm	++	- -	++	- -		+		++	- -	+++	- -	- -	+++	- -	-	- -	- -	- -	- -	- -	-	- -	-	-	-	- -	-	- -	- -	+++	- -	-	-
<2mm	+++	++	+++	+++	+	+++	+++	+++	++	+++	++	+++	+++	+	+	+++	++	++	++	++	++	++	++	++	++	++	+	+++	+++	+++	+	+	+
volume (ml)	40	2	10	2	0	3	0.5	9	1	15	1	2	70	0.5	0	1.5	1	1	2	1	0	1	0.5	1	1	0.5	0.5	2	2.5	75	1.5	0	0
Cereals																																	
T.monococcum L. 1-grained				1		1							23											4						1			1
T.monococcum L. 2-grained													3																				
T. monococcum grain													8								1									1			
Triticum dicoccum Schübl.	1					1		7	2			1	58			1	1			1									1	2	1		
T. monococcum/dicoccum			2						1				27					1					1	4					2	2			
T. cf. *timopheevi* Zhuk.				1									1					2															
T.dicoccum/'new' type													21				1	1															
Triticum sp. grain	3	1		6					3				58			2			1	1				1		1			1	2			
Indeterminate cereal		2	5			3	1	8	7		2	1	29			6	2	2		5	1					1				1			
Indet. cereal grain fragments														2					3		4			41	7		3	2					
WGE (1 = 0.0133g)														1					1		1			4	1		1	1					
Total grains	**4**	**3**	**7**	**8**	**0**	**5**	**1**	**15**	**13**	**0**	**2**	**2**	**228**	**1**	**0**	**9**	**4**	**6**	**2**	**7**	**3**	**0**	**1**	**13**	**1**	**2**	**1**	**1**	**4**	**9**	**1**	**0**	**1**
Preservation index mean	1	0.3	0.4	1.4	/	1.2	0	0.7	0.8	/	0	1	1.8	0	/	0.4	0.8	1.5	1	0.4	0.7	/	1	1.9	0	0.5	0	0	2	1.6	2	/	2
mode	1	0	0	1	/	0	0	0	1	/	0	0, 2	3	0	/	0	0	0, 3	1	0	0, 2	/	1	2	0	0, 1	0	0	2	1	2	/	2
Fragmentation index	0	0	0	0	/	0	0	0	0	/	0	0	0	N/A	/	0	0	0	3	0	2	/	0	4.6	N/A	0	N/A	N/A	0	0	0	/	0
T. monococcum glume base				1		1							1											1	1			2		1			
T. monococcum sp. fork	4			3		1					2		1			7								1	3			4		1	1		
T. mono/dicoccum gl. base															1																1		
T. mono/dicoccum sp. fork			1																									1					
T. dicoccum glumes base	3		3					2	1	1	1					2			1					1	2		2	11	1	5			1
T. dicoccum spikelet fork			2					4								1			2				1	1			2	2			1		1
T. cf. *timopheevi* gl. base																							1					35					
T. cf. *timopheevi* sp. fork																												8					
T.dico./'new' type gl. base	2		2					1					1															17		4			
T.dico./'new' type sp. fork	2		1								1		1						1						2			11					
Triticum sp. glume base	4	6	9	3		2		5	2		7		3			9				1			1	1	6			93	2	6	1		2
Triticum sp. spikelet fork	5	1		2				2			1		4			1			1	2			1				1	40		8			
Total glume bases	**31**	**8**	**22**	**14**	**0**	**5**	**0**	**20**	**3**	**1**	**16**	**0**	**17**	**0**	**1**	**29**	**0**	**0**	**8**	**3**	**0**	**0**	**6**	**7**	**21**	**0**	**8**	**290**	**3**	**34**	**6**	**0**	**5**
Glume base:grain ratio	**7.8**	**2.7**	**3.1**	**1.8**	**/**	**1**	**0**	**1.3**	**0.2**	**N/A**	**8**	**0**	**0.1**	**0**	**N/A**	**3.2**	**0**	**0**	**4**	**0.4**	**0**	**/**	**6**	**0.5**	**21**	**0**	**8**	**290**	**0.8**	**3.8**	**6**	**/**	**5**
Triticum sp. rachis internodes																											1	2					
Pulses																																	
Lens culinaris	1	1		1 cf.		1							1cf.			1	1	9	3					18	4								1
Pisum sativum		2		1																					1								1
Vicia sp.				1																													
Vicia cf. *ervilia*																								2									
Vicia faba																													2				
Vicia cf. *sativa*																								1									
Indet. Large legume frag.	1		1	2		3										2		1						13	2	1							
Legume equivalent	1		1	1		1										1		1						8	1	1							
Total pulses	**2**	**3**	**1**	**4**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**1**	**10**	**3**	**0**	**0**	**0**	**0**	**29**	**6**	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**2**

New sample number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**
Cornus mas fruit fragments		1		1							2		1cf.				1							5						5	5		
C. mas whole equivalent		1		1							1		1				1							1						2	1		
Corylus avellana shell frags						1												1	1														
Fragaria vesca								1 cf.																	1								
Physalis alkakengi								1			4		1							3				2	2		1						
Prunus sp. fruit stone frag.						1																											
Sambucus sp.				1																													
Sambucus ebulus																1																	
Sambucus racemosa				1																													
indet. Large fruit stone frag.				2																													
Total fruits and nuts	**0**	**1**	**0**	**4**	**0**	**2**	**0**	**2**	**0**	**0**	**5**	**0**	**2**	**0**	**0**	**1**	**1**	**1**	**1**	**3**	**0**	**0**	**0**	**3**	**3**	**0**	**1**	**0**	**0**	**2**	**1**	**0**	**0**
Wild/Weed seeds																																	
Agrostis sp. (1mm long)																	1																
Aphanes/Alchemilla sp.																						2					1						
Atriplex spp.														1																			
Brassica/Sinapis sp.											3				1							1		1									
Chenopodium sp.						3	1						4	1			1		2			1	1					4		1			
Chenopodium album		3	1			7		1	1				5	1						2					1			2		1			1
Echinocloa crus-galli													1	2										4									
Fallopia convolvulus													2																				
Galium aparine				1																								1					
Hyoscyamus niger															1					1			3			1 cf.	1						
Juncus spp.																														5			
Lolium/Festuca sp.																														2			
Lychnis flos-cuculi			1																														
Medicago sp.	1																							2									
Papaver somniferum																1cf.M																	
P. somniferum/dubium																						1											
Phleum sp.							1																					1					
Physalis/Solanum sp.				1		1	1				1 M						1			1			1		2				1				
Plantago lanceolata										1															1 cf.								
Poa sp.											1																						
Polygonum sp.	1		1																					2									
Potentilla/Fragaria sp.																							1										
Rumex sp.							1																					1					
Trifolium sp.															1																		
Trifolium/Medicago sp.																								1									
cf. *Urtica dioica*																									1								
Verbena officinalis											1 M																						
Large Poaceae WGE (wild/dom.)			1	1			1	2			1	1							1		1												1
Large Poaceae WGE (wild,>4mm)				1																								1		1	1		
Medium Poaceae (wild, 2-4mm)																			1														
Small Poaceae (wild,<2mm)							1																	1									
Indeterminate seed	1		1	1							1					1				4		2		1	1		1	2		2			
Total wild seed	**3**	**3**	**5**	**5**	**0**	**11**	**6**	**3**	**1**	**1**	**8**	**1**	**12**	**5**	**3**	**2**	**3**	**0**	**4**	**8**	**1**	**7**	**6**	**12**	**6**	**1**	**3**	**12**	**1**	**12**	**1**	**0**	**2**
Total wild seed (Fat-hen ex.)	3	0	4	5	0	4	6	2	0	1	8	1	7	4	3	2	3	0	4	6	1	7	6	12	5	1	3	10	1	11	1	0	1
Grain:seed ratio	**1.3**	**1.0**	**1.4**	**1.6**	**/**	**0.5**	**0.2**	**5.0**	**13.0**	**0.0**	**0.3**	**2.0**	**19.0**	**0.2**	**0.0**	**4.5**	**1.3**	**N/A**	**0.5**	**0.9**	**3.0**	**0.0**	**0.2**	**1.1**	**0.2**	**2.0**	**0.3**	**0.1**	**4.0**	**0.8**	**1.0**	**/**	**0.5**
Gl. base:seed ratio	**10.3**	**2.7**	**4.4**	**2.8**	**/**	**0.5**	**0.0**	**6.7**	**3.0**	**1.0**	**2.0**	**0.0**	**1.4**	**0.0**	**0.3**	**14.5**	**0.0**	**N/A**	**2.0**	**0.4**	**0.0**	**0.0**	**1.0**	**0.6**	**3.5**	**0.0**	**2.7**	**24.2**	**3.0**	**2.8**	**6.0**	**/**	**2.5**
Non-cereal P.I. mean	**1.2**	**2.1**	**1.2**	**1.2**	**/**	**1.9**	**1.2**	**1.2**	**3**	**3**	**1.6**	**0**	**1.8**	**2.4**	**2.3**	**1.6**	**1.8**	**2.3**	**1.3**	**1.3**	**0**	**1**	**2**	**1.8**	**1.7**	**1**	**2**	**1.6**	**1.3**	**1.7**	**1**	**/**	**1.8**
mode	**1, 2**	**2**	**0, 1**	**1**	**/**	**2**	**1**	**2**	**3**	**3**	**2**	**0**	**2**	**3**	**2**	**2**	**1**	**2**	**1, 2**	**0**	**0**	**0,1,2**	**1,2,3**	**2**	**1, 2**	**1**	**3**	**2**	**1**	**2**	**1**	**/**	**2**
Indet. seed pod fragment			1																														
Food/Parenchyma																26					17							15					2
Grain/Seed density	**2.3**	**1.3**	**2.6**	**2.6**	**0**	**3.3**	**2.3**	**2.5**	**2.3**	**0.2**	**1.9**	**3.0**	**40.5**	**1.0**	**0.4**	**1.4**	**1.1**	**1.7**	**1.7**	**2.3**	**0.5**	**2.3**	**3.5**	**7.1**	**2.0**	**1.3**	**1.3**	**1.6**	**1.2**	**2.9**	**1.0**	**0**	**0.6**
№ items / litre (ex. charcoal)	**10.0**	**2.3**	**7.2**	**4.4**	**0**	**4.2**	**2.3**	**5.0**	**2.8**	**0.3**	**3.9**	**3.0**	**43.3**	**1.0**	**0.5**	**6.9**	**1.1**	**1.7**	**3.0**	**2.6**	**2.6**	**2.3**	**6.5**	**8.0**	**4.6**	**1.3**	**3.5**	**40.0**	**1.7**	**7.1**	**3.0**	**0**	**1.5**
Other finds																																	
bone fragments		-	- -							- -			-																				
burnt bone fragments												-				-								-			- -	-					
bones	- -		- -						-		-		-											-								-	-
burnt stone																														-			
fish scales	- -		- -	-							-					-																	
intrusive roots	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
intrusive seeds		P	P	P		P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P		P	P	P	P	P	P	P		P	P

Table 1.17: Criteria used to identify cereal remains, nuts and seeds. The descriptive terminology for cereals is based on Jacomet 2006, Nesbit 2006 for wild grasses, Bergren 1969 for sedges and Anderberg 1994 for all other taxa.

Taxa & common name	**Code**	**Identification criteria**
Cereal grains and chaff		
Triticum monococcum L. 1-grained einkorn grain	TRITMOO	Laterally compressed, slender grains with rather straight, almost parallel sides. Light, assymetrical dorsal ridges. Strongly attenuated basal and apex ends in side view, and a rounded embryo end on the ventral side. Arched dorsal surface with the highest point generally above the embryo, though for some it was more towards the middle. Curved ventral side with a tight ventral groove. Asymmetrical, elliptical transverse section due to the dorsal ridges.
Triticum monococcum L. 2-grained einkorn grain	TRITMOT	Slender grains, not as compressed as 1-grained varieties. Sides slightly curved with the widest point towards the base of the grain. Light, assymetrical dorsal ridges. In side view the basal and apex ends are still pointy but less attenuated, and the embryo end less rounded than in 1-grained varieties. Arched dorsal surface with the highest point above the embryo. Flat or slightly convex ventral side with a tight ventral groove. Asymmetrical, triangular transverse section due to the dorsal ridges.
Triticum monococcum L. einkorn glume base/spikelet fork	TRITMOG/ TRITMOS	Narrow spikelet, gently fanning away from the internode. Long, narrow abscission scar. Prominent glume keel extending outwards in line with the dorsal face of the glume (abaxially). The keel stops at the abscission scar. Lateral glume surface smooth to lightly ridge. Einkorn chaff finer, more delicate than emmer and the 'new' type.
Triticum dicoccum Schübl emmer grain	TRITDIC	Oval grains with the widest point towards the centre of the grain. Arched dorsal surface with the highest point generally above the embryo. In side view slightly attenuated basal and apex ends, and curved embryo end on the ventral side. Ventral groove less tight than in einkorn. Ventral surface flat or slightly convex. Usually symmetrical, 'church-door' transverse section. Grains 'fatter' than einkorn.
Triticum dicoccum Schübl emmer glume base/ spikelet fork	TRITDIG/ TRITDIS	Flared spikelet. Shorter, oval to round abscission scar. Prominent glume keel extending away from/perpendicular to the main dorsal face of the glume. The keel stops before the abscission scar and is less prominent than in einkorn. Lateral glume surface lightly to strongly ridged.
Triticum cf. *timopheevi* Zhuk./Striate emmeroid grain (as described by Kohler-Schneider 2003)	TRITEMM	Long, 'rectangular' grains with the same height throughout. Sides almost parallel, very gently curved with the widest point towards the apex. Apex and base appear flat in side view but gently rounded in both dorsal and ventral view. Ventral surface flat with relatively tight groove. Symmetrical around the dorsal ridge, transverse section like that of emmer but more rounded and less high.
Triticum cf. *timopheevi* Zhuk/Striate emmeroid glume base/spikelet fork (as first described by Jones *et al*. 2000a)	TRITEMG/ TRITEMS	Narrow spikelet with glumes that extend 'upwards' slightly more than in einkorn, where they tend to fan out. Wide, round abscission scar. Primary keel like in einkorn but descends to almost below the abscission scar. The same can be said of the keel on the outside of the spikelet which curls inwards where the glume affixes to the internode. Lateral glume surface lightly to strongly ridged.
Triticum aestivum/durum free-threshing wheat grain	TRITFTW	Short, oval grains with the widest point towards the centre of the grain. Apex flat in dorsal view and rounded in side view. Apex and embryo end on the ventral side are gently attenuated. Highest point slighty back from the tip of the embryo. Very rounded ventral side with an open ventral groove. Flat to slightly convex in side view. Symmetrical oval transverse section. Grains shorter and 'rounder' than emmer.
Hordeum vulgare ssp. vulgare hulled barley grain	HORDSAI	Long, angular grains with impressions of enveloping lemna and palea still present on some. Flat/angular dorsal and ventral planes, both convex in side view. Widest point towards the centre of the grain.

Taxa & common name	Code	Identification criteria
		Highest point between the tip of the embryo and the middle of the grain. Apex appears flat in dorsal view but narrow and rounded in side view. Open ventral groove. Symmetrical angular transverse section. A twisted ventral grove on well preserved grains indicated the presence a of 6-row variety
Hordeum vulgare ssp. nudum naked barley grain	HORDSAN	Long, rounded grains with thin 'wiggly' parallel lines running perpendicular to the length of the grain. Rounded dorsal and ventral sides, in both plane and side views. Widest point towards the centre of the grain. Highest point between the tip of the embryo and the middle of the grain. Apex flat in dorsal view and rounded in side view, less narrow than in hulled barley. Symmetrical, almost circular transverse section. A twisted ventral groove on well preserved grains indicated the presence a of 6-row variety
Hordeum vulgare sensu lato undifferentiated barley grain	HORSASN	Grains and fragments of grains too poorly preserved to be identified to hulled or naked barley
Secale cereale L. rye grain	SECACEG	Thin oval grains with gently convex sides. The widest point of the grain is towards the middle. The highest point is just above the embryo, after which the height gently reduces to the narrowest point at the apex. Apex flat to angular in dorsal and side view. Attenuated basal end with a long scutellum. In side view the dorsal face is flat and the ventral slightly convex. Deep ventral groove. Symmetrical, almost circular transverse section.
Panicum miliaceum L. broomcorn millet grain	PANIMIL	Oval to rounded grains with a wide scutellum that reaches half way across the grain, rising abruptly in lateral view. Circular hilum slightly set back from the base of the scutellum
Pulses		
Lens culinaris Medik. lentil	LENSCUL	Lenticular, flattened seed, circular in outline with a sharp border/edge. Surface dull and smooth. Hilum not visible but lens (chalazal area) distinct in some. No bigger than 3mm in diameter. Often found as loose cotyledons with section of long, narrow radicle visible
Pisum sativum L. pea	PISUSAT	Globose with some flattened sections. Surface dull and smooth. Narrow, lenticular hium close to short, broader radicle. The seeds are no bigger than 3.5mm long and 4.4mm wide
Vicia ervilia (L.) Willd. bitter vetch	VICIERV	Ovoid seed with flat ventral (radicular) face, slightly concave side faces. Surface dull and smooth. Hilum poorly preserved and lens visible on one specimen. Similar in size to the peas: 3.7mm long and 3.3mm wide
Vicia faba L. broad bean	VICIFAB	Broadly ellipsoid seed with flattened seeds, though puffing is visible from charring. Quite broad, elliptic hilum almost covering the length of the basal surface. Specimens small: 4mm long and 5mm wide
Vicia sativa L. common vetch	VICISAT	Globose seed, circular in outline with dull, smooth surface. Hilum not well preserved but seems narrow and covers about ¼ of the circumference. Lens not visible. 3mm long and thick
Edible fruits and nuts (those more commonly known to have been collected as such)		
Cornus mas L. cornelian cherry stone	CORNMAS	Large ellipsoid seed. Surface with some longitudinal ridges and grooves and a main broader, shallow ridge encircling the seed. Often broken to reveal two cells (pyrene). Large, irregular vacuoles clearly visible in the mesocarp
Corylus avellana L. hazel nut shell fragments	CORYAVE	Thin, curved fragments with smooth surfaces. Longitudinal furrows visible in transverse section
Crataegus monogyna Jacq. hawthorn	CRATMON	Globose seed with pitted surface, with quite deep irregular, longitudinal grooves. Pit visible on ventral face
Fragaria vesca L.	FRAGVES	Generally ovoid with a strong rounded beak. Short ventral suture with

Taxa & common name	Code	Identification criteria
wild strawberry		a pointy attachment scar. Surface lightly veined
Physalis alkakengi L. bladder cherry	PHYSALK	Flattened mitaform seed, more elongated and rounded at the embryo tips than *H.niger*. Ruminate surface, like *H.niger* though not as deep
Prunus sp. Stone of the cherry group	PRUNSPE	Thick, ligneous fragment of a fruit stone. Surface deeply and irregularly veined
Sambucus ebulus L. dwarf elder	SAMBEBU	Ovoid seed with a globose to elliptic transverse section. Ventral face (attachment scar) short and flat. Scrobiculate-favulariate surface
Sambucus nigra L. common elder	SAMBNIG	Elliptic seed, narrower than *S.ebulus*. Surface ruminate-favulariate
Sambucus racemosa L. red elder	SAMBRAC	Seed broadly elliptic, more symmetrical around the transversee transverse-section that *S.ebulus*. Surface similar to *S.ebulus* but ridges not as pronounced
Other herbaceous taxa		
Agrostemma githago L. corncockle	AGROGIT	The seed is badly preserved but the flat dorsal face, curved obovate embryo and distinct 'spiky' testa surface survives: densely aculeate
Agrostis sp. bents	AGROSPE	Small (<2mm) grass seed with a short embryo with a deep ventral groove
Ajuga/Teucrium sp. bugleweed/germander	TEUCAJU	The seeds are ovate to broadly ovate with a broadly or circular ventral 'pit'. The surfaces are badly preserved but seem ruminate.
Alchemilla sp. lady's mantle	ALCHSPE	Ovoid seed with a slightly curved, acute apex. Ventral suture not visible. Short, sub-basal attachment scar. Surface finely areolate
Alchemilla/ Aphanes sp. lady's-mantles / parsley-pierts	APHAALC	Same as above but slightly smaller seed. Beak more pointy and hooked.
Anchusa sp. alkanet	ANCHSPE	Ovoid seed with an open, circular aril and slightly hooked beak. Rugose testa surface.
Anthemis arvensis L. mayweed	ANTHARV	Small obovoid seed with a flat apex with quite a broad, circular attachment scar. Surface finely areolate and irregularly indented with shallow furrows
Apium graveolens L. wild celery	APIUGRA	Ovate seed. Angular convex dorsal plane with five thin ridges, with valleculae wider than ridges. Flat ventral surface
Artemisia sp. mugworts	ARTESPE	Small obovoid seed with a flat attachment scar and open, circular apex. Surface lightly ridge, though not well preserved
Asteraceae type 1 daisy family	COMPIND	HV I Seed of similar shape and size to Artemisia but badly preserved. Flat apex with broadly circular attachment scar visible
Atriplex sp. oraches	ATRISPE	Circular seed with a slight notch where the curved radicle meets the cotyledons. Slightly laterally compressed. Diagnostic spiral pattern on the testa
Avena sp. oat, wild/domestic	AVENSPE	Long (>4mm) grass seed with a flattened, slightly puffed, ventral surface with a very tight groove. Long pointy embryo that seems to carry on down the mid dorsal ridge. Flat apex
Brassicaceae type 1 cabbage/mustard family	CRUCIND	HV I Small round seed. Hilum and testa indistinct
Brassica/Sinapis sp. Cabbages / mustards	BRASSIN	small round seed. Hilum indistinct. Testa seemingly areolate to reticulate
Bromus sp. bromes	BROMSPE	Large grass seed (>4mm), with a short, pointy embryo. Thin and convex transverse section. Side ventral furrow with a long linear hilum
Carex muricata L. prickly sedge	CAREMUR	Large, flattened seed with gently tapering ends. Narrow elliptic transverse section. Surface finely areolate
Carex nigra (L). Reichard	CARENIG	Small ellipsoid sedge seed with pointy apexes, ellipsoid transverse-

Taxa & common name	Code	Identification criteria
common-sedge		section
Carex sylvatica Huds. Wood-sedge	CARESYL	Trilete sedge seed with, smooth, rounded ridges. Asymmetrical around the horizontal plane. Slightly elongated beak and flattened base.
Cerastium sp. mouse-ears	CERASPE	Small cuneate type with an indistinct attachment scar. Testa not well preserved but ruminate to aculeate
Chenopodium album L. fat-hen	CHENALB	Circular seed with a slight notch where the curved radicle meets, and extends over the cotyledons. Small 'pimple' in the centre form which radiate very light furrows. Nutlet often separated from charred embryo
Chenopodium hybridum L. maple-leaved goosefoot	CHENHYB	Circular seed with a shallow notch where the curved radicle meets, but does not extend over the cotyledons. Larger than *C.album* and with a much more dimpled surface
Crucianella sp. cross-worts	CRUCSPE	Obovoid seed with a wide, oval attachment scar. Testa with short longitudinal ridges
Echinocloa crus-galli (L.) Beauv. - barnyard millet	ECHICRG	Small, oval seed. Broadly ovate transverse section, slightly dorsally depressed. Broad, long embryo covering about ¾ of the seed
Euphorbia peplus L. petty spurge	EUPHPEP	Seed elliptic in outline, obtusely 6-angled in transverse section. Truncated apex and clear raphe. Surface is scrobiculate with rows of oval pits
Fallopia convolvulus (L).Á Löve. - black bindweed	POLYCON	Large ovate, trilete Polygonaceae, asymmetrical about the mid-horizontal plane. Finely areolate ligneous testa.
Galeopsis/Stachys sp. Hemp-nettles / woundworts	GALESTA	Large Lamiaceae obovate seed with a prominent ventral ridge, slightly convex dorsal side and slightly concave dips by the attachment scar. Testa surface destroyed
Galium aparine L. cleavers	GALIAPA	Circular seed with oval attachment scar. Smooth charred surface
Hyoscyamus niger L. henbane	HYOSNIG	Broadly ovate seed with an oval transverse section. Attachment scar from the edge to almost the centre of the ventral side. Deeply ruminate surface.
Juncus sp. rushes	JUNCSPE	Narrowly ovate seed with a pointy apex and flat base. Areolate surface with some stronger longitudinal ridges just visible
Lamiaceae types 1, 2 and 3 mint family	LABIIND	Types 1 and 2 (Potporanj) are broadly elliptic and have a circular transverse section. They are c.1mm long and 0.8mm wide, but they seemed to have puffed out. Type 3 (Bapska House 2) is slightly more elongated and thinner. The testa are badly preserved
Lapsana communis L. nipplewort	LAPSCOM	Narrowly ovate seed with a convex side. The other side is divided into 3 by evenly spaced longitudinal ridges. Finer longitudinal ridges are visible between the main ridges and the across the other side.
Linum catharticum L. fairy flax	LINUCAT	Obovate, laterally flattened seed. 1.5mm long by 0.5mm wide
Lolium sp. rye-grasses	LOLITEM	Long grass seed (>4mm), rounded transverse section and straight basal end. Angled furrow with long thin hilum. Slightly pointy scutellum.
Lolium/Festuca sp. rye-grasses / fescues	FESTLOL	Medium grass seeds (2-4mm), short embryo and long linear hilum. Rounded transverse section which may be due to charring
Lychnis flos-cuculi L. catchflies	LYCHFLC	Small, sub-circular seed with a distinct attachment scar. Testa with a tight aculeate pattern radiating out from the attachment scar
Medicago sp. mediks	MEDISPE	Mitaform seed. Radicular lobe 1/3 of the length of the cotyledonary lobe. Radicular lobe is not beaked. Seeds 2mm to 3mm long
Montia fontana ssp. *Chondrosperma* (Fenzl) Walters. - blinks	MONTFON	Small circular seed with a notch where the curved radicle meets, and extends over the cotyledons. Testa with diagnostic dense tuberculate surface radiating out in a spiral

Taxa & common name	Code	Identification criteria
Odontites/Euphrasia sp. bartsias / eyebrights	ODONEUP	Narrowly elliptic seed. Attachment scar is not well preserved but some of the surface pattern is: fine densely packed transverse lines crossed by thicker longitudinal ones
Papaver somniferum L. opium poppy (Swarbrick & Raymond 1970)	PAPASOM	Rounded, reniform seed with a tight, concave but open ventral face. Surface areolate-reticulate with little change in size and shape of the individual polygons (unlike in other Papaver species where they tend to elongate towards the outer edges). Polygons with 5-6 angles. See Fig.1 above. *P.dubium/somniferum* is smaller and the testa not as well preserved
Persicaria lapathifolia (L.) Gray. - pale persicaria		Broadly elliptic seed with a broad ovate transverse-section; one side is flattened and the other slightly convex. Short, pointed apex and rounded base.
Persicaria maculosa Gray. redshank	POLYPER	Ovate, laterally flattened seed, elliptic in transverse section. Smooth testa
Phleum sp. cat's tail	PHLESPE	Small (<2mm) ellipsoid grass seed, round transversesection. No visible ventral furrow or hilum. Curved scutellum
Physalis/Solanum sp. Japanese lanterns /nightshades	PHYSSOL	Flattened mitaform seed. Badly preserved testa
Plantago lanceolata L. ribwort plantain	PLANLAN	Elliptic seed with a wide, elliptic 'dent' on the ventral side, in the middle of which the attachment scar is visible
Poa sp. meadow grasses	POASPEC	Small (<2mm) ellipsoid grass seed with a globose transverse section. Steep embryo and circular scutellum
Polygonum aviculare L. knotgrass	POLYCON	Trilete, obovoid seed, irregularly triangular. Elongated towards the apex. Striate surface texture
Polygonum sp. knotgrass	POLYSPE	Trilete Polygonum with the embryo on the angled ridge. Testa areolate
Potentilla sp. cinquefoils	POTESPE	Generally ovoid. The beak is not prominent and the suture runs almost the whole length of the ventral side. Surface veined but poorly preserved
Prunella vulgaris L. selfheal	PRULVUL	Obovate seed with an elliptic transverse section. The diagnostic 'life-jacket' pattern is visible
Ranunculus bulbosus/acris/repens	RANUARB	Obovate seed, elliptic transverse section. Apex is pointy and base gently rounded. Surface ligneous and finely areolate. Dorsal edge more strongly rounded than ventral suture.
Rumex sp. dock	RUMESPE	Ovate trilete seed, with long embryo running between two of the ridges. Not well preserved
Rumex acetosella L. sheep's sorrel	RUMEACE	Small broadly elliptic rumex with rounded ridges and smooth testa
Setaria verticillata/viridis wild millets	SETVIVE	Small (<2mm) ellipsoid grass seed. Flattened ventral face with a sub-basal oval hilum. Long, triangular embryo
Stellaria sp. stitchworts	STELSPE	Large, circular-ovate type with fairly distinct attachment scar. Surface covered in papillae which become more pointy towards the dorsal ridge
Thalictrum sp. meadow rue	THALSPE	Narrowly ovate seed with a little beak at the apex. Surface longitudinaly ridged
Trifolium sp. clover	TRIFSPE	Mitaform seed. Radicular lobe at least ½ of the length of the cotyledonary lobe. Radicular lobe is not beaked. Seeds no longer than 1mm
Urtica dioica L. common nettle	URTIDIO	Ovate seed with tapered base and slightly tapered apex. Elliptic transverse section. Dull surface
Valerianella locusta (L.) Laterr lamb's lettuce	VALELOC	Mineralised fuite from Bapska House 2. Strongly convex side suggesting it is wild

Taxa & common name	**Code**	**Identification criteria**
Verbena officinalis L. common verbena	VEREOFF	Elliptic seed with tapered ends. About 1/3 of the dorsal side is irregularly veined, before turning regular and longitudinal
Veronica hederifolia L. Ivy-leaved speedwell	VEROHED	Similar to Galium aparine, only more ovate and with a ribbed surface texture

APPENDIX II
Tables, Figures and additional Information for Chapter 8

2.1 Average summer (June, July, August) and winter (December, January, February) temperatures

Table 2.1: Average temperatures (C°) at 8000 BP, based on data from (Mauri *et al*. 2015)

BIOREGION	COUNTRY	SITE	LAT	LON	Summ. Temp	Winter Temp.
CONTINENTAL	FYROM	Anza	41.810	22.000	19.62	1.80
		Vršnik III	41.480	22.370	24.22	4.89
	BiH	Kakanj	44.130	18.123	19.36	1.09
		Obre I	44.103	18.151	19.36	1.09
	Romania	Măgura-Buduiasca	44.02	25.406	23.11	0.84
	Serbia	Mesarci	44.600	19.900	22.40	3.05
		Zablaće	44.630	19.690	22.40	3.05
		Belotić	44.570	19.710	22.40	3.05
		Divostin	44.030	20.830	19.96	1.55
		Blagotin	43.720	21.100	19.96	1.55
		Drenovac	43.780	21.440	19.96	1.55
		Međurec	43.960	21.180	19.96	1.55
		Jaričište 1, Mali Borak	44.47	20.22	18.95	0.97
PANNONIAN	Serbia	At	45.136	21.281	21.70	2.29
		Starčevo-Grad	44.810	20.680	21.70	2.29
	Croatia	Sopot	45.280	18.800	22.01	2.91
		Tomašanci-Palača	45.380	18.410	20.84	2.02
	Hungary	Ecsegfalva	47.150	20.920	22.06	0.55
		Battonya-Basarága	46.270	21.050	21.97	1.53
		Méhtelek-Nádas	47.930	22.840	20.14	-1.95
		Ibrány-Nagyerdő	48.100	21.700	21.12	-1.05
		Berettyóújfalu-Nagy	47.600	21.900	21.12	-1.05
		Tiszaszölös-Domaháza	47.560	20.700	21.55	-0.76
	Romania	Circea	44.270	23.900	23.11	0.84
		Tăşnad-Sere	47.780	22.970	20.14	-1.95
		Foeni-Salaş	45.49	20.86	21.70	2.29
COASTAL	Croatia	Crno Vrilo	44.200	15.300	23.60	9.57
		Pokrovnic	43.804	16.070	22.77	7.03
		Tinj-Podlivade	44.030	15.440	23.60	9.57
		Kargadur-Ližnjan	44.800	13.900	23.10	8.73
	Italy	Fiorano	44.530	10.830	24.11	5.59
		Valler	45.880	12.710	22.59	6.42
		Scamuso	41.080	16.990	24.81	11.70
		Torre Canne	40.830	17.480	24.81	11.70
		Coppa Nevigata	41.500	15.750	23.03	9.91
		Masseria Valente	41.630	15.900	23.03	9.91
		Rippa Tetta	41.510	15.310	23.03	8.13
		Torre Sabea	40.070	18.000	26.86	13.21
		Rendina	40.990	15.650	23.03	9.91
		Sito 3 Lago di Rendina	41.020	15.740	23.03	9.91
		Foggia ex-Ippodromo	41.450	15.560	23.03	9.91
		Monte Calvello	41.360	15.310	22.33	8.13
		Monte San Vincenzo	41.360	15.310	22.33	8.13
		Titolo	41.159	16.762	24.81	11.70
		Lagnano da Piede	41.200	15.700	23.03	9.91
		Villa Comunale di Foggia	41.450	15.560	23.03	9.91
		Canosa	41.220	16.070	23.03	9.91
		Grotta della Mura	40.950	17.290	24.81	11.70
		Pulo di Molfetta	41.194	16.575	24.81	11.70
		Defensola A	41.880	16.170	23.03	9.91
		Masseria Candelaro	41.620	15.900	23.03	9.91
		Terragne	40.391	17.620	26.86	13.21

Table 2.2: Average inland temperatures (C°) at 7000 BP, based on data from (Mauri *et al*. 2015)

BIOREGION	COUNTRY	SITE	LAT	LON	Summ. Temp	Winter Temp.
CONTINENTAL	BiH	Korića Han	44.690	18.290	21.66	1.98
		Obre II	44.103	18.151	19.32	0.74
		Donje Moštre	44.025	18.170	19.32	0.74
		Laminci Jaružani	45.108	17.373	20.18	1.00
		Laminci Jaružani-Njiva	45.114	17.362	20.18	1.00
		Zagrebnice	44.082	18.090	19.32	0.74
		Jagnilo	43.640	18.970	16.07	-1.44
		Butmir	43.824	18.310	19.32	0.74
		Kočićevo	45.070	17.409	20.18	1.00
		Kosjerovo	44.963	17.393	20.18	1.00
		Kundruci	44.038	18.069	19.32	0.74
		Okolište	44.033	18.141	19.32	0.74
	Romania	Liubcova	44.660	21.890	18.97	-1.27
		Tell Laceni	44.720	24.880	21.23	-1.81
		Vladiceasca	44.670	26.090	23.01	-1.08
		Măgura-Buduiasca	44.02	25.406	22.40	-1.08
	Serbia	Drenovać	43.780	21.440	21.06	1.70
		Gomolova	44.889	19.749	23.70	2.31
		Medvednjak	44.400	20.960	21.06	1.70
		Motel-Slatina	43.864	21.438	21.06	1.70
		Vinča-Belo brdo	44.762	20.623	22.79	2.17
		Selevac	44.500	20.880	21.06	1.70
		Valač	42.940	20.820	14.76	-2.17
		Pavlovac-Gumnište	42.490	21.850	20.61	2.36
		Petnica	44.245	19.936	18.99	0.72
		Belovode	44.320	21.430	21.06	1.70
		Divostin	44.030	20.830	21.06	1.70
		Pločnik	43.210	21.360	14.76	-2.17
		Jaričište 1	44.470	20.220	18.99	0.72
PANNONIA		Opovo	45.048	20.461	23.70	2.31
		Potporanj	45.020	21.240	22.79	2.17
	Croatia	Sopot	45.280	18.800	23.19	2.38
		Virovitika-Brekinja	45.840	17.350	22.58	1.53
		Slavća	45.250	17.380	20.18	1.00
		Ravnjaš-Nova Kapela	45.190	17.640	21.66	1.98
		Ivandvor—Šuma Gaj	45.320	18.380	21.66	1.98
		Hermanov Vinograd	45.550	18.690	23.61	1.42
		Tomašanci-Palača	45.380	18.410	21.66	1.98
		Otok	45.150	18.860	23.19	2.38
		Bapska	45.193	19.259	23.19	2.38
	Hungary	Ludas, Varjú dűlő	46.1	18.01	22.60	1.40
		Tiszaszőlős-Domaháza puszta	47.560	20.700	22.49	-1.52
		Füzesaboy-Gubakút	47.750	20.400	21.46	-1.93
		Szentgyörgyvölgy-Pityerdomb	46.720	16.400	20.61	-0.48
		Becsehely-Bükkalji dűlő	46.440	16.780	22.58	1.53
		Becsehely-Újmajori tábla	46.48	16.84	22.58	1.53
		Dévaványa-Réhelyi gát	47.030	20.960	23.20	-0.29
		Abony 49	47.210	19.910	23.17	0.10
		Regéc	48.400	21.340	22.49	-1.52
		Marcali-Lókpuszta	46.560	17.370	22.11	0.42
		Mosonszentmiklós-Pálmajor	47.720	17.460	21.69	-0.21
		Pári-Altäcker dűlőple	46.630	18.210	23.13	0.63
		Petrivente	46.430	16.840	22.58	1.53
		Sormás-Mántai dűlő	46.48	16.91	22.58	1.53
		Törökbálint Dulácska	47.440	18.880	23.50	0.82
		Szombathely – A. lakópark	47.210	16.580	22.11	0.42
		Battonya-Parázstanya	46.286	21.019	23.22	0.79
		Battonya-Vertán major	46.390	20.970	23.22	0.79
		Berettyóújfalu-Herpálye	47.080	21.330	23.20	-0.29
		Berettyóújfalu-Szilhalom	47.080	21.330	23.20	-0.29
		Tiszapolgár-Csőszhalom	47.520	21.060	22.49	-1.52
		Polgár 6	47.880	21.080	22.49	-1.52
		Polgár 7	47.880	21.080	22.49	-1.52
		Polgár 10/11	47.880	21.080	22.49	-1.52
		Polgár 31	47.880	21.080	22.49	-1.52
		Polgár 34	47.880	21.080	22.49	-1.52
		Börcs-Paphomlok	47.680	17.530	22.01	-0.41
		Lengyel	46.380	18.340	23.60	1.35
		Moha-Homokbánya	47.240	18.330	23.13	0.63
		Lébény-Billedomb	47.750	17.390	21.69	-0.21
		Sümeg-Mogyorósdomb	46.960	17.290	22.11	0.42
	Romania	Uivar	45.690	20.900	23.22	0.79

Table 2.3: Average coastal temperatures (C°) at 7000 BP, based on data from (Mauri *et al*. 2015)

BIOREGION	COUNTRY	SITE	LAT	LON	Summ. Temp	Winter Temp.
COASTAL	Croatia	Grapčeva cave	43.130	16.750	26.83	10.36
		Pokrovnic	43.804	16.070	23.98	6.32
		Danilo	43.710	16.030	23.98	6.32
		Čista Mala Velištak	43.880	15.780	23.98	6.32
		Turska Peć	44.330	15.440	24.59	7.79
	South Italy	Grotta S'Angelo	40.720	17.570	24.56	9.81
		Scamuso	41.080	16.990	25.51	11.01
		Masseria Candelaro	41.620	15.900	24.56	9.81
		Vhó di Piadena	45.128	10.384	23.99	3.34
		Masseria Fontanarosa	41.620	15.840	24.56	9.81
		Masseria Santa Tecchia	41.620	15.900	24.56	9.81
		Passo di Corvo	41.540	15.610	24.56	9.81
		Oria Sant'Anna	40.500	17.630	27.10	12.77
		Grotte Santa Croce	41.176	16.468	24.56	9.81
		Capo Rondinella	40.480	17.180	24.56	9.81
		San Domenico	40.700	17.330	25.51	11.01
		Serra Cicora	40.171	17.949	27.10	12.77
		Carpignano Salentino	40.197	18.34	27.10	12.77
		Grotta della Tartaruga	41.080	16.990	25.51	11.01
		Olivento di Lavello	41.049	15.790	24.56	9.81
	North Italy	Spilamberto	44.450	11.020	19.02	2.66
		San Marco Gubbio	43.130	12.361	23.47	7.66
		Defensola A	41.880	16.170	24.56	9.81
		Sammardenchia	45.980	13.220	23.49	4.89
		Vela in Trento	46.080	11.010	15.79	-1.62
		Piancada	45.780	13.080	23.49	4.89
		Fagnignola	45.854	12.687	23.49	4.89
		Pavia di Udine	45.990	13.300	23.49	4.89
		Isorella	45.300	10.310	23.99	3.34
		Lugo di Romagna	45.820	12.200	20.69	0.93
		Catignano	42.350	13.950	20.69	4.70
		Palù di Livenza	46.011	12.481	20.69	0.93
		Forli- via Navicella	44.250	12.090	22.53	4.98
		Fimon Molino Casarotto	45.470	11.510	24.60	4.87
		Rivarolo Mantovano	45.087	10.455	23.99	3.34
		Casatico di Marcaria	45.120	10.530	24.58	4.54
		Maserà	45.325	11.859	24.60	4.87

2.2 The presence of plant macro-remains by site (site references are listed at the end of the tables by site number)

Table 2.4: The Early Neolithic - Inland

		FYROM		BiH			CROATIA		SERBIA										HUNGARY													ROMANIA				
		1.Anza	2.Vršnik	3.Gornja Tuzla	4.Kakanj	5.Obre I	6.Sopot	7.Tomašanci-Palača	8.Mesarci	9.Zablaće	10.Belotić	11.Divostin	12.Blagotin	13.Drenovac	14.Međurec	15.Jaričište 1, Mali Borak	16.Starčevo-Grad	17.Aṫ	18.Ecsegfalva	19.Battonya-Basarága	20.Méhtelek-Nádas	21.Ibrány-Nagyerdő	22.Berettyóújfalu-Nagy	23&24.Tiszaszőlős-Domaháza	25.Röske-Ludvár	26.Győmaendrőd	27.Hódmezővásárhely–G.–Kovácstanya	28.Kéthely-Falu	29.Szeged–Gyálarét	30.Szarvas	31.Szarvas–Szappanosi	32.Tăşnad-Sere	33.Circea	34.Hărman	35.Foeni-Salaş	36.Măgura-Buduiasca
AGRMSPE	*Agrostemma* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AJUGSPE	*Ajuga sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASTRSPE	Astragalus sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENFAT	*Avena fatua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AVENHOR	*Avena/Hordeum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSAT	*Avena sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSPE	Avena sp.	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BRASSIN	Brassica/Sinapis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BROMARV	*Bromus arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMHOR	*B. hordeaceus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSEC	*B. secalinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
BROSTTE	*B. sterilis/tectorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BUGLARV	*Buglossoides arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CALANEP	*Calamintha nepeta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CAPPSPI	*Capparis spinosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAREELA	*Carex elata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CARVUMU	*C. vulpina/muricata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CARYIND	Caryophyllaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERINDG	Cereal indeterminate grains	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	1
CHENALB	*Chenopodium album*	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENIND	Chenopodiaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CHENSPE	*Chenopodium* sp.	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
COMPIND	Compositeae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	1	0	0	1	1	0	1	0	0	0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CORNSAN	*Cornus sanguina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRUCIND	Cruciferae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
CYPESPE	*Cyperus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIANSPE	*Dianthus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIGISPE	*Digitaria* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELEOPAL	*Eleocharis palustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHCYP	*Euphorbia cyparissias*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHHEL	*Euphorbia helioscopia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHPAL	*Euphorbia palustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHSPE	*Euphorbia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4	**Site number**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23|4**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
FRAGVES	*Frageria vesca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FUMASPE	*Fumaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALELAD	*Galeopsis ladanum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
GALIAPA	*Galium aparine*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
GALISPU	*Galium spurium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
GRAMIND	Poaceae indeterminate	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1
GRAMINH	Poaceae indet. husks/glumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0
HELOEUR	*Heliotropium europaeum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HELOSPE	*Heliotropium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	1	0	1	0	0	0	0	1	1	0	1	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	1
HORDSAN	*H. vulgare* var *nudum* naked grain	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAS	*H. vulgare* 6-row hulled grain	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
HORDSNR	*H. vulgare var nudum* r. internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSPE	*Hordeum* sp. grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
HORDSRI	*H. vulgare* hulled r. internode	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRT	*H. vulgare* 2-row hulled rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORSASN	*Hordeum vulgare* grain	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1
HORSSNR	*H. vulgare* rachis internode	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYPISPE	*Hypericum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHSAT	*Lathyrus sativus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHSPE	*Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUINL	Large Fabaceae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LEGUINS	Small Fabaceae	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LENSCUL	*Lens culinaris*	1	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
LENSSPE	*Lens* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LILIIND	Liliaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLIRIG	*Lolium rigidum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLISPE	*Lolium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LOLITEM	*Lolium temulentum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MALUPUM	*Malus pumila*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUSYL	cf. *Malus sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MALVSYL	*Malva sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MELISPE	*Melilotus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MORAIND	Moraceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MYOSARV	*Myosotis arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
ODONEUP	*Odontites/Euphrasia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLEAEUR	*Olea europaea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNIPYR	*Ornithogalum pyramidale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
PANISPE	*Panicum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAPASOM	*Papaver* cf. *Somniferum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAPASPE	*Papaver* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
PHYSALK	*Physalis alkekengi*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
PISULAT	*Pisum/Lathyrus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSAT	*Pisum sativum*	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1
PISUSPE	*Pisum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUVIC	*Pisum/Vicia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLANSPE	*Plantago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4	Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23|4	25	26	27	28	29	30	31	32	33	34	35	36
POAANNU	*Poa annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYAVI	*P. aviculare*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCON	*P. convolvulus*	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
POLYCYP	Polygonaceae/Cyperaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYDUMP	*P. dumetorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPER	*P. persicaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYSPE	*Polygonum sp.*	0	0	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PORTOLE	*Portulaca oleracea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRULVUL	*Prunella vulgaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
PRUNSPE	*Prunus* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PYRUMAL	*Pyrus/Malus* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUSPE	*Pyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERROB	*Quercus robur*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERSPE	*Quercus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
RANUREP	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
RESESPE	*Reseda* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROSACAN	*Rosa canina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBIIND	Rubiaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUFRU	*Rubus fruticosus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUIDA	*Rubus idaeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUSPE	*Rubus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
RUMESPE	*Rumex* sp.	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
SAMBNIG	*Sambucus nigra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SAMBSPE	*Sambucus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMNIRA	*S. nigra/racemosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SANGOFF	*Sanguisorba officinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SAPOOFF	*Saponaria officinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SCIMALA	*Scirpus maritimus/lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEEDIND	Indeterminate seed	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1
SETAVIR	*Setaria viridis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETISPE	*Setaria* sp.	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETVIVE	*Setaria viridis/verticillata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SHERARV	cf. *Sherardia arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SILEALB	*Silene alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILESPE	*Silene* sp.	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SOLAIND	Solanaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
SONCASP	*Sonchus asper*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
STACANN	*Stachys annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
STELMED	*Stellaria media*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STELSPE	*Stellaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TEUCCHA	*Teucrium chamaedrys*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TEUCSPE	*Teucrium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
THALMIN	*Thalictrum minus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TRIDEMG	*T.dicoccum*/*timopheevi* gl. base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDICS	*T. dicoccum* spikelet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDIEM	*T.dicoccum*/*timopheevi* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDSPG	*T. dicoccum/spelta* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFARV	*Trifolium arvense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.4	Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	2223|4		25	26	27	28	29	30	31	32	33	34	35	36
TRIFTHR	Hexaploid free-thr wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFTTR	Tetraploid free-thr wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIGLWG	Glume wheat glume bases	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TRIGLWS	Glume wheat spikelet forks	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIHORG	Wheat / Barley grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODG	*T. dicoccum/monococcum* gl.base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
TRIMODI	*T. dicoccum/monococcum* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TRIMODS	*T. mono./dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRISPLS	*Triticum spelta* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	0	1	0	0	0	1	1	1	0	0	0	1	0	0	1	0	1	1	1
TRITDIG	*T. dicoccum* glume base	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TRITEMG	*T.timopheevi* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRITEMM	*T.timopheevi* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTH	Hexaploid free-thr wheat grain	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
TRITFTR	Free-thr wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTT	Tetraploid free-thr wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
TRITFTW	Free-threshing wheat grain	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOG	*T. monococcum* glume base	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1
TRITMON	*T. monococcum* grain (1 or 2g)	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1	0	0	0	1	0	0	0	1	1	1	1
TRITMOO	*T. monococcum* grain (1g)	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRITMOS	*T. monococcum* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOT	*T. monococcum* grain (2g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRITSPE	Indeterminate wheat grain	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	1
TRITSPH	Indet. wheat glumes/husks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0
URTISPE	*Urtica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UTRIVUL	*Utricularia vulgaris*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALESPE	*Valerianella* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEROHED	*Veronica hederifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VICIHIR	*Vicia hirsuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICISAT	*Vicia sativa*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIOLSPE	*Viola* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISYL	*Vitis sylvestris*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

References for Early Neolithic inland sites: **1**-Renfrew 1976; **2, 4&5**-Renfrew 1974; **3**-Hopf 1967; **6&7**-Reed 2015; **8, 9, 10**-Borojević 2006; **11**, **13&14**-Filipović & Obradović 2013, Obradović 2013; **12**&**35**-Jezik 1998; **15**-Borojević 2013; **16**-Renfrew 1979; **18**-Bogaard *et al*. 2007; **19, 20, 23** to **31**-Gyulai 2010a; **21**&**22**-Gyulai 2010b; **33**- Cârciumaru 1991; **34**- Cârciumaru 1996; **36**-Bogaard & Walker 2011.

Table 2.5: E. Neolithic - Coastal

		CROATIA						SOUTH ITALY																							N. ITALY	
		37.Grapčeva cave	38.Krčina cave	39.Pokrovnic	40.Tinj-Podlivade	41.Crno Vrilo	42.Kargadur-Ližnjan	43.Torre Sabea	44.Terragne	45.Fontanelle	46.Grotta S'Angelo	47.Torre Canne	48.Grotta della Mura	49.Scamuso	50.Titolo	51.Pulo di Molfetta	52.Canosa	53.Sito 3 Lago di Rendina	54.Rendina	55.Lagnano da Piede	56.Monte Calvello	57.Monte San Vincenzo	58.Foggia ex-Ippodromo	59.Villa Comunale di Foggia	60.Rippa Tetta	61.Coppa Nevigata	62.Monte Aquilone	63.Masseria Candelaro	64.Masseria Valente	65.Defensola A	66.Fiorano	67.Valler
AGRMSPE	*Agrostemma* sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AJUGSPE	*Ajuga* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ASTRSPE	*Astragalus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENFAT	*Avena fatua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENHOR	*Avena/Hordeum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
AVENSAT	*Avena sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
AVENSPE	*Avena* sp.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BRASSIN	*Brassica/Sinapis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMARV	*Bromus arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMHOR	*B. hordeaceus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSEC	*B. secalinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1
BROSTTE	*B. sterilis/tectorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BUGLARV	*Buglossoides arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CALANEP	*Calamintha nepeta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAPPSPI	*Capparis spinosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAREELA	*Carex elata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARVUMU	*C. vulpina/muricata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARYIND	Caryophyllaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
CERINDG	Cereal indeterminate grains	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
CHENALB	*Chenopodium album*	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENIND	Chenopodiaceae indeterminate	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENSPE	*Chenopodium* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
COMPIND	Compositeae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNSAN	*Cornus sanguina*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
CRUCIND	Cruciferae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
CYPESPE	*Cyperus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIANSPE	*Dianthus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIGISPE	*Digitaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ELEOPAL	*Eleocharis palustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHCYP	*Euphorbia cyparissias*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHHEL	*Euphorbia helioscopia*	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
EUPHPAL	*Euphorbia palustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
EUPHSPE	*Euphorbia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
FRAGVES	*Frageria vesca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.5	**Site number**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**
FUMASPE	*Fumaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
GALELAD	*Galeopsis ladanum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALIAPA	*Galium aparine*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALISPU	*Galium spurium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAMIND	Poaceae indeterminate	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAMINH	Poaceae indet. husks/glumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HELOEUR	*Heliotropium europaeum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HELOSPE	*Heliotropium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	0	1	0	0	0	0	0	0	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1
HORDSAN	*H. vulgare* var *nudum* naked grain	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
HORDSNR	*H. vulgare* var *nudum* r. internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
HORDSPE	*Hordeum sp. Grain*	0	0	0	0	0	0	0	1	1	0	0	1	1	1		1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
HORDSRI	*H. vulgare* hulled r. internode	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRT	*H. vulgare* 2-row hulled r.internode	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORSASN	*Hordeum vulgare* grain	0	1	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	1
HORSSNR	*Hordeum vulgare* rachis internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYPISPE	*Hypericum* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHSAT	*Lathyrus sativus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHSPE	*Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
LEGUINL	Large Fabaceae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUINS	Small Fabaceae	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LENSCUL	*Lens culinaris*	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
LENSSPE	*Lens* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
LILIIND	Liliaceae indeterminate	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLIRIG	*Lolium rigidum*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLISPE	*Lolium* sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LOLITEM	*Lolium temulentum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUPUM	*Malus pumila*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUSYL	cf. *Malus sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALVSYL	*Malva sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MELISPE	*Melilotus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MORAIND	Moraceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MYOSARV	*Myosotis arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ODONEUP	*Odontites/Euphrasia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLEAEUR	*Olea europaea*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORNIPYR	*Ornithogalum pyramidale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANISPE	*Panicum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PAPASOM	*Papaver* cf. *Somniferum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAPASPE	*Papaver* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PHYSALK	*Physalis alkekengi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISULAT	*Pisum/Lathyrus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSAT	*Pisum sativum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.5	Site number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
PISUSPE	*Pisum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
PISUVIC	*Pisum/Vicia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PLANSPE	*Plantago* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POAANNU	*Poa annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYAVI	*P. aviculare*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCON	*P. convolvulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCYP	Polygonaceae/Cyperaceae indet.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
POLYDUM	*P. dumetorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPER	*P. persicaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYSPE	*Polygonum* sp.	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
PORTOLE	*Portulaca oleracea*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNSPE	*Prunus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUMAL	*Pyrus/Malus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUSPE	*Pyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERROB	*Quercus robur*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANUREP	*Ranunculus repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RESESPE	*Reseda sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
ROSACAN	*Rosa canina*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBIIND	Rubiaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUFRU	*Rubus fruticosus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUIDA	*Rubus idaeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
RUBUSPE	*Rubus* sp.	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMESPE	*Rumex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMNIRA	*S. nigra/racemosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SANGOFF	*Sanguisorba officinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAPOOFF	*Saponaria officinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCIMALA	*Scirpus maritimus/lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEEDIND	Indeterminate seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
SETAVIR	*Setaria viridis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETISPE	*Setaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETVIVE	*Setaria viridis/verticillata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHERARV	cf. *Sherardia arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILEALB	*Silene alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILESPE	*Silene* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SOLAIND	Solanaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STACANN	*Stachys annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STELMED	*Stellaria media*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STELSPE	*Stellaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEUCCHA	*Teucrium chamaedrys*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEUCSPE	*Teucrium* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THALMIN	*Thalictrum minus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDEMG	*T.dicoccum/timopheevi* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDICS	*T. dicoccum* spikelet	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDIEM	*T.dicoccum/timopheevi* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDSPG	*T. dicoccum/spelta* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.5	Site number	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
TRIFARV	*Trifolium arvense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFTHR	Hexaploid free-thr wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFTTR	Tetraploid free-thr wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRIGLWG	Glume wheat glume bases	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRIGLWS	Glume wheat spikelet forks	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
TRIHORG	Wheat / Barley grain	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
TRIMODG	*T. dicoccum/monococcum* gl.base	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODI	*T. dicoccum/monococcum* grain	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TRIMODS	*T. dicoccum/monococcum* sp. Fork	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
TRISPLS	*Triticum spelta* spikelet fork	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1
TRITDIG	*T. dicoccum* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0
TRITEMG	*T.* cf. *timopheevi* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITEMM	*T.* cf. *timopheevi* grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTH	Hexaploid free-thr wheat grain	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
TRITFTR	Free-threshing wheat rachis	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TRITFTT	Tetraploid free-thr wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOG	*T. monococcum* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRITMON	*T. monococcum* grain (1 or 2g)	0	0	1	0	1	1	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	1
TRITMOO	*T. monococcum* grain (1g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOS	*T. monococcum* spikelet fork	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0
TRITMOT	*T. monococcum* grain (2g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPE	Indeterminate wheat grain	0	0	1	1	0	0	1	1	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	1	0	1
TRITSPH	Indeterminate wheat glumes/husks	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta* grain	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
URTISPE	*Urtica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
UTRIVUL	*Utricularia vulgaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALESPE	*Valerianella* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
VEROHED	*Veronica hederifolia*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIHIR	*Vicia hirsuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICISAT	*Vicia sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0
VIOLSPE	*Viola* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISYL	*Vitis sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

References for Early Neolithic coastal sites: **37**-Borojević *et al*. 2008; **38**-Müller 1994:64; **39**-Reed & Colledge 2016; **40**-Huntley 1996; **41**-Marijanović 2009; **42**-Komšo 2005; **43**- Costantini & Lentini 2003, Marinval 2003; **44, 48, 49, 50, 52, 55, 60, 63, 64, 65**-Fiorentino *et al.* 2013; **45**-Coppola & Costantini 1987; **43, 46, 49, 53, 54, 55, 60, 61, 63**-Costantini & Stancanelli 1994; **47, 62**-Evett & Renfrew 1971; **51**-Primavera & Fiorentino 2011; **55**-Jones 1987b; **56**&**57**-D'Oronzo *et al*. 2008; **58**-D'Oronzo & Fiorentino 2006; **59**-Nisbet 1982; **66**-Carugati 1993; **66**&**67**-Rottoli & Castiglioni 2009; Rottoli & Pessina 2007.

Table 2.6: E. Neolithic – Bulgaria and Greece

		BULGARIA																		GREECE & CRETE												
		1.Kovačevo	2.Gălăbnik	3.Slatina	4.Elešnika	5.Kapitan Dimitrievo	6.Karanovo	7.Poljanica Platoto	8.Koprivec	9.Orlovec	10.Kremenik	11.Rakitovo	12.Čavdar	13.Okrăžna Bolnica	14.Tell Azmak	15.Malăk Preslavec	16.Dzhulyunitsa	17.Samavodene	18.Kazanlak	1.Mavropigi-Fyllotsairi	2.Franchthi cave	3.Gediki	4.Achilleion	5.Argissa	6.Soufli	7.Sesklo	8.Otzaki	9.Podromos	10.Nea Nikomedeia	11.Giannitsa B	12.Knossos	13.Toumba Balomenou
ADONFLA	*Adonis flammea*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGRIEUP	*Agrimonia eupatoria*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
AJUGCHA	*Ajuga chamaendrys*	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AJUGGEN	*Ajuga genevensis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALKASPE	*Alkanna* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
ALYSSPE	*Alyssum* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMARSPE	*Amaranthus* sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMYGCOM	*Amygdalus communis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
ANAGARV	*Anagallis arvensis*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APHAARV	*Aphanes arvensis*	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARENSPE	*Arenaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
ASPEARV	*Asperula* sp.	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASTRSPE	*Astragalus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
ATRISPE	*Atriplex* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATROBED	*Atropa bella-donna*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSPE	*Avena* sp.	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	0	1	1
BRASSPE	*Brassica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMARV	*Bromus arvensis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSEC	*B. secalinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	1	0	1	0	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BROSTTE	*B. sterilis/tectorum*	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BUGLARV	*Buglossoides arvensis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0
CAPPIND	Capparaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARPBET	*Carpinus betulus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARYIND	Caryophyllaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
CENTSPE	*Centaurea* pp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CERINDG	Cereal indeterminate grains	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	1	0	1	0	0	1
CHENALB	*Chenopodium album*	1	0	1	0	1	1	0	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENFIC	*Chenopodium ficifolium*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENFOL	*Chenopodium foliosum*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENIND	Chenopodiaceae indeterminate	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
CHENMUR	*Chenopodium murale*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENPOL	*Chenopodium polyspermum*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENSPE	*Chenopodium* sp.	1	0	1	0	1	1	0	1	1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CHLOSPE	*Chloris* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CICEARI	*Cicer arietinum*	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CIRSCAR	*Cirsium/Carduus* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CIRSVUL	*Cirsium vulgaris*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMPIND	Asteraceae indeterminate	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.6	**Bulgarian and Greek sites**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
CONVARV	*Convolvulus arvensis*	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORISAT	*Coriandrum sativum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	1	1	1	0	1	1	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0
CORNSAN	*Cornus sanguina*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COROSCO	*Coronilla scorpioides*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	1	0	1	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYSPE	*Corydalis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
CRUCIND	Cruciferae indeterminate	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
CYPESPE	*Cyperus* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIGISAN	*Digitaria sanguinalis*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIPSIND	Dipsacaceae indeterminate	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ERODSPE	*Erodium* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHIND	Euphorbiaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
FESTLOL	*Festuca/Lolium*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FICUCAR	*Ficus carica*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	1
FRAGVES	*Frageria vesca*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FUMAOFF	*Fumaria officinalis*	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FUMASPE	*Fumaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GALAPSP	*Galium aparine/spurium*	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALEOFF	*Galega officinalis*	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALIAPA	*Galium aparine*	0	0	1	0	0	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
GALIMOL	*Galium mollugo*	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
GALISPE	*Galium* sp.	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
GALISPU	*Galium spurium*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
GRAMIND	Poaceae indeterminate	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	1	1	0	1	0	0	1
HELOEUR	*Heliotropium europaeum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HELOSPE	*Heliotropium* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIBITRI	*Hibiscus trionum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare*	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	1	1	1	0	0	1	0
HORDSAN	*H. vulgare* var *nudum*	0	1	1	1	1	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	1	0	1	1	0	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0
HORDSPE	*Hordeum* sp. Grain	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRI	*H. vulgare* rachis internode (hulled)	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRS	*H. vulgare* rachis (6-row hulled)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
HORDSRT	*H. vulgare* rachis (2-row hulled)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
HORSASN	*Hordeum vulgare*	1	0	1	1	1	1	1	0	0	0	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0
HORSPSA	*H. spontaneum/vulgare* grains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
HORSPSR	*H. spontaneum/vulgare* rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
HORSSNR	*Hordeum vulgare*	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYPIPER	*Hypericum perforatum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUGLSPE	*Juglans* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
JUNCSPE	*Juncus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LABIIND	Lamiaceae indeterminate	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LAMISPE	*Lamium* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAPSCOM	*Lapsana communis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.6	**Bulgarian and Greek sites**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
LATCISA	*Lathyrus cicera/sativus*	1	1	1	1	1	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LATHCIC	*Lathyrus cicera*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LATHSAT	*Lathyrus sativus*	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
LATHSPE	*Lathyrus* sp.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LEGUINL	Large Fabaceae	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	1	0	1	0	0	1
LEGUINS	Small Fabaceae	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LENSCUL	*Lens culinaris*	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0	1
LENSNIG	*Lens nigricans*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LENSSPE	*Lens* sp.	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	1	0	1	1	1	0	0	1	0
LINUBIE	*Linum bienne*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUSPE	*Linum* sp.	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LITHOFF	*Lithospermum officinalis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLIREM	*Lolium remotum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLISPE	*Lolium* spp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
LOLITEM	*Lolium temulentum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
MALUSPE	*Malus* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MALVSPE	*Malva* sp.	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MEDISPE	*Medicago* sp.	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
NESLSPE	*Neslia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
OLEASPE	*Olea* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PANIIND	Panicoideae indeterminate	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PANISPE	*Panicum* spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PAPARHO	*Papaver rhoeas*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLEPHL	*Phleum phleoides*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYSALK	*Physalis alkekengi*	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISTALT	*Pistacia atlantica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PISTSPE	*Pistacia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0
PISTTER	*Pistacia terebinthus*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PISUSAT	*Pisum sativum*	1	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	0	0	0	0	1	0	1	1	1	1	1	1	0	0	1
PISUSPE	*Pisum* sp.	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1	0	0	1	0
PLANIND	Plantaginaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
PLANLAN	*Plantago lanceolata*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLANSPE	*Plantago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
POAANNU	*Poa annua*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLCARV	*Polycnemum arvense*	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYAVI	*P. aviculare*	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCON	*P. convolvulus*	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYIND	Polygonaceae indet.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
POLYMIN	*Polygonum minus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPER	*P. persicaria*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYSPE	*Polygonum* sp.	1	1	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
POOIIND	Pooideae indeterminate	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PORTOLE	*Portulaca oleracea*	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0

Table 2.6	**Bulgarian and Greek sites**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
POTESPE	*Potentilla* sp.	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNDOM	*Prunus domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNSPE	*Prunus* sp.	1	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
PRUNSPI	*Prunus spinosa*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
PUNISPE	*Punica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PYRMASO	*Pyrus/Malus/Sorbus* sp.	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUAMY	*Pyrus amygdaliformis*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUMAL	*Pyrus/Malus* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYRUSPE	*Pyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERSPE	*Quercus* sp.	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	1	0	0	1
ROSASPE	*Rosa* spp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBIPER	*Rubia peregrina*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUCAE	*Rubus caesius*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUFRU	*Rubus fruticosus*	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUSPE	*Rubus* sp.	1	0	1	0	1	1	0	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1
RUMEACE	*Rumex acetosella*	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMECRI	*Rumex crispus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMESPE	*Rumex* sp.	1	0	1	0	1	1	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SAMBEBU	*Sambucus ebulus*	0	0	1	0	1	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
SAMBNIG	*Sambucus nigra*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBRAC	*Sambucus racemosa*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SCLEANN	*Scleranthus annuus*	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCLESPE	*Scleranthus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SCIRLAC	*Scirpus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECASPE	*Secale* sp.	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETAVER	*Setaria verticillata*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETAVIR	*Setaria viridis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETVIVE	*Setaria viridis/verticillata*	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHERARV	cf. *Sherardia arvensis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILEALB	*Silene alba*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILESPE	*Silene* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SINAARV	*Sinapis arvensis*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOLASPE	*Solanum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
STELSPE	*Stellaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
TEUCCHA	*Teucrium chamaedrys*	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THYMPAS	*Thymelaea passerina*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIFTHR	Hexaploid free-threshing rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TRIGLWG	Glume wheat glume bases	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIGLWS	Glume wheat spikelet forks	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODI	*T. dicoccum/monococcum*	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODS	*T. mono./dicoccum* spikelet forks	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
TRITBOE	*Triticum boeoticum* grains (1/2g)	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.6	**Bulgarian and Greek sites**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
TRITDIC	*T. dicoccum*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
TRITDIG	*T. dicoccum*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIO	*T. dicoccum* (1g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
TRITDIS	*T. dicoccum* spikelet	1	0	1	0	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0
TRITEMG	'New' glume wheat glume base	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
TRITFTH	Hexaploid free-threshing grain	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
TRITFTR	Free-threshing wheat rachis	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	1	1	1	1	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TRITMOG	*T. monococcum*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
TRITMON	*T. monococcum*	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1
TRITMOO	*T. monococcum*	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0
TRITMOS	*T. monococcum* spikelet fork	1	0	1	0	1	1	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TRITMOT	*T. monococcum*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
TRITSPE	Indeterminate wheat grain	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMBEIND	Apiaceae indeterminate	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
URTISPE	*Urtica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VALEDEN	*Valerianella dentata*	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VERBPHL	*Verbascum phlomoides*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VERBSPE	*Verbascum* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
VEREOFF	*Verbena officinalis*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VEROHED	*Veronica hederifolia*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	1
VICIHIR	*Vicia hirsuta*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICILAT	*Vicia/Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
VICISAT	*Vicia sativa*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* spp.	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
VICITET	*Vicia tetrasperma*	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICTEHI	*Vicia tetrasperma/hirsurta*	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
VITISYL	*Vitis sylvestris*	1	0	1	0	1	1	0	0	1	1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1

References for Early Neolithic Bulgarian sites (c.6000-5400 cal. BC): **1, 3, 5**- Marinova 2006; **2, 4, 6, 7, 10, 11, 12, 13, 14, 15**- Marinova 2007; **2, 10**- Marinova *et al.* 2002; **8, 9, 16, 17**- Marinova & Krauss 2014; **6, 12, 14, 18**- Renfrew 1979; **18**- Dennell 1974, 1978.
References for Early Neolithic Greek sites (c.62000-53000 cal. BC): **1**- Valamoti 2011; **2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13**- Valamoti & Kotsakis 2007; **2, 3, 4, 5, 6, 7, 10, 12-** Renfrew 1979.

Table 2.7: Middle/Late Neolithic BiH and Serbia

		BOSNIA and HERZEGOVINA															SERBIA																
		68.Gornja Tuzla	69.Lisičići	70.Lug (Goražde)	71.Jagnilo	72.Butmir	73.Donje Moštre	74.Kundruci	75.Okolište	76.Zagrebnice	77.Obre II	78.Korića Han	79.Kosjerovo	80.Laminci Jaružani	81.Laminci Jaružani-Njiva	82.Kočićevo	93.Vinča-Kragujevac	94.Predionica	95.Valač	96.Pavlovac-Gumnište	97.Pločnik	98.Drenovač	99.Motel-Slatina	100.Divostin	101.Petnica	102.Jaričište 1, Mali Borak	103.Medvednjak	104.Belovode	105.Selevac	106.Vinča-Belo brdo	107.Gomolava	108.Opovo	109.Potporanj
ABIEALB	*Abies alba* needles	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
AJUGCHA	*Ajuga chamaepitys*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ALCHSPE	Alchemilla sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALNUGLU	*Alnus glutinosa*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALTHOFF	*Althaea officinalis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMARSPE	*Amaranthus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
ANAGSPE	*Anagallis* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANDRSPE	Androsace sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
ANTHARV	*Anthemis arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ANTHCOT	*Anthemis cotula*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANTHSPE	*Anthemis* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASPESPE	*Asperula* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
ATRIPAT	*Atriplex patula*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATROBED	*Atropa bella-donna*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ATRPAHA	*Atriplex patula/hastata*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSPE	*Avena* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0
BRASSIN	Brassica/Sinapis sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BRASSPE	Brassica sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMARV	*Bromus arvensis*	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
BROMMOL	*B.mollis*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSEC	*B. secalinus*	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	1	1
BUGLARV	*Buglossoides arvensis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0
CAMPIND	*Campanulaceae indeterminate*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CAPSBUP	*Capsella bursa-pastoris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
CAREVUL	*Carex vulpina*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARPBET	*Carpinus betulus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARYIND	Caryophyllaceae	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
CENTSPE	*Centaurea* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CERASPE	*Cerastium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
CERINDG	Cereal indeterminate grains	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	1	1
CERINDH	Cereal indet. husk/glumes/etc.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHENALB	*Chenopodium album*	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	1	0	1
CHENCAR	Chenopodiaceae/Caryophyllaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
CHENFIC	*C. ficifolium*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
CHENIND	Chenopodiaceae indeterminate	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
CHENPOL	*C. polyspermum*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
CHENSPE	Chenopodium sp.	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	0
COMPIND	Compositeae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CONVARV	*Convolvulus arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 2.7	Site number	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
CORNMAS	*Cornus mas*	0	0	0	1	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	1	1	1	1	1	1
CORNSAN	*C. sanguina*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	0	0	0	1	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1
CRUCIND	Cruciferae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
CYNOSPE	*Cynodon* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYPESPE	*Cyperus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIGISPE	*Digitaria* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0
EUPHHEL	*E. helioscopia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
EUPHSPE	*Euphorbia* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRAGSPE	*Fragaria* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRAGVES	*Frageria vesca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1
GALIAPA	*Galium aparine*	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1
GALIMOL	*G. mollugo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
GALISPU	*G. spurium*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
GALIVER	*G. verum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GERASPE	*Geranium* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAMIND	Poaceae indeterminate	0	0	0	1	0	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	1
GRAMINS	Poaceae indeterminate stems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
HORBUSP	*Hordeum bulbosum/spontaneum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	1	1	1	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0
HORDSAN	*H. vulgare* var *nudum* naked grain	0	0	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRI	*H. vulgare* hulled r. internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
HORSASN	*Hordeum vulgare* grain	0	1	0	1	0	1	1	1	1	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	0	1	0	0	0
HORSSNR	*Hordeum vulgare* rachis internode	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
HYOSSPE	*Hyoscyamus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYPISPE	*Hypericum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
JUNICOM	*Juniperus communis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LABIIND	Lamiaceae indeterminate	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
LAPSCOM	Lapsana communis	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
LATCISA	*Lathyrus cicera/sativus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
LATHNIS	*Lathyrus nissolia*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHSAT	*Lathyrus sativus*	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
LEGUINL	Large Fabaceae	0	0	0	1	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0
LEGUINS	Small Fabaceae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LENSCUL	*Lens culinaris*	0	0	0	1	1	1	0	1	0	1	1	0	0	0	0	0	0	0	1	1	1	1	0	0	1	0	1	1	1	1	1	1
LILIIND	Liliaceae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUCAT	*Linum catharticum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
LINUSPE	*Linum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	0	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	1	1	1	0
LOLIPER	*Lolium perenne*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LOLISPE	*Lolium* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
LOLITEM	*Lolium temulentum*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUSPE	*Malus* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUSYL	cf. *Malus sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
MALVIND	Malvaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 2.7	**Site number**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
MENTSPE	*Mentha* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MESOIND	Indeterminate fruit mesocarp	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MYOSARV	*Myosotis arvensis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
PHALSPE	*Phalaris* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
PHLESPE	*Phleum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
PHRACOM	*Phragmites communis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
PHYSALK	Physalis alkekengi	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	0	1
PISUSAT	*Pisum sativum*	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	1	1	1	1	0	0	0	0	0	1	1	1	1	0	0
PISUSPE	*Pisum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PLANLAN	*Plantago lanceolata*	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
POASPEC	*Poa* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
POLYARE	*P. arenastrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
POLYAVI	*P. aviculare*	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0
POLYCON	*P. convolvulus*	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	0	1
POLYIND	Polygonaceae indeterminate	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPER	*P. persicaria*	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
POLYSPE	*Polygonum* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	1	1
PRULVUL	*Prunella vulgaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRUNDOM	*Prunus domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
PRUNFRU	*P. fruticosa*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNSPE	Prunus sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
PRUNSPI	*P. spinosa*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1
PYRUCOM	*Pyrus communis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
PYRUMAL	*Pyrus/Malus* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
PYRUSPE	*Pyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
QUERSPE	*Quercus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
RANUARV	*R. arvensis*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANUREP	*R. repens*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANUSPE	*Ranunculus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
RAPHRAN	*Raphanus raphanistrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
ROSASPE	*Rosa* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBIDFR	*Rubus idaeus/fruticosus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
RUBUCAE	*R. caesius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
RUBUFRU	*Rubus fruticosus*	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
RUBUIDA	*R. idaeus*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUSPE	*Rubus* sp.	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	0
RUMEACE	*Rumex acetosella*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMECRI	*R. crispus*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMESPE	*Rumex* sp.	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1
SAMBNIG	*S. nigra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
SAMBRAC	*S. racemosa*	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SCHOSPE	*Schoenoplectus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SCIMALA	*Scirpus maritimus/lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SCIRSCH	*Scirpus/Schoenoplectus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SCLEANN	*Scleranthus annuus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.7	**Site number**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**
SCROSPE	*Scrophularia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SECACEG	*Secale cereale*	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECASPE	*Secale* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
SEEDIND	Indeterminate seed	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	1	1
SETAITA	*Setaria italica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SETAPAN	*Setaria/Panicum*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETAPUM	*S. pumila*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETAVIR	*Setaria viridis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETISPE	*Setaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
SETVIVE	*S. viridis/verticillata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1
SILESPE	*Silene* sp.	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
SISYSPE	*Sisymbrium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SOLADUL	*Solanum dulcamara*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SOLAIND	Solanaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0
SOLANIG	*Solanum nigrum*	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
SOLASPE	*Solanum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SONCARV	*Sonchus arvensis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STACANN	*Stachys annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
STELMED	*Stellaria media*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STELPAL	*S. palustris*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEUCAJU	*Teucrium/Ajuga* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TEUCCHA	*Teucrium chamaedrys*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TEUCHSC	*T. chamaedrys/scorodonia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
TEUCSPE	*Teucrium* sp.	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
THALSPE	*Thalictrum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
THYMPAS	*Thymelaea passerina*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TILISPE	*Tilia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
TRIDEMG	*T. dicoccum*/'new' type gl. base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
TRIDEMS	*T. dicoccum*/'new' type spk.fok	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIDICS	*T. dicoccum spikelet*	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDIEM	*T. dicoccum*/'new' type grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIFARV	*Trifolium arvense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
TRIFMED	*Trifolium/Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIFREP	*T. repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1
TRIFTHR	Hexaploid free-threshing rachis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
TRIFTTR	Tetraploid free-threshing rachis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIGLWG	Glume wheat glume bases	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TRIGLWS	Glume wheat spikelet forks	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIGSPE	*Trigonella* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIHORG	Wheat / Barley grain	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMDEG	*T. mono/dico.*/'new' type gl base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
TRIMDEM	*T. mono/dico.*/'new' type grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
TRIMODG	*T. mono./dicoccum* gl.base	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
TRIMODI	*T. mono./dicoccum*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
TRIMODS	*T. mono./dicoccum* spk.fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 2.7	**Site number**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**
TRISPLG	*T.spelta* gl.base	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	0	0	0	1	0	1	1	1	1	1	1	1	0	0	1	0	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1
TRITDIG	*T. dicoccum* glume base	0	0	0	1	0	1	1	1	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	1	1
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
TRITEMG	'New' type gl. base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
TRITEMM	'New' type grain	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1
TRITFTH	Hexaploid free-threshing grain	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTR	Free-threshing wheat rachis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRITFTW	Free-threshing wheat grain	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	1	1	0	1	1	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRITMOG	*T. monococcum* glume base	0	0	1	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	1	1
TRITMON	*T. monococcum* grain (1/2g)	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	1
TRITMOO	*T. monococcum* grain (1g)	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	1	1	1
TRITMOS	*T. monococcum* spk.fork	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
TRITMOT	*T. monococcum* grain (2g)	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TRITSPE	Indeterminate wheat grain	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1	1	1	0	0	1
TRITSPH	Indet. wheat glumes/husks	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPR	Indet. *Triticum* rachis inernode	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMBEIND	Umbelliferae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
URTIDIO	*Urtica dioica*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VACCPYR	*Vaccaria pyramidata*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VACCSPE	*Vaccaria* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEREOFF	*Verbena officinalis*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VERBSPE	*Verbascum* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEROHED	*Veronica hederifolia*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEROSPE	*Veronica* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICILAT	*Vicia/Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
VIOLSPE	*Viola* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
VITISYL	*Vitis sylvestris*	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
XANTSTR	*Xanthium strumarium*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

References for Middle/Late Neolithic BiH and Serbian sites: **68**-Hopf 1967; **69**&**70**-Hopf 1958; **71**-Kroll Unpublished; **72**-Renfrew 1979, Schröter 1895; 7**3, 74, 75, 76**-Kroll 2013b; **75**-Kroll 2013a; **77**- Renfrew 1974; **93, 94, 95, 105**-Hopf 1974; **94, 95, 108**-Borojević 2006; **96, 99, 101, 103, 106**-Filipović & Obradović 2013; **98**-Obradović 2013; **97**-Filipović Submitted-a; **99**-Perić *et al*. 2015; **100**-Grüger & Beug 1988; **102**-Borojević 2013; **104**-Filipović Submitted-b; **106**-Filipović 2004, Filipović & Tasić 2012; **107**-van Zeist 1975, 2001.

Table 2.8: Middle/Late Neolithic Hungary

		HUNGARY																																		
		110.Ludas, Varjú dűlő	111.Becsehely-Újmajori	112.Becsehely-Bükkalji dűlő	113.Petrivente	114.Sormás-Mántai dűlő	115.Szent.-Pityerdomb	116.Marcali-Lókpuszta	117.Lengyel	118.Pári-Altäcker dűlő	119.Sümeg-Mogyorósdomb	120.Szom.-Aranypatak	121.Moha-Homokbánya	122.Börcs-Paphomlok	123.Moson.-Pálmajor	124.Lébény-Billedomb	125.Törökbálint Dulácska	126.Abony 49	127.Battonya-Parázstanya	128.Battonya-Vertán major	129.Dévaványa-Réhelyi	130.Berettyóújfalu-Herpály	131.Berett.-Szilhalom	132.Tiszaszőlős-Domaháza	133.Tisza.-Csőszhalom	134.Füzesaboy-Gubakút	135.Polgár 6	136.Polgár 7	137.Polgár 10/11	138.Polgár 31	139.Polgár 34	140.Regéc	141.Tiszavasvár-Keresztfal	142.Szeg.-Kovácshalom	143.Szegvár-Tűzköves	144.Hód.-Cukortania
AETHCYN	*Aethusa cynapium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
ALCHVUL	*Alchemilla vulgaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AMARLIV	*Amaranthus lividus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AMARSPE	*Amaranthus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANAGARV	*Anagallis arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANEMNEM	*Anemone nemorosa*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APHAALC	*Aphanes/Alchemilla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
ASTRGLY	*Astragalus glycyphyllos*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATRIPAT	*Atriplex patula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
AVENFAT	*Avena fatua*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0
AVENSPE	*Avena* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BRASRAP	*Brassica rapa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BROINRA	*Bromus inermis/ramosus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMARV	*Bromus arvensis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
BROMSEC	*B. secalinus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BROSEMO	*Bromus secalinus/mollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
CAMESAT	*Camelina sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CAREHIR	*Carex hirta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAREVUL	*Carex vulpina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CARVUMU	*C. vulpina/muricata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CERINDG	Cereal indeterminate grains	1	1	0	1	1	1	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	0	1	0	1	0	1
CHENALB	*Chenopodium album*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
CHENSPE	Chenopodium sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CICHINT	*Cichorium intybus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
CONVARV	*Convolvulus arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
COROVAR	*Coronilla varia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CRATMON	*Crataegus monogyna*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
CUSCEUR	*Cuscuta europaea*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DIGIISC	*Digitaria ischaemum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
DIGISAN	*Digitaria sanguinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
ELEOPAL	*Eleocharis palustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
EUPHCYP	*Euphorbia cyparissias*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
FESTPRA	*Festuca pratensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
FRAGVES	*Frageria vesca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
GALIMOL	*G. mollugo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0

Table 2.8	**Site number**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**	**141**	**142**	**143**	**144**
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALISPU	*G. spurium*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0
GALIVER	*G. verum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
GLAUCOR	*Glaucium corniculatum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
GLYCNAX	*Glyceria maxima*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
GRAMIND	Poaceae indeterminate	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0
GRAMINH	Poaceae husks/glumes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
GRAMINS	Poaceae indeterminate stems	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
HELOEUR	*Heliotropium europaeum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
HORDMUR	*Hordeum murinum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	1	0	0	1	0	0	1	1	0	0	1	0	1	1	0	1	1	0	0	1	0	0	1	0	1	0	1	1	1	0	1	0	0	0	0
HORDSAN	*H. vulgare* var *nudum* naked grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0
HORDSRI	*H. vulgare* hulled r. internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
HORSASN	*Hordeum vulgare* grain	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
LATHSAT	*Lathyrus sativus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LEGUINS	Small Fabaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LENSCUL	*Lens culinaris*	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0
LEOPCOM	*Leopoldia comosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LINUSPE	*Linum* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LOLIREM	*Lolium remotum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LOTUCOR	*Lotus corniculatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LYCHFLC	*Lychnis flos-cuculi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MALUSYL	cf. *Malus sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
MALVPUS	*Malva pusilla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MALVSPE	*Malva* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MALVSYL	*Malva sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MEDILUP	*Medicago lupulina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0
MEDIMIN	*Medicago minima*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MELAARV	*Melampyrum arvense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MELIALB	*Melilotus albus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MOLICAE	*Molinia caerulea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OXALCOR	*Oxalis corniculata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	0	0
PHLEPRA	*Phleum pratense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PHRAAUS	*Phragmites australis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PIMMASA	*Pimpinella major/saxifraga*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PINUSYL	*Pinus sylvestris*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSAT	*Pisum sativum*	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0
PISUSPE	*Pisum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PLANLAN	*Plantago lanceolata*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
POAANNU	*Poa annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
POAPRAT	*Poa pratensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
POASPEC	*Poa* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
POLYAVI	*Polygonum aviculare*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
POLYCON	*P. convolvulus*	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0
POLYDUM	*P. dumetorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Table 2.8	Site number	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
POLYIND	Polygonaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
POLYMIN	*Polygomun minus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
POLYMIT	*Polygonum mite*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
POLYSPE	*Polygonum* sp.	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
POTEREP	*Potentilla reptans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
PRULVUL	*Prunella vulgaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PRUNAVI	*Prunus avium*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNCAR	*Prunus ceracifera*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PRUNDOM	*Prunus domestica*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PRUNSPE	Prunus sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
PRUNSPI	*P. spinosa*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
QUERPUB	*Quercus pubescence*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERSPE	*Quercus* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
RANUREP	*R. repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
RUMEACE	*Rumex acetosella*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
RUMEACT	*Rumex acetosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
RUMECRI	*R. crispus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
RUMEOBT	*Rumex obtusifolius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
RUMESAN	*Rumex sanguineus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SANGOFF	*Sanguisorba officinalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
SAPOOFF	*Saponaria officinalis*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SCHOMUC	*Schoenoplectus mucronatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SCIRLAC	*Scirpus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0
SCIRMAR	*Scirpus maritimus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SCLEANN	*Scleranthus annuus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
SECACEG	*Secale cereale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
SEEDIND	Indeterminate seed	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0	1	0	1	1	0	1	1	0	0	0	0	0
SETAGLA	*Setaria glauca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SETAITA	*Setaria italica*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETAVER	*S. verticillata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SETAVIR	*Setaria viridis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
SETVIVE	*S. viridis/verticillata*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHERARV	cf. *Sherardia arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
SILEALB	*Silene alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SOLADUL	*Solanum dulcamara*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
SPARERE	*Sparganium erectum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
STACANN	*Stachys annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
STELMED	*Stellaria media*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
TEUCSPE	*Teucrium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
THALFLA	*Thalictrum flavum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
TRIDICS	*T. dicoccum spikelet*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRIDISP	*T. dicoccum/spelta* grains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRIDSPG	*T. dicoccum/spelta*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.8	Site number	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
TRIFARV	*Trifolium arvense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
TRIFPRA	*Trifolium pratense*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TRIFREP	*T. repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TRIGLWS	Glume wheat spikelet forks	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRIMODG	*T. mono./dicoccum* gl.base	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODI	*T. mono./dicoccum*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
TRIMODS	*T. mono./dicoccum* spk.fork	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRISPLS	*T.spelta* spk.fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	1	0	0	1	0	0	1	0	1	0	1	0	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	0	0	0
TRITDIG	*T. dicoccum* glume base	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRITDIS	*T. dicoccum* spikelet fork	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0
TRITFTH	Hexaploid free-threshing grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0
TRITFTR	Free-threshing wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
TRITFTT	Tetraploid free-threshing grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOG	*T. monococcum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMON	*T. monococcum*	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	1	1	1	0	1	1	1	0	1	0	0	1	0	0	1	0	0	0
TRITMOS	*T. monococcum* spk.fork	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
TRITMOT	*T. monococcum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPE	Indeterminate wheat grain	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0
TRITSPL	*T. spelta*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0
TYPHANG	*Typha angustifolia*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPHLAT	*Typha latifolia*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPHSPE	*Typha* sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
URTIURE	*U. urens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICICRA	*Vicia cracca*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICISAT	*Vicia sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
VICITET	*Vicia tetrasperma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
VICTESA	*Vicia tetrasperma/sativa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
VIOLARV	*Viola arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
VITISYL	*Vitis sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
XANTSTR	*Xanthium strumarium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

References for Middle/Late Neolithic Hungarian sites: **110** to **144**-Gyulai 2010a; **115**-Berzsényi & Dálnoki 2005; **134**-Gyulai 2010b; **137**-Gyulai 2010d; **140**-Gyulai 2010c.

Table 2.9: Middle/Late Neolithic Hungary and Romania

		HUNGARY																											ROMANIA							
		145.Hód.-Kökénydomb	146.Hód.-Kotacpart	147.Cegléd 4	148.Abony 8	149.Aszód-Papi földek	150.Szob-Kilenec	151.Bicske-Galagonyás	152.Pápa-Vaszar	153.Ador.-Kenderáztató	154.Hegyesd-Ágói dűlő	155.Zánka-Vasúti bevágás	156.Balatonszárszó-Gönye	157.Balatonszentgyörgy	158.Tapolca-Plébániakert	159.Szólád-Hadúti dűlő	160.Pusztaszemes-Majorság	161.Keszthely-Zsidi út	162.Alsópáhok-Kátyánalja	163.Fenékpuszta-Vámház	164.Kéthely-Sziget	165.Mernye-Szentmiklós	166.Magyaratád	167.Szenyér-Mesztegnyő	168.Dombóvár-Gunaras	169.Kaposvár-Kisapáti dűlő	170.Kaposvár-Villanytelep	171.Zengővárkony	172.Parţa	173.Gradistea Ulmilor	174.Uivar	175.Liubcova	176.Tell Laceni	177.Vladiceasca	178.Măgura-Buduiasca	179.Tell Hirsova
AGRIEUP	*Agrimonia eupatoria*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGRISPE	*Agrimonia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
AGROSPE	*Agrostis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
ATRISPE	*Atriplex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
AVENSAT	*Avena sativa*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSPE	*Avena* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
BRASNIG	*Brassica nigra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BRASSIN	Brassica/Sinapis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BROMARV	*Bromus arvensis*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BROMSTE	*Bromus sterilis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMTEC	*Bromus tectorum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CAMESPE	*Camelina* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CAREDIS	*Carex distans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CAREFLA	*Carex flacca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CAREMUR	*C.muricata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CERINDG	Cereal indeterminate grains	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
CERINDH	Cereal indet. husk/glumes/etc.	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHENALB	*Chenopodium album*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHENHYB	*C. hybridum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHENIND	Chenopodiaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
CHENPOL	*C. polyspermum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CHENSPE	Chenopodium sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
COMPIND	Compositeae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CONIMAC	*Conium maculatum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CORNMAS	*Cornus mas*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CORYAVE	*Corylus avellana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CRUCIND	Cruciferae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
FRAGSPE	*Fragaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
FUMASCH	*Fumaria schleicheri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GALAPTR	*Galium aparine/tricornutum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
GALISPU	*G. spurium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
GRAMIND	Poaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
GRAMINH	Poaceae husks/glumes	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
GRAMINS	Poaceae indeterminate stems	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0
HORDSAN	*H. vulgare* var *nudum* naked grain	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
HORDSPE	*Hordeum* sp. grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
HORSASN	*Hordeum vulgare* grain	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
HORSSNR	*Hordeum vulgare* rachis internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table 2.9	Site Number	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179
LAMIAMP	*Lamium amplexicaule*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LEGUINL	Large Fabaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
LEGUINS	Small Fabaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LENSCUL	*Lens culinaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
LINUUSI	*Linum usitatissimum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LOLIHOR	*Lolium/Hordeum sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
LOLISPE	*Lolium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MALVSPE	*Malva* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MALVSYL	*Malva sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MEDILUP	*Medicago lupulina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MELIALB	*Melilotus albus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MENTSPE	*Mentha* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PANIIND	Panicoideae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
PANIMIL	*Panicum miliaceum*	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
PAPASPE	*Papaver* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PHRAAUS	*Phragmites australis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
PHYSALK	Physalis alkekengi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PISUSAT	*Pisum sativum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0
PLANLAN	*Plantago lanceolata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POASPEC	*Poa* sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLAVCO	*Polygonum aviculare/convolvulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYAVI	*P. aviculare*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYCON	*P. convolvulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
POLYIND	Polygonaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYMIN	*Polygomun minus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POLYSPE	*Polygonum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
POTEREP	*Potentilla reptans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POTESPE	*Potentilla sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PRUNAVI	*Prunus avium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PRUNDOM	*Prunus domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
PRUNINS	*Prunus insititia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PRUNSPE	Prunus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
PRUNSPI	*P. spinosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
PUCCSPE	*Puccinellia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RANUREP	*R. repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RUBUCAE	*R. caesius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RUBUIDA	*R. idaeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RUBUSPE	*Rubus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
RUMEACT	*Rumex acetosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
RUMEOBT	*Rumex obtusifolius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
RUMESAN	*Rumex sanguineus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
SAMBNIG	*S. nigra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
SCIRLAC	*Scirpus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SCIRSPE	*Scirpus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SCLESPE	*Scleranthus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SECACEG	*Secale cereale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SECACER	*Secale cereale* rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SEEDIND	Indeterminate seed	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SETAITA	*Setaria italica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SETVIVE	*S. viridis/verticillata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0

Table 2.9	Site Number	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179
SOLAIND	Solanaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
SPARSPE	*Sparganium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
STACANN	*Stachys annua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TEUCSPE	*Teucrium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIDEMG	*T. dicoccum/*'new' type gl. base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIDISP	*T. dicoccum/spelta* grains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIDIEM	*T. dicoccum/*'new' type grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIFCAM	*Trifolium campestre*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIFREP	*T. repens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIGLWG	Glume wheat glume bases	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TRIGLWS	Glume wheat spikelet forks	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TRIMDEG	*T. mono/dico.*/'new' type gl base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIMODG	*T. mono./dicoccum* gl.base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIMODI	*T. mono./dicoccum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIMODS	*T. mono./dicoccum* spk.fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TRITBOS	*T.boeticum* spikelet fork	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	1	1	1	0	1
TRITDID	*Triticum* dicoccoides grains	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TRITDIG	*T. dicoccum* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
TRITEMG	'New' type gl. base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
TRITEMM	'New' type grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRITFTH	Hexaploid free-threshing grain	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
TRITFTR	Free-threshing wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRITGLW	Glume wheat grain	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRITMOG	*T. monococcum* glume base	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
TRITMON	*T. monococcum* grain (1/2g)	0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1	1	1	1	0	1	1	1
TRITMOO	*T. monococcum* grain (1g)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
TRITMOS	*T. monococcum* spk.fork	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
TRITSPE	Indeterminate wheat grain	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1
TRITSPH	Indet. wheat glumes/husks	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1
TYPHANG	*Typha angustifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
TYPHLAT	*Typha latifolia*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
VEROHED	*Veronica hederifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VEROSPE	*Veronica* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VICILAT	*Vicia/Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
VIOLTRI	*Viola tricolor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

References for Middle/Late Neolithic Hungarian and Roamanian sites: **145** to **171**-Gyulai 2010a; **172, 173, 175**-Cârciumaru 1996; **174**-Fischer & Rösch 2004; **176**-Colledge 2016; **177**&**179**-Cârciumaru 1991; **178**-Bogaard & Walker 2011.

Table 2.10: Middle/Late Neolithic Eastern Croatia and Northern Italy

		CROATIA – SLAVONIA										NORTHERN ITALY																		
		83.Ravnjaš-N. Kapela	84.Slavća	85.Otok	86.Bapska	87.Sopot	88.Ivandvor—Šuma Gaj	89.Tomašanci-Palača	90.Hermanov Vinograd	91.Virovitika-Brekinja	92.Brezovljani	206.Forli - via Navicella	207.Spilamberto	208.Rivarolo Mantovano	209.Vhó di Piadena	210.Casatico di Marcaria	211.Isorella	212.Maserà	213.Fimon M.Casarotto	214.Vela in Trento	215.Lugo di Romagna	216.Palù di Livenza	217.Fagnignola	218.Piancada	219.Sammardenchia	220.Pavia di Udine	221.Savignano	222.Chiozza	223.Albinea	224.Ostiano
AGROGIT	*Agrostemma githago*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
AGROSPE	*Agrostis* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AJUGCHA	*Ajuga chamaepitys*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
AJUGREP	*Ajuga reptans*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANCHSPE	*Anchusa* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APHAALC	*Aphanes/Alchemilla*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
APIUGRA	*Apium graveolens*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARTESPE	*Artemisia* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATRISPE	*Atriplex* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATRPAHA	*Atriplex patula/hastata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
AVENSPE	*Avena* sp.	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BRASSIN	Brassica/Sinapis sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMHOR	*B. hordeaceus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CAREMUR	*C.muricata*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARENIG	*C.nigra*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARESYL	*C.sylvatica*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARPBET	*Carpinus betulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CARYIND	Caryophyllaceae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CERASPE	*Cerastium* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERINDC	Cereal indeterminate culm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CERINDG	Cereal indeterminate grains	1	1	0	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
CERINDR	Cereal indeterminate rachis	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENALB	*Chenopodium album*	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
CHENBOT	*C. botrys*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENIND	Chenopodiaceae indeterminate	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
CHENSPE	Chenopodium sp.	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMPIND	Compositeae indeterminate	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CONVARV	*Convolvulus arvensis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0
CORNSAN	*C. sanguina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0
COROVAR	*Coronilla varia*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1
CRATMON	*Crataegus monogyna*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRATSPE	*Crataegus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0
CRUCIND	Cruciferae indeterminate	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ECHICRG	*Echinochloa crus-galli*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHPEP	*E. peplus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FESTLOL	*Festuca/Lolium*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FESTPRA	*Festuca pratensis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.10	**Site Number**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**206**	**207**	**208**	**209**	**210**	**211**	**212**	**213**	**214**	**215**	**216**	**217**	**218**	**219**	**220**	**221**	**222**	**223**	**224**
FESTSPE	*Festuca* sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FICUCAR	*Ficus carica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
FRAGPOT	*Fragaria/Potentilla*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FRAGVES	*Frageria vesca*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
GALESTA	*Galeopsis/Stachys*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALIAPA	*Galium aparine*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GALISPE	*Galium* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
GRAMIND	Poaceae indeterminate	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
HORDSAN	*H. vulgare* var *nudum* naked grain	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSRI	*H. vulgare* hulled r. internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
HORSASN	*Hordeum vulgare* grain	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1
HORSSNR	*Hordeum vulgare* rachis internode	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUGLREG	*Juglans regia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
JUNCSPE	*Juncus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LABIIND	Lamiaceae indeterminate	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATCISA	*Lathyrus cicera/sativus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LATHSAT	*Lathyrus sativus*	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUIND	Fabaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0
LEGUINL	Large Fabaceae	0	1	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUINS	Small Fabaceae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LENSCUL	*Lens culinaris*	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0
LOLIMUL	*Lolium multiflorum*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLISPE	*Lolium* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLITEM	*Lolium temulentum*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LYCHFLC	*Lychnis flos-cuculi*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MALUSPE	*Malus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MALUSYL	cf. *Malus sylvestris*	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
MEDILUP	*Medicago lupulina*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISAT	*Medicago sativa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MELIOFF	*Melissa officinalis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MONTFON	*Montia fontana*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NIGEARV	*Nigella arvensis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PANISPE	*Panicum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
PAPASOM	*Papaver somniferum*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PAPASPE	*Papaver* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PAPDUSO	*Papaver dubium/somniferum*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHALSPE	*Phalaris* sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHLESPE	*Phleum* sp.	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHYSALK	Physalis alkekengi	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
PHYSSOL	*Physalis/Solanum*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PICRHIE	*Picris hieracioides*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSAT	*Pisum sativum*	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0
PISUSPE	*Pisum* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0

Table 2.10	Site Number	83	84	85	86	87	88	89	90	91	92	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
PLANLAN	*Plantago lanceolata*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POASPEC	*Poa* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYAVI	*P. aviculare*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYCON	*P. convolvulus*	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
POLYLAP	*P. lapathifolium*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYPER	*P. persicaria*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POLYSPE	*Polygonum* sp.	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
POTASPE	*Potamogeton* sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POTESPE	*Potentilla sp.*	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIMIND	Primulaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNAVI	*Prunus avium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PRUNSPE	Prunus sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0
PRUNSPI	*P. spinosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	1	0	0	0	0
PYRUMAL	*Pyrus/Malus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PYRUSPE	*Pyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
QUERSPE	*Quercus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	1	0	1	1	0	0	0	0	0
RANUARB	*R. acris/repens/bulbosus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUFRU	*Rubus fruticosus*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0
RUBUIDA	*R. idaeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
RUMEACE	*Rumex acetosella*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMEACT	*Rumex acetosa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMECRI	*R. crispus*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUMESPE	*Rumex* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	1	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0
SAMBRAC	*S. racemosa*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	0	0
SAMNIRA	*S. nigra/racemosa*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
SECACEG	*Secale cereale*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEEDIND	Indeterminate seed	1	1	0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SETAITA	*Setaria italica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
SETAPAN	*Setaria/Panicum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
SETAVIR	*Setaria viridis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SETISPE	*Setaria* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
SHERARV	cf. *Sherardia arvensis*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOLADUL	*Solanum dulcamara*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SOLANIG	*Solanum nigrum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TARAOFF	*Taraxacum officinale*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRAPNAT	*Trapa natans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
TRIDEMG	*T. dicoccum/*'new' type gl. base	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRIDEMS	*T. dicoccum/*'new' type spk.fok	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRIDIEM	*T. dicoccum/*'new' type grain	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFCAM	*Trifolium campestre*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFMED	*Trifolium/Medicago* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.10	Site Number	83	84	85	86	87	88	89	90	91	92	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224
TRIGLWG	Glume wheat glume bases	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRIGLWS	Glume wheat spikelet forks	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIHORG	Wheat / Barley grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRIMDEG	*T. mono/dico.*/'new' tpe gl base	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMDEM	*T. mono/dico.*/'new' type grain	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODG	*T. mono./dicoccum* gl.base	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRIMODI	*T. mono./dicoccum*	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
TRIMODS	*T. mono./dicoccum* spk.fork	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRISPLG	*T.spelta* gl.base	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	1	1	0	1	1	1	0	1	0	0	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	0	0	0	0
TRITDIG	*T. dicoccum* glume base	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
TRITEMG	'New' type gl. base	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0
TRITEMM	'New' type grain	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITEMS	'New' type sikelet fork	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TRITESP	*T. spelta*/'new' type grain	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTH	Hexaploid free-threshing grain	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTR	Free-threshing wheat rachis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	1	1	0	0	1	0	0	1	0	0	1	1	1	0	0	1	1	0	0	1	1	1	0	1	1	0	0	0	0
TRITGLW	Glume wheat grain	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOG	*T. monococcum* glume base	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
TRITMON	*T. monococcum* grain (1/2g)	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	0	0	0	0
TRITMOO	*T. monococcum* grain (1g)	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOS	*T. monococcum* spk.fork	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
TRITMOT	*T. monococcum* grain (2g)	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPE	Indeterminate wheat grain	1	1	0	0	1	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	1	1	0	0	0
TRITSPH	Indet. wheat glumes/husks	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPL	*T. spelta*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0
TRITSPR	Indet. *Triticum* rachis inernode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
URTIDIO	*Urtica dioica*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
URTIURE	*U. urens*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALEDEN	*Valerianella dentata*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VALELOC	*Valerianella locusta*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEREOFF	*Verbena officinalis*	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
VICISAT	*Vicia sativa*	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VITISYL	*Vitis sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1	1	0	0	0	0	0

References for the Middle/Late Neolithic sites from eastern Croatia (Slavonia) and northern Italy: **83, 84, 87, 88, 89, 91**-Reed 2012; **83, 85, 87, 88, 91**-Reed 2015; 92-Rožić 2003; **206**&**207**-Gobbo 2010; **209**-Castelletti & Maspero 1992; **208** to **215, 217** to **224**-Rottoli & Castiglioni 2009; **209, 211, 214, 215, 218** to **222, 224**-Rottoli & Pessina 2007; **214-** Degasperi *et al*. 2006; **216**-Corti *et al*. 1998; **217**&**219**-Carugati 1993; **218**&**219**-Rottoli 2006; **221**-Starnini *et al.* 2000; **222, 223**-Evett & Renfrew 1971; **224**-Nisbet 1995.

Table 11: Middle/Late Neolithic Adriatic Croatia and South & Central Italy

		ADRIATIC CROATIA						SOUTHERN ITALY																	CENTRAL I.		
		180.Grapčeva cave	181.Danilo	182.Pokrovnic	183.Čista Mala Velištak	184.Turska Peć	185.Gromače-Brijuni	186.Serra Cicora	187.Carpignano Salentino	188.Capo Rondinella	189.Oria Sant'Anna	190.Grotta S'Angelo	191.San Domenico	192.Scamuso	193.Grotta della Tartaruga	194.Grotte Santa Croce	195.Olivento di Lavello	196.Passo di Corvo	197.Masseria Candelaro	198.Masseria Fontanarosa	199.Masseria St. Tecchia	200.Defensola A	201.Palese	202.Le Macchie	203.Ripoli	204.Catignano	205.San Marco Gubbio
AJUGSPE	*Ajuga* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
AMYGCOM	*Amygdalus communis*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AMYGSPE	*Amygdalus* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASTRCIC	*Astragalus cicer*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AVENSAT	*Avena sativa*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0
AVENSPE	*Avena* sp.	0	1	1	1	0	0	1	0	1	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	1
BRASSIN	Brassica/Sinapis sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BROMSPE	*Bromus* sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BUGLARV	*Buglossoides arvensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BUGLSPE	*Buglossoides* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARESPE	*Carex* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARYIND	Caryophyllaceae	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERASPE	*Cerastium* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CERINDG	Cereal indeterminate grains	1	1	1	1	1	0	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	1
CHENALB	*Chenopodium album*	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
CHENIND	Chenopodiaceae indeterminate	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHENSPE	Chenopodium sp.	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMPIND	Compositeae indeterminate	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNMAS	*Cornus mas*	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORNSAN	*C. sanguina*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COROVAR	*Coronilla varia*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CORYAVE	*Corylus avellana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
CUPRSPE	*Cupressus* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYPEIND	Cyperaceae indeterminate	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
CYPESPE	*Cyperus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
EUPHHEL	*E. helioscopia*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
FICUCAR	*Ficus carica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
GALESPE	*Galeopsis* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
GALISPE	*Galium* sp.	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
GRAMIND	Poaceae indeterminate	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HORDSAI	*Hordeum vulgare* hulled grain	0	1	1	1	1	0	1	0	1	0	1	1	1	1	1	0	1	1	0	0	0	0	1	0	1	1
HORDSAN	*H. vulgare* var *nudum* naked grain	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
HORDSAS	*H. vulgare* 6-row hulled grain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
HORDSAT	*H. vulgare* 2-row hulled grain	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	1	0	1	0
HORDSRI	*H. vulgare* hulled r. internode	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
HORSASN	*Hordeum vulgare* grain	1	0	0	1	0	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1

Table 11	**Site Number**	**180**	**181**	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**194**	**195**	**196**	**197**	**198**	**199**	**200**	**201**	**202**	**203**	**204**	**205**
HORSSNR	*Hordeum vulgare* rachis internode	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
HYOSNIG	*Hyoscyamus niger*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYOSSPE	*Hyoscyamus* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYPISPE	*Hypericum* sp.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUNIPHO	*Juniperus phoenicea*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUNISPE	*Juniperus* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAMISPE	*Lamium* sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LATHCIC	*Lathyrus cicera*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
LATHSAT	*Lathyrus sativus*	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
LATHSPE	*Lathyrus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	1	0
LEGUIND	Fabaceae indeterminate	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
LEGUINL	Large Fabaceae	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LEGUINS	Small Fabaceae	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LENSCUL	*Lens culinaris*	1	1	0	1	1	0	0	0	1	0	1	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0
LENSSPE	*Lens* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LILIIND	Liliaceae indeterminate	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUSPE	*Linum* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LINUUSI	*Linum usitatissimum*	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLISPE	*Lolium* sp.	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LOLITEM	*Lolium temulentum*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISAT	*Medicago sativa*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDISPE	*Medicago* sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
OLEAEUR	*Olea europea*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PANIMIL	*Panicum miliaceum*	0	0	1	0	1	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
PHLESPE	*Phleum* sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PINUSPE	*Pinus* sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISTSPE	*spPistacia.*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISULAT	*Pisum/Lathyrus* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSAT	*Pisum sativum*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PISUSPE	*Pisum* sp.	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
POLYIND	Polygonaceae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
POLYRUM	*Polygonum/Rumex* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
POLYSPE	*Polygonum* sp.	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
POTEARG	*Potentilla argentea*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POTESPE	*Potentilla sp.*	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNDOM	*Prunus domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRUNSPE	Prunus sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 11	**Site Number**	**180**	**181**	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**194**	**195**	**196**	**197**	**198**	**199**	**200**	**201**	**202**	**203**	**204**	**205**
QUERILE	*Quercus ilex*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
QUERSPE	*Quercus* sp.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RANUSPE	*Ranunculus* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ROSACAN	*Rosa canina*	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROSASPE	*Rosa* sp.	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUFRU	*Rubus fruticosus*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUBUSPE	*Rubus* sp.	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
RUMESPE	*Rumex* sp.	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBEBU	*Sambucus ebulus*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SAMBSPE	*Sambucus* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SECACEG	*Secale cereale*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SECASPE	*Secale* sp.	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEEDIND	Indeterminate seed	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SETAVIR	*Setaria viridis*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SILESPE	*Silene* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SOLASPE	*Solanum* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SORBARI	*Sorbus aria*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPARJUN	*Spartium junceum*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TEUCSPE	*Teucrium* sp.	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIDICS	*T. dicoccum spikelet*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIFSPE	*Trifolium* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIFTHR	Hexaploid free-threshing rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TRIGLWG	Glume wheat glume bases	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRIGLWS	Glume wheat spikelet forks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
TRIGSPE	*Trigonella* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIHORG	Wheat / Barley grain	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMDEG	*T. mono/dico.*/'new' type gl base	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODG	*T. mono./dicoccum* gl.base	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRIMODI	*T. mono./dicoccum*	0	1	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1
TRIMODS	*T. mono./dicoccum* spk.fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

Table 11	**Site Number**	**180**	**181**	**182**	**183**	**184**	**185**	**186**	**187**	**188**	**189**	**190**	**191**	**192**	**193**	**194**	**195**	**196**	**197**	**198**	**199**	**200**	**201**	**202**	**203**	**204**	**205**
TRISPLG	*T.spelta* gl.base	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIC	*T. dicoccum* grain	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TRITDIG	*T. dicoccum* glume base	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITDIS	*T. dicoccum* spikelet fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
TRITEMG	'New' type gl. base	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITFTH	Hexaploid free-threshing grain	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	1	1
TRITFTR	Free-threshing wheat rachis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TRITFTW	Free-threshing wheat grain	1	1	0	1	1	0	1	0	1	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	1
TRITMOG	*T. monococcum* glume base	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMON	*T. monococcum* grain (1/2g)	0	0	1	0	0	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	1	1
TRITMOO	*T. monococcum* grain (1g)	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITMOS	*T. monococcum* spk.fork	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0
TRITMOT	*T. monococcum* grain (2g)	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRITSPE	Indeterminate wheat grain	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	0	1	1
TRITSPH	Indet. wheat glumes/husks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
TRITSPL	*T. spelta*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
TRITSPR	Indet. *Triticum* rachis internde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMBEIND	Umbelliferae indeterminate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
URTIURE	*U. urens*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VERBSPE	*Verbascum* sp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VICIERV	*Vicia ervilia*	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
VICIFAB	*Vicia faba*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0
VICIGRA	*Vicia grandiflora*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
VICISPE	*Vicia* sp.	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
VITISPE	*Vitis* sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
VITISYL	*Vitis sylvestris*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

References for Middle/Late Neolithic sites from Adriatic Italy and South and Central Italy: **180-**Borojević *et al*. 2008; **181, 182-**Karg & Müller 1990, Reed 2006, Reed & Colledge 2016; **183**-Reed & Podrug 2016; **183**&**184**-Reed 2012; **184**&**185**-Reed 2015; **186, 187, 188, 189, 191, 192, 193, 194, 196, 198, 199, 200**-Fiorentino *et al*. 2013; **190, 192**, **195, 197, 198, 199, 201, 203, 202, 204, 205**-Costantini & Stancanelli 1994; **196, 201, 203**-Evett & Renfrew 1971; **202-**Coppola & Costantini 1987, Rottoli & Castiglioni 2009.